ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2004

BUDGET ACTIVITY
3 - Advanced technology development

PE NUMBER AND TITLE
0603005A - Combat Vehicle and Automotive Advanced Technology

	COST (In Thousands)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
	Total Program Element (PE) Cost	304885	270656	203126	157373	161795	184293	186166
221	COMBAT VEH SURVIVABLTY	40566	45155	27479	20326	21190	23240	23597
440	ADV CBT VEHICLE TECH	22226	1976	16326	0	48157	60277	56244
441	COMBAT VEHICLE MOBILTY	35758	35495	31283	54707	57495	75644	79760
497	COMBAT VEHICLE ELECTRO	4403	6661	5831	9868	9618	13108	13407
502	HAECO II	1170	0	0	0	0	0	0
506	METAL MATRIX COMPOSITES	1406	0	0	0	0	0	0
515	ROBOTIC GROUND SYSTEMS	8309	7337	12056	22334	23305	9942	11024
533	GROUND VEHICLE DEMONSTRATIONS	0	14175	0	0	0	0	0
539	MOBILE PARTS HOSPITAL	7025	0	0	0	0	0	0
53B	FUEL CELL AUX POWER UNITS FOR LINE HAUL TRUCKS	2809	0	0	0	0	0	0
53D	NAC DEMONSTRATION INITIATIVES (CA)	2529	46228	0	0	0	0	0
53E	IMPACT TRUCK PROGRAM	3278	0	0	0	0	0	0
53F	NAC STANDARD EXCHANGE OF PRODUCT MODEL DATA	2341	0	0	0	0	0	0
53G	FUTURE COMBAT SYSTEMS (FCS)	162000	112659	109360	48188	0	0	0
C66	DC66	3105	970	791	1950	2030	2082	2134
CA3	CORROSION PREVENTION AND CONTROL PROGRAM	2388	0	0	0	0	0	0
CA4	VEHICLE BODY ARMOR SUPPORT SYSTEM	2388	0	0	0	0	0	0
CA5	FUEL CATALYST RESEARCH EVALUATION	936	0	0	0	0	0	0
CA6	INTEGRATED PROGRAM MANAGEMENT FRAMEWORK	936	0	0	0	0	0	0
CA7	RAPID PROTOTYPING	1312	0	0	0	0	0	0

A. Mission Description and Budget Item Justification: The Army vision demands a force that is deployable, agile, versatile, lethal, survivable, and sustainable across the spectrum of operations. The goal of this program element (PE) is to mature and demonstrate leap-ahead combat vehicle automotive technologies to realize the Army's vision and enable transformation to the Future Force and, where feasible, exploits opportunities to enhance Current Force capabilities. Army S&T continues to play an important role in the Future Combat Systems (FCS) program by providing critical technology solutions for enhanced capabilities in current force vehicles, FCS Increment 1, as well as capability-enhancing technologies for FCS Increment 1 Spirals and Increment 2. Supporting FCS remains the highest priority for Army S&T and is the primary effort funded in this PE; therefore a significant portion of the FY03-FY05 funds supports the collaborative Army/Defense Advanced Research Projects Agency (DARPA) FCS program. FCS Memoranda of Agreement (MOA) between the Army and DARPA delineate the collaborative enabling technologies, cost-shared funding profile and responsibilities associated with this partnership. In addition, this PE supports maturation and demonstration of enabling component technologies in the areas of survivability (Project 221), mobility (Project 441) and intra-vehicular digital electronics (Project 497). It also funds efforts to integrate and evaluate diverse vehicle technologies matured by the Army, other DoD agencies and industry. These advanced technologies are demonstrated in coordination with Army warfighter organizations through vehicle component and system level technology demonstrations. The Future Tactical Truck Systems (FTTS) Advanced Concept Technology Demonstration (ACTD) will demonstrate, through hardware, modeling and simulation, high payoff vehicle technologies coupled with current and Future Force sustainment concepts in a User operational environment. The ACTD will integrate technologies including advanced propulsion (hybrid electric), vehicle intelligence (C4ISR, diagnostics, prognostics), mobility (electromechanical suspension, electronically controlled active braking) and intelligent load handling. The Crew Integration and Automation Testbed (CAT) Advanced Technology Demonstrator (ATD) demonstrates multi-mission capable crew stations required for the versatility of the Future Force. The Robotic Follower ATD (Project 515) will mature and demonstrate an unmanned ground system capability for the FCS and the Objective Force Warrior. The intent is to reduce the soldier's equipment burden, increase survivability and reduce the logistics burden. The Integrated Survivability ATD (Project 221) identifies the integration issues associated with upgrading FCS baseline survivability capabilities to meet FCS objective system survivability requirements, while monitoring individual technologies for direct transition opportunities into System Development and Demonstration. Hybrid electric and electric vehicle technologies are key enablers for enhancing current force, FCS and Future Force capabilities. Future vehicles will be designed with hybrid electric architectures, providing power for propulsion, communications and control systems, life support systems, and electric weapons and protection systems. In the mid-term, electromagnetic (EM) armor will be matured and demonstrated. In the longer term, vehicle energy and power levels will be increased to accommodate advanced electric weapons (e.g., lasers, high power microwave and electric guns) and advanced electric-based protection systems. Project 441 will demonstrate critical power, propulsion and electric systems, including energy storage, power distribution and pulse forming networks (PFNs). This PE adheres to Tri-Service Reliance Agreements on advanced materials, fuels and lubricants, and ground vehicles with oversight and coordination provided by the Joint Directors of Laboratories. Work in this program element is related to, fully coordinated with PE 0602601A (Combat Vehicle and Automotive Technology) and 0602618 (Ballistics Technology). The PE is coordinated with the Marine Corps through the Naval Surface Warfare Center, the Naval Research Laboratory, Air Force Armaments Command, and other ground vehicle developers within the Departments of Energy, Commerce, Transportation and DARPA. The program element 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 in this PE is performed by the Tank Automotive Research, Development and Engineering Center (TARDEC), Warren, MI.

B. Program Change Summary	FY 2003	FY 2004	FY 2005
Previous President's Budget (FY 2004)	264795	210856	205245
Current Budget (FY 2005 PB)	304885	270656	203126
Total Adjustments	40090	59800	-2119
Congressional program reductions		-2333	
Congressional rescissions			
Congressional increases		63150	
Reprogrammings	40090	-1017	
SBIR/STTR Transfer			
Adjustments to Budget Years			-2119

Significant Change Explanation.
FY03 - Funds realigned to support DARPA efforts for the Future Combat Systems (FCS) Lead System Integrator (LSI) to continue in preparation for Milestone B.

FY04 - Twenty Six FY04 Congressional Adds totaling $63150 were added to this PE.

FY04 Congressional Adds with no R-2A:
21st Century Truck, Project 53D ($8055)
Advanced Army Modular Composite Bridge, Project 533 ($2015)
Advanced Collaborative Technologies, Project 53D ($2014)
Advanced Thermal Management Controls, Project 53D ($964)
Advanced Thermal Management System, Project 53D ($1918)
Aluminum Lightweight Structures Initiative, Project 533 ($959)
Battery Charging Technology, Project 53D ($959)
Center for Advanced Vehicular Systems, Project 533 ($719)
Chemical Warfare Agent Detection Devices, Project 533 ($1439)
Electrochromatic Material Windows, Project 53D

($2397)
Electrochromatics Research, Project 53D ($2446)
Fastening & Joining Technologies, Project 533 ($959)
Fuel Cell Technology, Project 53D ($2685)
High Power Density & Efficiency OPOC Engine & Electric Power Cell, Project 53D ($1151)
IMPACT (Action pending to change name to HAMMER / THOR) , Project 53D ($4315)
Mechanically Assisted Spare Tire Carrier (MASTC) for the HMMWVs, Project 53D ($1630)
Mobile Parts Hospital, Project 53D ($4028)
NAC Standardized Exchange of Product Data (N-STEP) , Project 53D ($3357)
Pacific Rim Corrosion Research Program, Project 533 ($2493)
Rapid Optimization of Commercial Knowledge (ROCK) for FCS, Project 53D ($2158)
Tactical Vehicle Design Tools, Project 533 ($959)
Turbo Fuel Cell Engine, Project 53D ($4891)
Ultra Reliability for Combat Systems, Project 533 ($959)
Ultra-High Performance Hybrid Structures and Armors, Project 533 ($3260)
US Army Hydrogen Infrastructure, Project 53D ($1918)

Projects with FY04 Congressional Adds and no R-2A are not defined due to space limitations.

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

February 2004

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
3 - Advanced technology development	**0603005A - Combat Vehicle and Automotive Advanced Technology**	**221**

COST (In Thousands)		FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
221	COMBAT VEH SURVIVABLTY	40566	45155	27479	20326	21190	23240	23597

A. Mission Description and Budget Item Justification: This project matures and demonstrates combat vehicle survivability technologies essential for FCS and the Future Force as well as providing a potential upgrade path for survivability capabilities of the current force. These technologies include: electronic warfare (EW), active protection (AP), advanced lightweight armor and signature management. As combat vehicle systems become smaller and lighter to provide the necessary strategic deployability and tactical mobility, one of the greatest technological and operational challenges is providing adequate crew and vehicle protection without reliance on heavy passive armor. This challenge will be met by using a layered approach, including long-range situational awareness, multi-spectral signature reduction, EW and AP systems, and advanced lightweight armor instead of heavy conventional armor. Initial AP efforts demonstrate technologies needed for a system that is effective against Chemical Energy (CE) anti-tank guided missiles (ATGMs), rocket propelled grenades (RPGs) and tank fired high explosive anti-tank (HEAT) munitions. The goal of the AP against CE effort is to demonstrate hard kill, physical interruption with a countermeasure (CM) warhead and soft kill, EW spoofers and jammers while the vehicle is on-the-move (OTM). Defeat of Kinetic Energy (KE) threats offers a substantial challenge due to size and speed of the threat. The goal of the AP against KE effort is to defeat KE with a multi-purpose hard kill CM warhead. The project uses component technologies from PEs 0602601A, 0602120A, 0602618A and 0602624A. The goal of the ballistic protection effort is to provide a suite of lightweight armor component technologies for all manned FCS ground vehicle variants. Armor technologies include electromagnetic, smart and ceramic armors integrated with advanced composite and laminate structures. Lightweight, integrated armor technologies, including components from PE 0602601A, 0602618A and 0602105A, will be demonstrated by ballistic testing of quarter vehicle sections to validate performance versus weight as required for frontal and side armor protection. The signature management effort will improve existing multi-spectral signature modeling tools, characterize hardware performance, and provide inputs to FCS virtual prototyping. The technical goal is to achieve an 80% signature reduction in a validated virtual combat vehicle concept. Multi-spectral combat vehicle signature models will be validated using hardware samples with measured signature characteristics and will be used to assess FCS platform designs 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 in this project is performed by TARDEC, Warren, MI.

Accomplishments/Planned Program	FY 2003	FY 2004	FY 2005
Active Protection against CE - In FY03, designed and implemented threat tracking radio detection and ranging (RADAR) and countermeasure launcher stabilization algorithms required for OTM operation of a limited capability AP system; conducted approximately 80 field demonstrations to support the FCS Milestone B decision; demonstrated live threat AP hard kill of ATGM, RPG and tank fired HEAT live threat defeat(s) from a moving test vehicle; completed live threat EW soft kill of ATGMs from a moving vehicle; designed a more capable countermeasure warhead and cueing sensor RADAR for hemispherical threat detection. In FY04, demonstrate the full capability hemispherical CE AP system against advanced tank fired HEAT threats, ATGMs, RPGs and Faller/Flyers; design and integrate EW countermeasures into a multi-function jam head; design and demonstrate explosive countermeasure; develop tracking RADAR and countermeasure launcher components for improved performance; conduct testing with the system integrated on a moving test vehicle in an operational environment; mature stabilization algorithms for objective vehicle speeds. In FY05, will mature OTM algorithms for EW; field test Multi-Function EW Countermeasure; field test OTM full hemispherical, integrated AP/EW system.	31471	8437	7324
Active Protection against KE - In FY03, tested and validated multiple explosive formed pentrator (MEFP) countermeasure warhead and tested blast concept countermeasure warhead against KE, CE and ATGM flying threats; designed and tested warhead fusing technologies for blast warhead; designed fuse for MEFP warhead; improved model fidelity to represent MEFP and blast warheads. In FY04, downselect KE AP subsystem to be demonstrated for the Integrated Survivability ATD and FCS; conduct comprehensive tests of complete integrated countermeasure interceptor; upgrade AP tracking RADAR to incorporate KE capability. In FY05, will complete KE/CE AP system design, fabricate and integrate with tracking RADAR, interceptor and launcher onto a testbed; demonstrate effectiveness, accuracy and robustness of KE capable interceptor in static fly out field testing.	5500	13702	6307
Active Protection against close-in threats (Full Spectrum Active Protection Close In Layered Shield: FCLAS) – In FY04, install prototype system on a test platform, including integrated FCLAS round, launcher and smoke controller; and demonstrate performance on the move. In FY05, will demonstrate an improved FCLAS soldier-machine interface and demonstrate system modularity; modify existing sensor to increase effectiveness against RPG's, Dual Purpose Improved Conventional Munitions (DPICM); investigate FCLAS configurations for other possible applications including man portable surface to air missiles and smart mines.	0	8954	5635

Accomplishments/Planned Program (continued)	FY 2003	FY 2004	FY 2005
Signature Management In FY03, delivered proof of principle virtual prototyping signature field test capability to FCS Lead System Integrator; performed breadboard testing to quantify field performance and commenced FCS signature modeling predictions. In FY04, develop enhanced modeling capability including exhaust plume signature effects and integration with synthetic imagery; optimize field performance of hardware for FY05 model validation tests. In FY05, will perform full-scale validation tests; develop and validate full capability signature management virtual models; provide robust signature modeling capability to Research Development and Engineering Command's Modeling Architecture for Technical and Research Experimentation (MATREX) (formerly Joint Virtual Battlespace).	3595	4954	5079
Ballistic Protection for FCS - In FY04, complete electro-magnetic (EM) armor component maturation, build vehicle quarter section ballistic targets and range test these fully integrated 3rd generation armor/structure designs against FCS objective threats; demonstrate armor/structural capability at FCS weights and determine armor/structural reliability. In FY05, will conduct ballistic range tests to optimize and validate the best achievable integrated armor packages for lightweight test platforms; complete integration of armor appliqué solutions for FCS objective threats.	0	7975	3134
Small Business Innovative Research/Small Business Technology Transfer Programs	0	1133	0
Totals	40566	45155	27479

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

February 2004

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
3 - Advanced technology development	**0603005A - Combat Vehicle and Automotive Advanced Technology**	**440**

COST (In Thousands)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
440 ADV CBT VEHICLE TECH	22226	1976	16326	0	48157	60277	56244

A. Mission Description and Budget Item Justification: This project demonstrates the operational potential, technical feasibility and maturity of advanced combat and tactical vehicle technologies through integrated demonstrations of subsystems, systems, and systems of systems. Computer simulations and hardware demonstrations (subscale and full scale) are conducted to accomplish a rapid and seamless transition of advanced technologies into systems applications. In FY 2002, funds from this project were transferred to PE 0603005, project 53G for FY 2004 – FY 2006, to fund the DAPRA/Army FCS Partnership – accounting for the lack of continuity in the funding stream. In FY 2003, funds were transferred into this project to support the Future Tactical Truck System (FTTS) Advanced Concept Technology Demonstration (ACTD) in FY 2005. The FTTS ACTD will build tactical maneuver sustainment and utility vehicle demonstrators and evaluate them in a User field environment. The demonstrators will evaluate future tactical vehicle technologies which may include high power density engines, hybrid electric propulsion, electric traction motors, advanced power distribution & control, advanced battery electrical storage, independent & variable height suspension, semi-active/selectable damping suspension, advanced digital driver displays & controls, in addition to looking at virtual vehicle structure & cab designs for survivability and mine protection. New methods and techniques for material handling will also be considered. The demonstrations will be supported by virtual prototyping through the use of 3D CAD models and analysis. These technologies and components will be assessed for applicability to the current fleet of tactical vehicle systems. 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 in this project is performed by TARDEC, Warren, MI.

Accomplishments/Planned Program	FY 2003	FY 2004	FY 2005
Future Tactical Truck System (FTTS) ACTD – In FY05, will build multiple maneuver sustainment and utility vehicle demonstrators/prototypes; test vehicles in a User field environment to evaluate performance and military utility; perform Cost as an Independent Variable Analysis; perform virtual prototyping through the use of 3D models and analysis. This effort uses technology matured in PE 0602601 Project AH77.	0	0	16326
Water Recovery from Vehicle Exhaust for FCS - In FY03, conducted maturation and demonstration of a system to recover water from vehicle exhaust gases using technology being matured in PE 0602601 Project AH91.	2617	0	0
Future Scout and Cavalry System (FSCS) Vehicle Demonstration – In FY03, this one-year Congressional Add continued risk reduction and subsystem maturation activities on sensor packages and associated algorithms to improve sensor capability on a manned, ground reconnaissance system developed under the FSCS Advanced Technology Demonstration (ATD) program which completed in FY02. No additional funds are required to complete this project.	8299	0	0

Accomplishments/Planned Program (continued)	FY 2003	FY 2004	FY 2005
Digital Human & Virtual Reality for FCS – In FY03, this one-year Congressional Add matured digital human modeling/simulation tools and applications that currently do not exist and are needed to analyze & evaluate the human interface for digital models of vehicle systems. No additional funds are required to complete this project.	3550	0	0
Composite Body Parts CAV Technology Transition – In FY03, this one-year Congressional Add implemented manufacturing trials to variations of HMMWV doors, 5 ton truck hood, HMMWV hood front corners, and 2 1/2 and 5 ton truck doors and conducted 12-month field evaluations. No additional funds are required to complete this project.	2220	0	0
Turbo Fuel Cell Engine – In FY03, this one-year Congressional Add matured materials, manufacturing processes, and tube interconnections for solid oxide fuel cell tubes, which are the core of a turbo-charged fuel cell vehicle engine. No additional funds are required to complete this project.	947	0	0
Future Force Cost Module – In FY03, this one-year Congressional Add matured a collaborative information and budget software tool for application to the management of programs being matured for the Future Force. No additional funds are required to complete this project.	3646	0	0
Advanced Thermal Management System – In FY03, this one-year Congressional Add matured advanced pumping technologies for parasitic reduction combined with advanced cooling technology for thermal control. No additional funds are required to complete this project.	947	0	0
Composite Army Vehicle (CAV) – The purpose of this one-year Congressional Add is to transition composite material and manufacturing processes developed for the Composite Armored Vehicle (CAV) to the tactical wheeled vehicle fleet, as well as develop these same materials and processes for use in FCS. No additional funds are required to complete this project.	0	1919	0
Small Business Innovative Research/Small Business Technology Transfer Programs	0	57	0
Totals	22226	1976	16326

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

February 2004

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
3 - Advanced technology development	**0603005A - Combat Vehicle and Automotive Advanced Technology**	**441**

COST (In Thousands)		FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
441	COMBAT VEHICLE MOBILTY	35758	35495	31283	54707	57495	75644	79760

A. Mission Description and Budget Item Justification: This project develops and tests advanced mobility and electric component technologies for next generation combat vehicles and will demonstrate increased vehicle performance and capability. It enables light, agile, deployable, fuel efficient and survivable ground combat vehicles needed for FCS and the Future Force. The main efforts funded by this project are Hybrid Electric Vehicle (HEV) FCS Propulsion Technologies, FCS Engine, Advanced HEV Technologies, Fuel Cells, and Pulse Power. HEV matures components, sub-systems and systems for hybrid-electric vehicles including power distribution and storage systems, traction motors, active suspension, high-density capacitors and pulse power components, and high-temperature silicon/silicon carbide electronics. Demonstrations of these items will be conducted in the Power and Energy Hardware in the Loop Systems Integration Laboratory (P&EHIL-SIL) that simulates combat vehicle power and performance characteristics. HEV offers improved automotive performance, significant reduction in fuel consumption (20-50% savings over today's combat vehicles), silent watch and silent mobility, and vehicle design flexibility. The P&EHIL-SIL will demonstrate electrical power and energy sources, significantly enhanced control methodologies and electrical architectures (enabled by high-speed switching) to provide on-board power management. These efforts support the DoD Power and Energy Initiative. The goal of the FCS Engine effort is to mature and demonstrate prime power (engines) for hybrid combat vehicles with a goal to double the power density (horsepower per cubic foot (hp/cu.ft.)) of a comparable, state-of-the-art, militarized commercial engine. The Army matures high power density engines because commercial engines lack robustness and power density required for Army vehicles. The goal of the effort is to demonstrate a prototype engine system with power density of no less than 6 hp/cu.ft. in FY05 for FCS Increment 1and an 8 to 10 hp/cu-ft power density propulsion systems for integration into FCS Increment 2. A fuel cell initiative is being pursued to accelerate the maturation and application to military vehicle power generation as an alternative to the reciprocating engine for prime power after 2010. The Advanced HEV Technologies will seek further increases in vehicle mobility, efficiency and mission capability without increasing vehicle weight and volume. This effort will apply advanced technologies (traction wheel motors, active suspension, high temperature electronic components, regenerative brakes, thermal management, lightweight track and band track) to next generation vehicles and identify changes in vehicle performance. (Army efforts in hybrid electric drive leverage two prior joint Army/DARPA programs, Combat Hybrid Propulsion System (CHPS) and the Electric Drive Vehicle Demonstration Program, and component technologies from PE 0602601A and PE 0602618A.) The objective of the Pulse Power effort is to mature pulse power component technology options and demonstrate compact pulse power components that enable revolutionary survivability and lethality applications. The goal is to accelerate maturation of high power density, capacitor-based PFNs for electro-magnetic (EM) armor and weapons for FCS Increment 2 and beyond. 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 in this project is performed by TARDEC, Warren, MI in conjunction with Army Research Laboratory (ARL), Adelphi, MD.

Accomplishments/Planned Program	FY 2003	FY 2004	FY 2005
HEV FCS Propulsion –. In FY03 accelerated maturation and demonstration of hybrid electric/hybrid technologies to support FCS Increment I; downsized components to fit the FCS-class manned ground combat vehicles (<20 tons) using a volume goal of 80 cubic feet for the power pack; configured PEHIL-SIL (previously the CHPS SIL) for FCS component testing; demonstrated power levels, control techniques and unique hybrid electric power architectures at the 600 volt level; tested traction motors; matured electric suspension to increase speed over cross country terrain by 70%; documented findings/results and transitioned mature components and subsystems to FCS Lead System Integrator. In FY04, implement strategy for upgrading hybrid electric, band track, and suspension technologies for potential FCS insertion; advance power densities of compact FCS components to objective (goal) power levels (200 kW per cu.m). In FY05, will evaluate advanced hybrid electric components in an integrated environment (SIL) and an integrated moving test rig along with band track and advanced suspension system for ruggedness and performance. Emphasis will be on demonstrating significantly increased hybrid electric system power density in the SIL; advance modeling and simulation capability to include real time power and energy System of Systems vehicle analyses.	13834	8838	8875
FCS Engine - In FY03, demonstrated the power density potential of the three competing engines through preliminary hardware testing in the laboratory. In FY04, downselect to one engine that will undergo performance improvement, mechanical durability testing and 50 hour NATO durability demonstration; optimize engine for hybrid electric application and reconfigure the design for FCS vehicle application. In FY05, will conduct 400 hours of laboratory NATO durability demonstration.	14673	9961	10884

Accomplishments/Planned Program (continued)	FY 2003	FY 2004	FY 2005
Advanced HEV Technologies - In FY04, demonstrate improved electric traction motor with reduced weight and volume characteristics; mature hi temperature all-Silicon Carbide (SiC) motor inverter for 10 kW level for improved power density; test improved Li-Ion batteries at 600 volts for improved efficiency and reduced volume; mature and demonstrate Si/SiC 50 kW DC-DC converter for higher frequency and reduced volume; mature all SiC 10 kW DC-DC converter and scale to 50 kW; and adapt lab capabilities to emulate full electric hybrid system for FCS Sprials or Increment 2. In FY05, will demonstrate 10-50 kW high temperature all-SiC motor inverter; advance Li ion battery technology; demonstrate improved traction motor and active electric suspension for FCS Spirals or Increment 2; continue to advance the performance and maturity of component technologies to allow integration and characterization at the subsystem and system level; perform optimization and validation in collaboration with the HEV FCS Propulsion efforts; provide upgrades to power and energy modeling and simulation efforts.	0	9231	6100
Pulse Power - In FY04, mature and demonstrate high energy density capacitors, high power density/high temp Silicon/Silicon Carbide pulse chargers; and high action, fast rise-time output switches. In FY05, will incorporate components into high-energy density, dual mode PFN for EM Armor and evaluate the PFN in the P&E HIL SIL; fabricate and demonstrate modular, high-action solid state output switches in P&E HWIL SIL. This is a collaborative TARDEC/ARL effort.	0	4867	3789
Fuel Cell Power Initiative: In FY04, conduct laboratory assessment of fuel cell technology state-of-the-art to quantify capabilities and limitations for combat vehicle prime power source consideration; award study contracts for the most power-dense conventional internal combustion and fuel cell prime power packages. In FY05, will complete prime power studies and select two conventional and two fuel cell approaches for advanced development; initiate design development for laboratory hardware integration, performance demonstration, and durability maturation to achieve future combat vehicle propulsion system power density requirements.	0	1619	1635
Hybrid Electric Vehicles – This one year Congressional add built light (hybrid electric HMMWV) and medium (hybrid electric FMTV) HEV demonstration platforms for field evaluation by the warfighter to determine the impact the advanced technologies will have on the warfighters' ability to reduce the logistics footprint while meeting mission requirements. No additional funds are required to complete this project.	4911	0	0
Tracked Hybrid Electric Vehicle – This one year Congressional add demonstrated the system integration and synergistic effects of Command & Control electronics integrated into a hybrid electric vehicle having on-board power generation and storage with a battery management system. No additional funds are required to complete this project.	936	0	0

Accomplishments/Planned Program (continued)	FY 2003	FY 2004	FY 2005
Hybrid Electric Drive: This one year Congressional add supported a systems engineering study that assessed hybrid electric drive systems on military and commercial trucks that identified the technologies and configurations within the design space that will support both a military and commercial requirement. No additional funds are required to complete this project.	1404	0	0
Small Business Innovative Research/Small Business Technology Transfer Programs	0	979	0
Totals	35758	35495	31283

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

February 2004

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
3 - Advanced technology development	**0603005A - Combat Vehicle and Automotive Advanced Technology**	**497**

COST (In Thousands)		FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
497	COMBAT VEHICLE ELECTRO	4403	6661	5831	9868	9618	13108	13407

A. Mission Description and Budget Item Justification: This project matures and demonstrates intra-vehicle electronics hardware and software, producing a multifunctional crew station that will result in increased crew efficiencies/performance and/or reduced crew size for potential upgraded capabilities of current force and FCS vehicles. In addition, the project advances open system architectures for ground combat vehicles that will allow the vehicle crew station to be adapted for a variety of FCS and Future Force ground platforms. The primary effort is the Crew Integration and Automation Testbed (CAT) Advanced Technology Demonstration (ATD), which focuses on automation of crew functions and integration of advanced electronic architecture compatible with automotive and system platform requirements. Products include simplified/user friendly, responsive controls for unmanned ground and air systems, and up to 30% reduction in software and modified commercial power architecture. Vehicle demonstrations to evaluate configurations of multi-role crew stations that will enable a two-man crew to perform functions associated with fighting the battle, reconnaissance, logistics and sustainment, as well as control of unmanned ground and air vehicle assets are scheduled in FY03 and FY06. Goals include a 30% reduction in software cost, a ten-fold increase in architecture throughput, and full mission rehearsal via embedded simulation that will be relevant to FCS. In FY05-FY09, efforts will focus on increased capabilities for potential FCS spiral or increment insertion. These efforts will include increased levels of autonomy for both manned and unmanned systems, an advanced user interface supporting improved and increased span of control for mixed initiative (e.g. reconnaissance and lethality) robotic operations, mixed mode operations with both unmanned ground and aerial assets, collaborative vehicle operations for workload management, continued maturity of auto driving aids, commanders aids, embedded simulation for battlefield visualization, and fully integrated virtual test and evaluation. In addition to the CAT ATD, the Human-Robot Interaction (HRI) effort will mature a common user interface that maximizes multi-functional soldier performance of primary mission tasks by minimizing required interactions and workload in the control of ground and air unmanned systems and minimizes unique training requirements. It will mature advanced models, metrics, and design guidelines for optimal mounted and dismounted soldier-robotic performance, and employ this information to mature, integrate and demonstrate technology required for effective interaction with both air and ground unmanned battlefield systems. This effort will implement model-driven embedded intelligent agents that optimize soldier workload, reduce and or automate controlling tasks, support adaptive and dynamic performance across mounted (embedded) and dismounted systems and enable efficient mixed-initiative operations where manned and unmanned systems team to perform missions. The common interface will increase situational awareness and understanding and provide FCS mounted and dismounted troops control for all unmanned assets. The Advanced Mobile integrated Power System (AMPS) will mature commercial and military power technologies in the area of power generation, energy storage devices, and smart power switching components to develop smart architecture/components to allow management of dynamic power allocation and graceful degradation of loads.. The AMPS open architecture will allow integration and use of emerging commercially developed automotive systems and sub-systems (e.g. 42VDC, 120 VAC, etc.). This effort will integrate and demonstrate diagnostic health monitoring for energy storage, smart battery management, starter-alternator combinations, fuel cells, power control modules, and reusable switching software. 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 in this project is performed by TARDEC, Warren, MI in conjunction with Army Research Laboratory - Human Resources Engineering Directorate

(ARL-HRED), Aberdeen, MD.

Accomplishments/Planned Program	FY 2003	FY 2004	FY 2005
Crew Integration and Automation Testbed (CAT) ATD: In FY03, conducted both virtual and live unmanned combat experiments using an advanced crew station configuration; demonstrated two-crew operation of armor and scout crew tasks; demonstrated 1to 1 control of unmanned ground assets; demonstrated on- and off-road indirect vision driving capability; matured an in-vehicle crew training and mission rehearsal system. In FY04; define cognitive decision aids; continue integration and field testing of advanced crew station configurations; refine component technologies for an electronics architecture and embedded simulation system; add system automation features to the commander's aid, such as the ability to infer operator's intent; integrate UAV control and route planning aids into the Soldier-Machine Interface (SMI); augment combat vehicle driver's aid to use pedestrian and/or dismounted soldier camera vision identification for improved safety and workload reduction; perform trade studies that include technology assessment to support a distributed digital indirect vision system for closed hatch combat vehicle driving operations; integrate the Embedded Combined Arms Team Training – Mission Rehearsal intelligent agent/real time tutoring system for combat operations and training into the CAT ATD Embedded Simulation System (ESS) for experimentation in a militarily relevant environment; extend the ESS to support mission rehearsal capabilities for dismounted soldiers; In FY05, will participate in command and control robotic experiments at Ft. Dix, NJ between 4Q FY04 and 1Q FY05; continue to investigate technology to mix live and virtual imagery, enabling on-the-move embedded simulation and mission rehearsal; implement and test ground vehicle autopilot capability using an upgraded Autonomous Mobility Sensor (AMS) suite; mature a distributed workload management system across manned/unmanned assets that support the FCS network centric concept by integrating FC-Net weapon/target	4403	5487	3963
Technology for Human-Robot Interactions (HRI) in Soldier-Robot Teaming: This is a joint effort between TARDEC and ARL-HRED. In FY05, will leverage ARL-HRED FY04 task identification/analysis and cognitive modeling to implement baseline intelligent agent software that reduces and automates the soldier workload to control ground and air unmanned assets; develop a baseline scalable interface that reduces mounted and dismounted soldier training burden.	0	0	1368
Advanced Mobile Integrated Power System (AMPS): In FY04, investigate and develop advanced smart 42V power alternator, smart energy storage devices, and smart power architecture; demonstrate power architecture concept using modeling & simulation. In FY05, will adapt and develop advanced power distribution, power modules, and smart switching technologies; demonstrate AMPS in a System Integration Laboratory; update AMPS modeling & simulation.	0	500	500

Accomplishments/Planned Program (continued)	FY 2003	FY 2004	FY 2005
Enhanced Combined Arms Team Training: - In FY04, with RDECOM STC, develop the vehicle requirements, architecture specification, and vehicle Soldier-Machine Interface. Integrate these efforts into the Crew Integration and Automation Test bed for testing.	0	500	0
Small Business Innovative Research/Small Business Technology Transfer Programs	0	174	0
Totals	4403	6661	5831

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

February 2004

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
3 - Advanced technology development	**0603005A - Combat Vehicle and Automotive Advanced Technology**	**515**

COST (In Thousands)		FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
515	ROBOTIC GROUND SYSTEMS	8309	7337	12056	22334	23305	9942	11024

A. Mission Description and Budget Item Justification: This project matures and demonstrates unmanned ground vehicle technologies for the FCS and other Future Force ground systems. The main focus is on demonstrating sensor technologies/perception hardware, software and robotic control technologies that are required to enable unmanned ground vehicle (UGV) systems to maneuver with minimal human intervention, on-and off-road, at militarily significant speeds. Mature technologies are incorporated in UGV technology demonstrators, whose performance can be evaluated for multiple tactical and logistics applications. Technical challenges addressed include: obstacle avoidance, perception limitations, intelligent situational behaviors, command and control, frequency of human intervention, and adverse weather operation. In the near term, the Robotic Follower ATD focuses on UGVs that follow other vehicles directly or follow a designated path, requiring little human intervention. The Demo III experimental UGV (XUV) and a converted Stryker Infantry Carrier variant (robotic Stryker) serve as test vehicles. The goals for the ATD are: 5-200km separations between leader and follower, 160-750km range, obstacle detection for objects 0.3 x 1sq.m. in size, and minimum operator intervention (1 per km @20km/hr). This ATD is a cooperative effort between TARDEC and the Army Research Laboratory (ARL), using component technologies matured in PE 0602618A. In the near term, this ATD provides critical information on design and performance of robotic technologies and demonstrations of Follower UGVs for FCS Increment I. Potential applications include re-supply vehicles and Soldier "mules" that may be used to reduce each Soldier's carried load by 40-50 pounds. In the farther term, the project will advance UGV technologies to enable semi-autonomous and autonomous operation and to expand the missions to which UGVs contribute in FCS Increment 2 and beyond. The Armed Robotic Vehicle (ARV) Robotic Technologies (ART) effort will mature a set of automated tactical behaviors that are consistent with the unmanned platform missions in the FCS Unit of Action. These behavior algorithms will be integrated with sensor hardware, components that enable advanced mobility and UGV survivability and appropriate mission modules onto surrogate ARV demonstrator(s) to support FCS enhancement (via spiral insertion and/or for Increment 2.) Potential missions/functions include perimeter security, medical supply and evacuation, scout/reconnaissance and remote weapons delivery. This project was established by the Army in recognition of the increasing maturity of robotics technology, growing user interest in unmanned platforms, and an urgent need to make the force lighter, more agile strategically and tactically and more survivable. The approach builds upon previous and ongoing investments such as the Demo III program, conducted under the Joint Robotics Program Office, and the DARPA UGCV program. 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 in this project is performed by TARDEC, Warren, MI, in conjunction with the Army Research Laboratory, Adelphi, MD.

Accomplishments/Planned Program	FY 2003	FY 2004	FY 2005
Robotic Follower Increment 1: In FY03, successfully demonstrated robust leader follower capability both on and off roads and participated in the Lead Systems Integrator's Unmanned Combat Demo; obtained speeds of 65km/hr on primary roads and cross-country following speed of 20km/hr; completed software build of geometric planning and road following; conducted warfighter experiments, testing and demonstrations (at Fort Bliss, TX Feb-March 2003) of on-road, high speed, line of sight follower; completed cross country, low speed follower for the dismounted soldier using XUV. In FY04, mature sensor data/map registration and trail detection technologies to obtain following speeds of 40km/hr cross-county; integrate enhanced autonomous mobility algorithms and next generation perception sensor from ARL Semi-autonomous Robotics for FCS effort; mature robotic virtual construction and test environment to enable hardware in the loop modeling and simulation.; conduct engineering evaluations and soldier operational testing of follower capability in logistic and tactical mission scenarios. In FY05, will mature/incorporate intelligent situational behavior to significantly increase separation times and distances and assist in prevention of communication loss or mobility kill; mature/integrate vehicle tracking capability to enable operation within traffic; mature pedestrian detection capability to enable safe operation amongst pedestrian traffic; conduct engineering evaluations and soldier operational testing of follower capability in logistic and tactical mission scenarios; participate in command and control robotic experiments at Ft. Dix; conduct urban operations experiment at Fort Knox MOUT facility in 4Q.	8309	7123	6883
Armed Robotic Vehicle Technologies - In FY05, will create a tactical behavior suite that allows the unmanned system to act decisively while maneuvering around the battlefield (i.e. reacting to indirect fire with appropriate tactical maneuver); ensure that the unmanned systems have comparable maneuverability to the manned (mounted and dismounted) systems that will be operating them; demonstrate tactical behavior suite and maneuverability in a simulated setting prior to the technology being integrated into the surrogate ARV demonstrators.	0	0	5173
Small Business Innovative Research/Small Business Technology Transfer Programs	0	214	0
Totals	8309	7337	12056

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

February 2004

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
3 - Advanced technology development	**0603005A - Combat Vehicle and Automotive Advanced Technology**	**53G**

COST (In Thousands)		FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
53G	FUTURE COMBAT SYSTEMS (FCS)	162000	112659	109360	48188	0	0	0

A. Mission Description and Budget Item Justification: This project funds the Army's share of the Army/Defense Advanced Research Projects Agency (DARPA) collaborative FCS technology development program. From Feb 2000 through Sep 2003, the FCS program was executed through an Army/DARPA Memorandum of Agreement (MOA), with DARPA having the lead in the Concept and Technology Development (CTD) Phase. This project provided the Army's share of funds for the FCS Lead System Integrator and for several DARPA enabling technology efforts. Due to acceleration of the program from the original schedule, funding was added to FY03 over the original MOA amount. The Under Secretary of Defense (AT & L) approved the Army's request for FCS to enter into System Development and Demonstration (SDD) phase through a MS B decision in May 2003. This decision approved the Army's evolutionary acquisition strategy for FCS to improve capabilities over time through increments and spirals. The Army/DARPA collaboration will continue through 2006 to help ensure advanced technology improvements continue to push FCS toward objective capabilities. The technologies developed under this project will be inserted into the FCS acquisition program through a spiral development process. Funds in this project are provided to DARPA for selected collaborative projects focused on enabling technologies for FCS, and are executed by DARPA in accordance with project-specific Memoranda of Agreement. In FY05 a portion of the funds in this project will be used for technology development needed to transition deferred systems into FCS. The FY04 and FY05 funds will support technologies in three major thrust areas – 1) Find The Enemy, 2) Autonomy with Intent and 3) Affordable Combat ID. 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 in this project is managed by DARPA, Arlington, VA.

Accomplishments/Planned Program	FY 2003	FY 2004	FY 2005
FCS Design/Demonstration (CTD Phase): In FY03, funded Army's share of FCS Lead Systems Integrator efforts: finalized detailed design for threshold FCS; planned and conducted key tests and capstone demonstrations of the Network and other critical elements to support MS B decision; validated M&S tools created specifically for FCS and used these to support the May 2003 MS B decision; and supported successful transition of FCS into SDD.	90000	0	0

Accomplishments/Planned Program (continued)	FY 2003	FY 2004	FY 2005
Enabling Technologies (CTD Phase): In FY03, provided funds to DARPA for Army's share of technology maturation of programs listed below. More specific information on the DARPA programs and their accomplishments/plans can be found in the DARPA exhibits. NetFires: Designed, built and demonstrated missiles launched out of a container to provide non-line-of-sight lethality for FCS. In FY03, transitioned program management to Army. Maneuver Command, Control, and Communications: Evaluated novel cooperative engagement, cooperative survivability and command and control strategies to help TRADOC determine FCS-based tactics, techniques and procedures. BLOS Surveillance and Targeting Systems- JigSaw: Designed, built and demonstrated a Laser Detection and Ranging (LADAR) system that will allow warfighters to "see" through dense vegetation and under a jungle canopy. In FY03, evaluated LADAR system in limited field-testing. Perceptor: Matured and demonstrated sensors and perception algorithms for autonomous navigation of unmanned ground vehicles (UGVs). In FY03, upgraded perception prototypes and examined performance in degraded conditions. Unmanned Ground Vehicle: Designed, built and demonstrated 600 kilogram and 6000 kilogram UGVs to perform a variety of functions in the FCS-equipped force. In FY03, evaluated UGVs in limited field test. A-160 Hummingbird - In FY03, conducted initial functional and environmental ground-tests. Performed 11 flight tests totaling 4.7 flight hours, at airspeeds up to 112 knots and altitudes up to 4,000 feet. MAV/OAV - In FY03, fabricated and conducted tethered test flight with 9-inch MAV. Conducted test flights with autonomous waypoint navigation with 29-inch OAV.	72000	0	0
Enabling Technologies for Spiral Development: In FY04 and FY05; Conduct enabling technology efforts focused on three critical areas: 1) Find the Enemy, 2) Autonomy with Intent, and 3) Affordable Combat Identification. Find the Enemy will provide capabilities to better defeat camouflage, concealment, and deception and exploit situational awareness through improved sensors, assured communications, intelligent decision aids, and data fusion. Autonomy with Intent will focus on improving unmanned systems' (UAVs and UGVs) ability to function while minimizing soldier workload and interaction. Affordable Combat Identification will increase force survivability by improving identification of battlefield entities for high OPTEMPO in complex terrains and intermingled forces. Efforts included: Man-portable (Class I) UAV ACTD; Organic Air Vehicle (OAV) (Class II) UAV, Multi-cell Command and Control; Armed Recon UGV; and Mobile Networked Multiple-input, Multiple-output Communications.	0	109376	109360
Small Business Innovative Research/Small Business Technology Transfer Programs	0	3283	0

Accomplishments/Planned Program (continued)	FY 2003	FY 2004	FY 2005
Totals	162000	112659	109360