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

February 2003

BUDGET ACTIVITY
2 - Applied Research

PE NUMBER AND TITLE
0602303A - MISSILE TECHNOLOGY

	COST (In Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
	Total Program Element (PE) Cost	58855	53308	43269	50407	58650	47552	45293	39346
214	MISSILE TECHNOLOGY	52621	46729	31372	35662	43944	35794	37443	39346
223	AERO-PROPULSION TECHNOLOGY	6234	4576	0	0	0	0	0	0
340	SWORD	0	2003	0	0	0	0	0	0
G02	NATIONAL AEROSPACE INITIATIVE APPLIED RESEARCH	0	0	11897	14745	14706	11758	7850	0

A. Mission Description and Budget Item Justification: This applied research program element investigates advanced technologies for missiles, rockets, and unmanned vehicles for use in the Objective Force, including the Future Combat Systems (FCS). 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. Major technology areas include missile guidance systems, air defense acquisition systems, multi-spectral seekers, high fidelity simulations, missile aerodynamics and structures, missile propulsion, hypervelocity compact kinetic energy missile efforts and the development of a common high-g, low cost, Micro Electro-Mechanical Systems (MEMS) Inertial Measurement Unit (IMU). The high-g MEMS IMU program will provide affordability and precision to missile and munitions guidance. 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). The Compact Kinetic Energy Missile (CKEM) program transitioned from Applied Research (6.2) in FY02 to Advanced Technology Development (6.3) demonstrations in FY03. The advanced technology demonstrations will be conducted under PE 0603313A (Missile and Rocket Advanced Technology). The cited work is consistent with the Army Science and Technology Master Plan (ASTMP) and the Army Modernization Plan (AMP). The program element contains no duplication with any effort within the Military Departments. Work is performed at the Aviation & Missile Research, Development, and Engineering Center, U.S. Army Aviation and Missile Command, Redstone Arsenal, AL. This PE supports the Objective Force transition path of the Transformation Campaign Plan. No Defense Emergency Response Funds have been provided to this program.

B. Program Change Summary	FY 2002	FY 2003	FY 2004	FY 2005
Previous President's Budget (FY 2003)	61085	31884	36743	39208
Current Budget (FY 2004/2005 PB)	58855	53308	43269	50407
Total Adjustments	-2230	21424	6526	11199
Congressional program reductions				
Congressional rescissions		-2522		
Congressional increases		25350		
Reprogrammings	-888	-309		
SBIR/STTR Transfer	-1342	-1095		
Adjustments to Budget Years			6526	11199

Change Summary Explanation:

Significant Changes:
Funding - FY 2004/2005: Funds investments in OSD's National Aerospace Initiative (NAI) for hypersonics engine exploration.

FY03 Congressional Adds:
Quantum Optics, Project 223 ($1000); MEMS Technology Development Acceleration, Project 214 ($12750); LENS Facility Modifications for Advance Testing of Endo- and Es-Missile Interceptors and Launch Vehicles, Project 223 ($1000); Multiple Component Army Flight Test, Project 214 ($2550); MEMS IMU/M-Code GPS, Project 214 ($1750); E-STRIKE Short range air defense radar, Project 340 ($2100); Jet Interaction CFD Testbed ($2800); Advanced composite chassis, Project 214 ($1400)

Projects with no R-2A:
($2003), SWORD: E-Strike Short Range Air Defense Radar. Project 340: The objective of this one-year Congressional Add is to design a lightweight multipurpose radar based on interferometric radar technology. No additional funding is required to complete this project.
($954), Quantum Optics, Project 223: The objective of this one-year Congressional Add is to investigate concepts for optical remote sensing, quantum computation encryption and coding and navigation systems. No additional funding is required to complete this project.

($953), LENS Facility Modifications for Advance Testing of Endo- and Exo-Missile Interceptors and Launch Vehicles, Project 223: The objective of this one-year Congressional Add is to design modifications for the LENS facility to employ in the large-scale Shock-Tunnel/Ludweig Tube Facility at the Army's Aero-thermal and Aero-Optics Evaluation Center. No additional funding in required to complete this project.
($2669), Jet Interaction CFD Testbed, Project 223: The objective of this one-year Congressional Add is to perform Computational Fluid Dynamics (CFD) tests to explore hypervelocity aero-propulsion effects at endo-atmospheric attitudes. No additional funding is required to complete this project.

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

COST (In Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
214	MISSILE TECHNOLOGY	52621	46729	31372	35662	43944	35794	37443	39346

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 FCS and Objective Force. 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. 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-g, low cost MEMS 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). The High-g MEMS IMU will also be transitioned to Excalibur, Mid-Range Munition (MRM), and Multi-Role Armament and Ammunition System (MRAAS). This is a joint program with the Armament Research, Development and Engineering at Picatinny Arsenal. Another major effort in this project was the CKEM program, which ended its 6.2 work in FY02. As efforts in this project mature, work is transitioned to PE 0603313A (Missile and Rocket Advanced Technology). The cited work is consistent with the Army Science and Technology Master Plan (ASTMP) and the Army Modernization Plan (AMP). The program element contains no duplication with any effort within the Military Departments. Work is performed at the Aviation & Missile Research, Development, and Engineering Center, U.S. Army Aviation and Missile Command, Redstone Arsenal, AL. This project supports the Objective Force transition path of the Transformation Campaign Plan. No Defense Emergency Response Funds have been provided to this program.

Accomplishments/Planned Program	FY 2002	FY 2003	FY 2004	FY 2005
- High-G MEMS IMU - In FY02, performed detailed design and analysis of first generation devices, incorporating emerging results from development effort. Constructed, evaluated, and refined manufacturability processes to begin production automation and process control maturation. In FY03, mature and live-fire test IMUs to meet the following parameters: Gyro Bias <75 deg/hr, Vol <8 cu. in., Accel <9mg, Gun-Hardened to 10,000g. In FY04, mature and live-fire test IMUs to meet the following parameters: Gyro Bias <20 deg/hr, Vol <4 cu. in., Accel <4mg, Gun-Hardened to 20,000g. Test units by live firings resulting in TRL5. In FY05 build and test interim IMU with integrated GPS in laboratory and missile environments	9379	10000	8900	14000
- High-g MEMS/IMU Technology Development Acceleration– The purpose of this Congressional interest item is to support the integration of deeply integrated GPS prototypes into first generation hardware for testing and research and test GPS anti-jam hardwar	7000	12263	0	0
- MEMS IMU/M -Code GPS – The purpose of this Congressional interest item is to accelerates the development of MEMS IMU/M -Code GPS development	0	1693	0	0
- Low-Cost Guidance and Navigation Unit - This Congressional add provided research into a deeply integrated GPS/IMU.	4819	0	0	0
- CKEM – In FY02, successfully conducted full-scale (~5', 105lb) unguided CKEM technology testbed flight tests at Eglin, AFB. Achieved test goals include gathering velocity data, data relating to missile electronics operations and survivability, guidance link transmissibility, and target tracker information. Tested both radio frequency (RF) and electro-optic guidance techniques for CKEM. Successfully performed and simulated multiple full-scale lethality tests of novel penetrators and lethal mechanism components to evaluate target penetration, perforation and secondary lethal effects. Testing, modeling, and simulation have proven that a small, lightweight kinetic energy missile can provide lethality overmatch against current tanks and future advanced threat armor. This technology effort transitioned to 0603313 Missile and Rocket Advanced Technology at the end of FY02	10295	0	0	0
- CKEM IMU – The purpose of this Congressional interest item is risk reduction and maturation of an alternative design approach for the CKEM IMU. No additional funding is required to complete this project.	1000	0	0	0

Accomplishments/Planned Program (continued)	FY 2002	FY 2003	FY 2004	FY 2005
- Missile Guidance Systems and Seeker Technology - In FY02, tested MEMS-based angular rate sensors (ARSs) that incorporate technology developed by DARPA. Tested in the laboratory and in a relevant environment both the MEMS-based ARS and the single axis roll rate sensor. MEMS-based angular rate sensors (ARSs) are able to meet hypervelocity missile high-g operational requirements with a low cost small component. Designed an optical test bed to evaluate advancements in uncooled detector technology. Investigated concept designs for uncooled IR sensor for missile applications. In FY03 integrate MEMS-based angular rate sensors and roll rate sensor into a three-axis rate package, test and transition to FCS and industry. By the end of FY05 mature controlled arrays of MEMS sensors to provide full dynamic performance ranges for miniature sensing systems, focusing on inertial applications. Design geometry transformations for rapid retraining of automatic target recognition (ATR) systems that will allow precision strike of a target from a different direction than it was originally detected. Devise hardening techniques and algorithms for IR seekers to defeat laser counter-countermeasures (CCM). By the end of FY04 perform laboratory tests of IR CCM guidance algorithms in a seeker. By the end of FY05 perform field tests of IR CCM guidance algorithms in a seeker. Demonstrate concepts of advanced uncooled infrared seeker and sensor hardware. Design, mature, and test advanced optics, signal processing, and guidance and control techniques utilized in uncooled imaging infrared seeker and sensor packages. Conduct captive carry tests of prototype uncooled seeker and sensor systems (TRL 5) in FY05, and transfer optical and electronic technology (TRL 5) in FY05.	7874	6238	8202	8594

Accomplishments/Planned Program (continued)	FY 2002	FY 2003	FY 2004	FY 2005
- High Fidelity System Level Simulations and Aerodynamics - In FY02, designed signal generation capability for infrared (IR) LADAR Hardware-in-the-loop (HWIL) simulation; designed cold chamber background for IR target simulation; continued design and build of target signature databases. In FY03, develop and improve target signature and background scenario modeling and simulation techniques for real-time hardware-in-the-loop system simulations and perform wind tunnel tests and missile aerodynamic predictions. Complete the investigation of an improved method of RF millimeter wave scatter extraction from measurements and validate "spinning tail" and "bent nose" aerodynamic predictions. In FY04 complete the development of a method of rapid infrared passive signature prediction using the MuSES code and initiate techniques for modeling target signatures as perceived by LADAR sensors; characterize supersonic/hypersonic aerodynamic missile controls and power-on base drag; initiate FCS missile geometry and thrust level prediction methodologies. In FY05 continue development of techniques for modeling target signatures as perceived by LADAR sensors; complete FCS missile geometries and thrust levels characterization.	980	1000	2083	1720
- Smart, Stealthy, Smokeless Missile Propulsion and Smart Structures - In FY02, completed design, fabricated and tested brassboard of a deep throttling booster controllable thrust technology, which increases range and provides multi-mission capability for a family of FCS and Objective Force weapon systems. In FY03 design, fabricate, and static test integrated deep throttling booster that extends the capabilities of controllable thrust technology to increase range and provide multi-mission capability for a family of FCS and Objective Force weapon systems. Mature controllable thrust components applicable to the 2.75-inch and smaller diameter family of rockets and deliver a validated Computational Fluid Dynamics (CFD) tool for designing compact thrusters. By the end of FY03, mature system level concepts, select one propulsion option and one pressurization option for brassboard evaluation, evaluate designs using CFD model, and begin design of component hardware (TRL 3). In FY04, complete design of, fabricate, conduct functional demonstration of critical components, and begin CFD model validation (TRL 4). In FY05, demonstrate components in brassboard hardware.	2570	3720	3420	3670

Accomplishments/Planned Program (continued)	FY 2002	FY 2003	FY 2004	FY 2005
- Focused Technology Integration - In FY02, integrated a fully functional Remote Readiness Asset Prognostics/Diagnostics System (RRAPDS) brassboard system. Evaluated RRAPDS as a Horizontal Technology Integration (HTI) candidate for a launch platform and a high value conventional munition. Evaluated ability to provide the user with target information on stationary and moving military vehicles using small unmanned aerial vehicles. Defined critical technologies for a 2.75 inch Advanced Miniature Multi-Role Precision Guided Missile (AMMPGM). In FY03, complete Phase I Feasibility Demonstration (TRL 4) and Phase II Interface Demonstration of Fire Control-Node Engagement Technology (FC-NET) including interim fire control computer virtual simulation testing, integration of the baseline missile target pairing algorithms and transition FC-NET to 0603313 Missile and Rocket Advanced Technology. In FY03, establish the best technical approach for the component technologies for AMMPGM. Transition AMMPGM to 0603313 Missile and Rocket Advanced Technology. In FY04, perform concept development and subsystem/component level development of supporting technologies of an air defense capability for the Unit of Action. In FY05, mature system concepts and complete initial system and component design of an air defense capability for the Unit of Action.	6704	8016	8767	7678
- LAM-A – This Congressional interest item fabricated and assembled long range loiter missiles airframe and seeker components and prepared for integration of prototype hardware for ballistic flight test. No additional funding is required to complete this project.	2000	0	0	0
- Multiple Component Army Flight Test - The purpose of this Congressional interest item is to design alternative test processes to verify advanced missile components in a ground test facility under duplicated flight conditions to avoid performing the actual expensive and difficult flight tests. No additional funding is required to complete this project.	0	2453	0	0
Advanced Composite Chassis - - The purpose of this Congressional interest item is to demonstrate the feasibility of using advanced, novel, lightweight composites for hypervelocity missile airframe > and support structures. No additional funding is required to complete this project.	0	1346	0	0
Totals	52621	46729	31372	35662

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February 2003

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

COST (In Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
G02	NATIONAL AEROSPACE INITIATIVE APPLIED RESEARCH	0	0	11897	14745	14706	11758	7850	0

A. Mission Description and Budget Item Justification: This project funds applied research to explore and mature the critical technologies required to develop expendable hypersonic cruise missiles and ballistic missiles. Primary technology focus areas are those deemed critical by the National Aerospace Initiative (NAI) to the advancement of national goals in hypersonic weapon development and access to space. These focus areas include scramjet engine development, hypersonic airframe aerodynamics and structures, thermal protection systems, active and passive cooling mechanisms, turbulent mixing enhancement at low Reynolds numbers, computational fluid dynamics, high yield storable fuel grain development and alternate methods of hypersonic missile guidance, navigation and control. Initial effort will focus on development of a gun-launched, scramjet engine powered projectile scalable to larger missile applications. Efforts will be conducted through detailed system and subcomponent simulation, design, development and test in laboratory and operational settings. Funding for this effort is provided in coordination with other DOD and government elements participating in NAI. As a result, numerous leveraging and technology insertion opportunities are available. The cited work is consistent with the Army Science and Technology Master Plan (ASTMP) and the Army Modernization Plan (AMP). The program element contains no duplication with any effort within the Military Departments. Work is performed at the Aviation & Missile Research, Development, and Engineering Center, U.S. Army Aviation and Missile Command, Redstone Arsenal, AL. This project supports the Objective Force transition path of the Transformation Campaign Plan. No Defense Emergency Response Funds have been provided to this program.

Accomplishments/Planned Program	FY 2002	FY 2003	FY 2004	FY 2005
- NAI Airframe: In FY04, trade studies of component designs including, inlet, nozzle, thermal protection system, fuel and coolant supply system and shroud will be initiated. Computational fluid dynamic analysis shall be performed in FY04 to identify airframe components under critical aero thermal stress at worst-case operational conditions. In FY05, design trade studies culminating in initial subcomponent designs will be completed; fabrication of subcomponent hardware will be initiated for use in structural and thermal analysis.	0	0	4550	2700
NAI Engine: In FY04, computational fluid dynamic analysis will be performed to develop initial engine flow path design. Design concepts for inlet, combustor, fuel injector, and mixing enhancement methodologies will be formulated. In FY05, design concepts for engine flow path subcomponents will be completed by end of fiscal year. Lab testing of possible fuel options will be initiated.	0	0	5247	10045

Accomplishments/Planned Program (continued)	FY 2002	FY 2003	FY 2004	FY 2005
- NAI Hypersonic Launch: In FY04, initial feasibility study of gun-launched scramjet will be completed using computational fluid dynamic analysis. Results of analysis will be coupled with theoretical prediction to develop 6-DOF aerodynamic models to allow detailed simulation of event. In FY05, a detailed simulation analysis of separation event will be conducted to assess feasibility of separation concept; wind tunnel model design will be initiated.	0	0	2100	2000
Totals	0	0	11897	14745