ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2005

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

	COST (In Thousands)	FY 2004 Actual	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	262481	279260	142866	122661	138704	105418	100732	94306
221	COMBAT VEH SURVIVABLTY	48033	26661	18926	19951	34484	17622	27941	28153
440	ADV CBT VEHICLE TECH	1946	19954	0	0	0	0	0	0
441	COMBAT VEHICLE MOBILTY	28595	30016	52360	46025	49996	38543	49828	42774
497	COMBAT VEHICLE ELECTRO	6489	5603	9488	9324	13039	9234	9392	9539
515	ROBOTIC GROUND SYSTEMS	7126	11550	19011	20316	10026	11115	11336	11561
533	GROUND VEHICLE DEMONSTRATIONS	13961	44194	0	0	0	0	0	0
53D	NAC DEMONSTRATION INITIATIVES (CA)	45531	35758	0	0	0	0	0	0
53G	FUTURE COMBAT SYSTEMS (FCS)	109845	104766	41155	25000	29059	26753	0	0
C66	DC66	955	758	1926	2045	2100	2151	2235	2279

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 enable transformation to the Future Force and, where possible, exploit opportunities to enhance Current Force vehicle-related capabilities. Army S&T continues to play an important role in the Future Combat Systems (FCS) program by providing critical technology solutions for FCS vehicles. 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 FY04-FY07 funding supports the collaborative Army/Defense Advanced Research Projects Agency (DARPA) FCS Enabling Technologies (Project 53G). Memoranda of Agreement (MOA) between the Army and DARPA delineate the collaborative enabling technology efforts, the 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), robotic ground systems (Project 515) 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 Crew Integration and Automation Testbed (CAT) Advanced Technology Demonstrator (ATD) (Project 497) demonstrates multi-mission crew stations required for the versatility of the Future Force. The Robotic Follower ATD (Project 515) will mature and demonstrate unmanned ground vehicle technologies including those that enable UGVs to follow manned vehicles and that will allow UGVs to be more autonomous for FCS and the Future 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 Current Force

systems. 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 near term, Future Tactical Truck Systems (FTTS) Advanced Concept Technology Demonstration (ACTD) (Project 440) will assess military utility of tactical vehicles that are enhanced with high payoff technologies and coupled with current and Future Force sustainment concepts in a User operational environment. The ACTD will integrate technologies including advanced propulsion (hybrid electric), mobility (electromechanical suspension and electronically controlled active braking) and intelligent load handling. In the mid-term, electromagnetic (EM) armor will be integrated and demonstrated on combat vehicles. 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). Work in this program element is related to, and fully coordinated with PE 0602601A (Combat Vehicle and Automotive Technology) and 0602618 (Ballistics Technology). Work in this 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 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 2005	FY 2006	FY 2007
Previous President's Budget (FY 2005)	203126	157373	161795
Current Budget (FY 2006/2007 PB)	279260	142866	122661
Total Adjustments	76134	-14507	-39134
Net of Program/Database Changes			
Congressional Program Reductions	-4156		
Congressional Rescissions			
Congressional Increases	87900		
Reprogrammings			
SBIR/STTR Transfer	-7610		
Adjustments to Budget Years		-14507	-39134

Change Summary Explanation:
FY07 - Funds realigned ($39134K) to higher priority requirements.

Thirty-Six FY05 Congressional Adds totaling $87900 were added to this PE.

FY05 Congressional Adds with no R-2A:
Advanced Army Modular Composite Bridge, Project 533 ($5370)
Advanced Power Trains and Intelligent Control Systems for M-Gators, Project 53D ($1438)
Advanced Thermal Management System, Project 53D ($2493)
All Composite Military Vehicle, Project 533 ($4316)
Aluminum Lightweight Structures Initiative (ALSI), Project 533 ($4891)
Armored Composite Cab Development, Project 533 ($2397)
Army Lightweight Structures Initiative (ALSI), Project 533 ($2685)
Battery Charging Technology, Project 53D ($959)
CAV Technology Transitions, Project 440

($3356)
Combat Vehicle Research, Project 533 ($4076)
Development of Logistical Fuel Processors to Meet Army, TARDEC and TACOM needs, Project 53D ($2877)
Digital Humans & Virtual Reality, Project 53D ($959)
Electrochromatic Material Windows, Project 53D ($1919)
Fastening & Joining Research, Project 533 ($1439)
FREEDOM Software Environments, Project 533 ($959)
Fuel Cell Ground Support Equipment Demonstration, Project 53D ($4411)
High Strength, Powder Metal Gears for Vehicle Transmission, Project 533 ($959)
IMPACT – Concept Modeling Tool Suite Development/Sensitivity Analysis for Military Trucks, Project 53D ($959)
Innovative Materials for Infrastructure Security, Project 533 ($2110)
International Commercially Based Logistical Support Trucks, Project 53D ($2014)
In-Theater Systems Development, Project 53D ($2350)
Military Vehicle Technologies, Project 53D ($2685)
Mobile Hydrogen Infrastructure MHI, Project 53D ($1918)
Modular Logistics Transport Technology, Project 53D ($959)
Next Generation Non-Tactical Vehicle Propulsion, Project 533 ($2493)
N-STEP Enabled Manufacturing Cell for FCS, Project 53D ($3117)
Opposed Piston, Opposed Cylinder (OPOC) Engine for Use in Auxiliary Power Unit (APU), Project 53D ($959)
Pacific Rim Corrosion Research Program, Project 533 ($1630)

Rapid Optimization of Commercial Knowledge (ROCK) Program, Project 53D ($3356)
Rapid Prototyping TACOM-UMD, Project 53D ($1438)
Rotary, Multi-Fuel, Auxiliary Power Unit (RMF-APU), Project 533 ($2014)
Secure Pervasive Computing (PvC) for Advanced Combat Vehicles, Project 533 ($3356)
Tactical Vehicle Design Tools, Project 533 ($1438)
UAV Weaponization, Project 440 ($959)
U.S. Army Hybrid Vehicle Test & Maintenance Infrastructure, Project 533 ($4076)
Virtual Systems Integration Lab, Project 53D ($959)

Projects with FY05 Congressional Adds and no R-2A are not defined due to space limitations.

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

COST (In Thousands)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
221	COMBAT VEH SURVIVABLTY	48033	26661	18926	19951	34484	17622	27941	28153

A. Mission Description and Budget Item Justification: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 system, and advanced lightweight armor instead of heavy conventional armor. These technologies will be demonstrated over time as distinct focused efforts under an Integrated Survivability Advanced Technology Demonstration (IS ATD). The goal of the IS ATD is to provide "convincing evidence" of soldier/system survivability through actual hardware field demonstrations, and modeling and simulation (M&S) of AP systems in connection with light weight armor. Initial IS ATD efforts demonstrate technologies 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 warhead) and soft kill (EW spoofers and jammers) while the vehicle is On-The-Move (OTM). Once the CE APS has been demonstrated, the focus will shift to the defeat of Kinetic Energy (KE) threats. The goal of the AP against KE effort is to defeat KE threats with a multi-purpose hard kill countermeasure warhead. 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 (EM), smart and ceramic armors integrated with advanced composite and laminate structures. Lightweight, integrated armor technologies, using components from PEs 0602601A (Combat Vehicle and Automotive Technology), 0602618A (Ballistics Technology) and 0602105A (Materials Technology), will be demonstrated through ballistic testing of quarter vehicle sections to validate performance versus weight as required for frontal and side armor protection. The goal of the FCS Laser Hardened Vision & Sensor/Eye Protection efforts is to develop optical systems for battlefield viewing and fire control, which are protected from frequency agile laser weapons. Nonlinear optical materials will be incorporated into new optical designs to meet the needs of FCS. The goal of the Full Spectrum Active Protection Close in Layered Shield (FCLAS) effort develop the capability to defeat Rocket Propelled Grenades (RPGs) and small Anti-Tank Guided Missiles (ATGMs) on a light, moving platform with a vehicle integrated countermunition costing less than $3,000. The Signature Management effort will improve existing multi-spectral signature modeling tools, characterize hardware performance, and provide inputs to FCS virtual prototyping tools. 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. Work in this PE is related to and closely coordinated with work conducted in PE 0602601 (Combat Vehicle and Automotive Technology) and in collaboration with the Army Research Laboratory's PE 0602618 (Ballistics Technologies). 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 Tank Automotive Research, Development and Engineering Center (TARDEC), Warren, MI; Army Research

Laboratory (ARL), Aberdeen Proving Ground, MD; and Army Research, Development and Engineering Center (ARDEC), Picatinny, NJ.

Accomplishments/Planned Program	FY 2004	FY 2005	FY 2006	FY 2007
AP and EW against CE: In FY04, conducted OTM tests to demonstrate the CE AP system against advanced tank fired HEAT threats, ATGMs, and RPGs using explosive countermeasure; designed and integrated two EW countermeasures into a single multi-function jammer head; designed explosive countermeasure; developed tracking radar and countermeasure launcher components for improved performance; conducted OTM tests with the system mounted on a testbed vehicle in an outdoor range environment; matured stabilization algorithms for objective vehicle speeds. In FY05, test mature OTM algorithms for EW; field test multi-function EW countermeasure; complete OTM field test of the full hemispherical, vehicle-mounted AP/EW system; and provide design information on the demonstrated components and system to appropriate acquisition program(s).	10462	7143	0	0
AP against KE - In FY04, conducted technology trade studies, early component experimentation, M&S, and system concept evaluations; evaluated KE countermeasure warhead concepts including a pure blast warhead; assessed blast concept countermeasure warhead against KE, CE and ATGM flying threats; began radar upgrade toward enabling tracking of CE and KE threats; purchased threat munitions to support experimentation. In FY05, select KE AP countermeasure components to be demonstrated for the IS ATD and FCS; complete KE/CE AP system design, conduct laboratory tests of the countermeasure interceptor; complete upgrade to AP tracking radar to incorporate KE capability. In FY06, will test Mark II interceptors from stationary position to demonstrate accuracy of KE capable AP system; will assess tracking radar, interceptor, and launcher assembly against KE threats, characterize kill radius and warhead blast effect; will integrate tracking radar, interceptor and launcher onto IS ATD test bed; will demonstrate accuracy of KE-capable AP System in static fly-out field test and will initiate KE alternative warhead development. In FY07, will evaluate test results and re-evaluate AP system with candidate warhead designs; will select interceptor and warhead design by FCS Preliminary Design Review (PDR); will mature selected interceptor and warhead through design refinement, sensor redesign, kill mechanism, and sensor component tests; will begin detailed design of mature KE interceptor for fabrication.	14788	6132	12676	16658

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
AP against close-in threats (Full Spectrum Active Protection Close In Layered Shield (FCLAS)): In FY04, installed prototype system on a test platform, including integrated FCLAS munitions, launcher and smoke controller; conducted static tests to demonstrate the ability to defeat. In FY05, demonstrate an automated system by which FCLAS will minimize collateral damage and avoid opportunities for injury to personnel in the vicinity of the vehicle and demonstrate system modularity; modify existing sensor to increase effectiveness against RPG's; and demonstrate FCLAS system on a moving platform. In FY06, will test upgraded versions of FCLAS configurations for other possible applications including man portable surface to air missiles and smart mines.	9000	5512	3850	0
Signature Management - In FY04, developed enhanced modeling capability including exhaust plume signature effects and integration with synthetic imagery; optimized field performance of hardware in preparation for FY05 model validation tests. In FY05, 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).	5000	4937	0	0
Ballistic Protection for FCS - In FY04, completed electromagnetic (EM) armor component maturation; built vehicle quarter sections comprising of a combination of EM, ceramic and structural armor materials; conducted tests of armor sections against FCS objective threats; demonstrated capability to provide adequate protection at acceptable weights and determined soundness of armor/structural design. In FY05, conduct ballistic range tests to optimize and validate the performance of integrated armor packages for lightweight test platforms; complete integration of armor appliqué solutions for FCS objective threats; test advanced medium KE frontal armor and improved RPG defeat (with Signature Management treatments applied to determine their robustness) for the FCS-armor testbed.	7783	2441	0	0
Countermine (Lightweight Appliqués and Structures): In FY04, evaluated mine protection armor configurations; obtained improved mine blast test data, and validated M&S. In FY05, complete evaluation of FCS mine resistant lower hull appliqué concept(s) integrated into FCS prototype designs; use finite element models to evaluate FCS prototype vehicle designs against multiple mine scenarios to assess capabilities beyond single blast events.	1000	496	0	0
Synergistic Survivability: In FY07, evaluate survivability suite(s) and component technologies for regional protection to protect multiple vehicles and/or designated areas (such as formations, staging areas, or convoys) from various CE and/or KE threats.	0	0	0	564

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
FCS Laser Hardened Vision/ Sensor/Eye Protection from Frequency-Agile Lasers: In FY06, will initiate brassboard build of FCS targeting camera system for manned ground vehicle and design of FCS targeting optical system (using the eye as the sensor) protected from damage induced by wavelength-agile laser weapons. In FY07, will integrate and evaluate nonlinear optical materials solutions that protect the sensor from laser-induced damage and initiate a brassboard build of targeting system utilizing these concepts; design laser protected FCS navigation camera system.	0	0	2400	2729
Totals	48033	26661	18926	19951

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February 2005

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

COST (In Thousands)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
441	COMBAT VEHICLE MOBILTY	28595	30016	52360	46025	49996	38543	49828	42774

A. Mission Description and Budget Item Justification: A. Mission Description and Budget Item Justification: This project develops and tests advanced mobility and electric component technologies for next generation combat vehicles and demonstrates increased vehicle performance and capability. It enables lightweight, agile, deployable, fuel efficient and survivable ground combat vehicles needed for FCS, the Future Force, and enhancements to the Current 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 FCS Propulsion 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 (P&E) Hardware-in-the-Loop Systems Integration Laboratory (SIL) that replicates combat vehicle power and vehicle performance characteristics. (The P&E SIL is the name for the Combat Hybrid Powers Systems SIL, previously funded in this project.) HEV technology offers improved automotive performance, significant reduction in fuel consumption (in the range of 20% savings over today's combat vehicles), silent watch and silent mobility, and vehicle design flexibility. The P&E 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. The P&E SIL is also used as a cost effective way to validate vehicle performance models and simulations. Beginning in FY06, promising technologies will transition to the Hybrid Electric Mobile Dynamic Test Rig for component testing. These efforts support the DoD Power and Energy Initiative. The goal of the FCS Engine effort is to mature and demonstrate prime power (engines) options 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 goal of the effort is to demonstrate a prototype engine system with power density of no less than 6 hp/cu.ft. Beginning in FY05, Fuel Cell Power effort will be pursued to accelerate the maturation and application to military vehicle power generation as an alternative to the reciprocating engine for Auxiliary Power Units (APUs) and prime power. The Advanced HEV Technologies efforts 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. 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 Pulse-Forming Networks (PFNs) for Electromagnetic (EM) armor and advanced weapons for FCS spiral insertions. 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 Tank Automotive Research, Development and Engineering Center (TARDEC), Warren, MI in conjunction with Army Research Laboratory (ARL), Adelphi, MD.

Accomplishments/Planned Program	FY 2004	FY 2005	FY 2006	FY 2007
HEV FCS Propulsion – In FY04, implemented strategy for upgrading hybrid electric propulsion, band track, and suspension technologies for potential FCS insertion; demonstrated power densities of compact FCS components to objective (goal) power levels (200 kiloWatt (kW) per cubic meter (cu.m.)). In FY05, evaluate advanced hybrid electric components in the P&E SIL; demonstrate significantly increased hybrid electric system power density in the P&E SIL; advance M&S capability to include real time power and energy vehicle analyses; begin design of an integrated mobile Dynamic Test Rig (DTR). Perform trade-off and performance assessments of spiral upgrade concepts for FCS and the current force; develop detailed power and energy mission profile data; and provide vehicle integration support. In FY06, will integrate and evaluate enhanced hybrid electric components in the P&E SIL and in the DTR, with upgrades to band track and advanced suspension systems; demonstrate significantly increased hybrid electric system power density (from current 4 cu.m. volume range to 3 cu.m.). In FY07, will continue to integrate new component technologies to support the creation of a 2 cu.m. sized hybrid electric system power.	5718	9364	20471	12271
FCS Engine - In FY04, completed performance improvement, mechanical durability testing and 50 hour NATO durability laboratory demonstration for three FCS engine candidates (two diesel and one turbine). In FY05, optimize engine for hybrid electric FCS-specific vehicle application; reconfigure an in-line 4 cylinder FCS candidate engine for spiral technology application to current platforms.	9800	9880	0	0

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
Advanced Hybrid Electric Vehicle (HEV) Technologies - In FY04, demonstrated improved electric traction motor with reduced weight and volume characteristics; matured 10 kW high-temperature all-Silicon Carbide (SiC) motor inverter for improved power density; tested improved 600 Volt Lithium-Ion (Li-Ion) battery for improved efficiency and reduced volume; matured and demonstrated Si/SiC 50 kW DC-DC converter for higher frequency and reduced volume; matured SiC 10 kW DC-DC converter and scale to 50 kW; and adapted lab capabilities to emulate full electric hybrid system for FCS spiral insertions. In FY05, demonstrate 30 kW high-temperature all-SiC motor inverter; advance Li-Ion battery technology to achieve higher energy/power densities; demonstrate improved traction motor and active electric suspension for FCS spirals; 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. In FY06, will demonstrate 40 kW high temperature all-SiC motor inverter; will demonstrate enhancements to Li-Ion battery technology (up to 120 Wh/kg); will demonstrate 100 kW/cu.ft. traction motor; advance component and system performance and maturity, providing upgrades to power and energy M&S efforts. In FY07, will mature inverter, battery, traction motor and DC-DC converter component technologies; will provide demonstrations and test system integration in the P&E SIL; will validate advanced thermal management technologies for coolant temperatures in the range of 110 degrees C during system demonstrations.	8173	5418	11499	10148
Pulse Power: In FY04, matured and demonstrated high energy density capacitors, high power density/high temp Si/SiC pulse chargers; and high action/fast rise-time output switches. In FY05, incorporate components into high-energy density, dual mode PFN for EM Armor/Electrothermal Chemical Gun and evaluate the PFN in the P&E SIL; fabricate and demonstrate modular, high-action solid state output switches in support of EM Gun development; and design and develop higher energy density PFN circuit boards in support of the Solid State Laser (SSL); provide Operational Effectiveness Modeling and Life Cycle Cost Estimate support for Power Duty Cycle Analysis. In FY06, will continue to improve component (capacitors, pulse chargers and switches) characteristics and performance ranges, spiraling these into the high-energy density, dual mode PFN; integrate and test SSL PFN/Power Supply/Diode Load into P&E SIL. In FY07, will achieve technical maturity and size reduction goals for all components for the high-energy density, dual mode PFN, the SSL PFN and EM Gun switch, validating performance in the P&E SIL.	4904	4234	15972	15926

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
Fuel Cell Power: In FY05, complete power studies and select two conventional and two fuel cell approaches for advanced development; initiate design for laboratory hardware integration, performance demonstration, and durability maturation to achieve future combat vehicle propulsion system power density requirements. In FY06, will mature selected conventional and fuel cell technology approaches refining fuel cell system models and simulations in preparation for FY07 decisions. In FY07, will down-select an APU system development approach, mature selected technologies and begin system integration efforts to culminate in laboratory hardware APU performance demonstration.	0	1120	4418	7680
Totals	28595	30016	52360	46025

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February 2005

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

COST (In Thousands)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
497	COMBAT VEHICLE ELECTRO	6489	5603	9488	9324	13039	9234	9392	9539

A. Mission Description and Budget Item Justification: This project matures and demonstrates vehicle electronics hardware and software that will result in increased crew efficiencies/performance and/or reduced crew size for FCS vehicles and potential upgrades of Current Force systems. In addition, the project advances open system architectures for ground combat vehicles that will allow vehicle crew stations 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. CAT ATD, in cooperation with Robotic Follower ATD (Project 515), will evaluate configurations of multi-role crew stations that may 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. 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. Technical challenges include achieving increased levels of autonomy for both manned and unmanned systems, an advanced user interface supporting improved/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. The Human-Robot Interaction (HRI) effort will mature and demonstrate a common scaleable user interface that maximizes Soldier performance of primary mission tasks. A common interface will reduce platform unique training requirements through the use of intuitive interfaces and adaptive automation for the control of unmanned ground and air systems. 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. A common interface will increase situational awareness and understanding and provide FCS mounted and dismounted troops control of all unmanned assets. The Advanced Mobile integrated Power System (AMPS) effort previously in this project has been incorporated in the effort funded by Project 441; the remaining funds provide the support for the collaboration. 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 the Tank Automotive research, Development and Engineering Center (TARDEC), Warren, MI in conjunction with Army Research Laboratory - Human Resources Engineering Directorate (ARL-HRED), Aberdeen, MD.

Accomplishments/Planned Program	FY 2004	FY 2005	FY 2006	FY 2007
CAT ATD: In FY04, defined cognitive decision aids; continued integration and field testing of advanced crew station configurations; refined the electronics architecture and Embedded Simulation System (ESS); investigated the use of system automation features to the commander's aid, such as the ability to infer operator's intent; integrated UAV control and route planning aids into the Soldier-Machine Interface (SMI); investigated the use of pedestrian/dismounted soldier identification for improved safety and workload reduction; performed technology assessment to support a distributed digital indirect vision system for closed hatch combat vehicle driving operations; integrated an intelligent tutoring system for combat operations and training into the ESS for field experimentation; extended the ESS to support mission rehearsal capabilities for dismounted soldiers. In FY05, participate in Future Force Warrior (FFW) experiments; continue to investigate technology enablers for on-the-move embedded simulation and mission rehearsal; implement and test ground vehicle autopilot capability using an upgraded autonomous mobility sensor suite; mature a distributed workload management system across manned/unmanned assets that support the FCS network centric concept by integrating FC-Net weapon/target pairing. In FY06, will continue to participate in FFW experiments; will support the Joint-Manned/Unmanned Systems Teaming program; test the objective SMI; test commander's and driver's aids to include auto-pilot and unmanned asset planning features; test high frequency electronic control architecture; test embedded mission planning, mission rehearsal, and training capabilities; create final technical reports and provide to PM Unit of Action.	5489	3995	1945	0

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
Technology for Human-Robot Interactions (HRI) in Soldier-Robot Teaming: In FY05, establish baseline intelligent agent functionality and cognitive modeling for reduction and automation of soldier workload to control ground and air unmanned assets; establish platform baselines of scalable interface for the reduction of mounted and dismounted soldier training burden. In FY06, begin software development of intelligent agents; initiate design for common scalable interface; transition initial common scalable interface for control of air and ground unmanned systems to FCS and FFW; continue cognitive model development; demonstrate a reduction of non-critical alert frequency; show a reduction of mission planning/re-planning timelines; demonstrate a reduction of soldier control workload portion of overall mission; reduce unique training requirements between mounted/dismounted operations; refine and validate requirements for adaptive automation; refine and validate requirements for FCS compatible interfaces. In FY07, continue refinement and test of intelligent agent software; determine optimal workload levels for selected operational contexts; enhance cognitive models; decrease non-critical alert frequencies; reduce mission planning/re-planning timelines; reduce soldier control workload though advances in task automation; develop adaptive automation algorithms.	0	1341	7243	9324
Advanced Mobile Integrated Power System (AMPS): In FY04, Investigated and developed advanced smart 42V power alternator, smart energy storage devices, and smart power architecture; demonstrated power architecture concept using modeling & simulation.	500	0	0	0
Enhanced Combined Arms Team Training: - In FY04, developed vehicle requirements, architecture specification, and vehicle Soldier-Machine Interface to support in-vehicle intelligent tutoring; integrated these efforts into the Crew Integration and Automation Test bed for testing.	500	0	0	0
Hybrid Electric Component Development: In FY05, will adapt flex-bus power distribution and smart power and control modules. In FY06, will integrate intelligent power management architecture with power distribution and control modules.	0	267	300	0
Totals	6489	5603	9488	9324

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2005

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

COST (In Thousands)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
515	ROBOTIC GROUND SYSTEMS	7126	11550	19011	20316	10026	11115	11336	11561

A. Mission Description and Budget Item Justification:: This project matures and demonstrates unmanned ground vehicle technologies for the FCS, the Future Force, and to explore the feasibility to enhance the current force. The main focus is on integrating and demonstrating sensor technologies/perception hardware and software, and robotic control technologies that are required to enable unmanned ground vehicle (UGV) systems to maneuver with minimal human intervention, for on-and off-road missions while at militarily significant speeds. Mature technologies are incorporated in UGV technology demonstrators, whose performance can be evaluated for multiple tactical and sustainment applications. Technical challenges addressed include: obstacle avoidance, perception limitations, intelligent situational behaviors, command and control, frequency of human intervention, and adverse weather operation. The Robotic Follower, Advanced Technology Demonstrator (ATD) focuses on UGVs that follow other vehicles directly or follow a designated path, requiring little human intervention. An experimental UGV (XUV) and a converted Stryker Infantry Carrier variant (robotic Stryker) serve as test vehicles. The minimum exit criteria for the ATD are: 5 km separations between leader and follower, 160 km mobility range, obstacle detection for objects 0.3 sq.m. in size, and minimum operator intervention of no more than 1 per 5km @20km/hr). This ATD is a cooperative effort between the Tank Automotive, Research, Development and Engineering Center (TARDEC) and the Army Research Laboratory (ARL), using component technologies matured in PE 0602618A (Ballistics Technology). In the near term, this ATD provides critical information on design and performance of robotic technologies and demonstrations of Follower UGVs for FCS. 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. The Armed Robotic Vehicle (ARV) Robotic Technologies (ART) effort matures 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, and integrated onto surrogate ARV demonstrators to support FCS enhancement via spiral insertion. Potential missions/functions include perimeter security, medical supply and evacuation, scout/reconnaissance and remote weapons delivery. The Technology for Human-Robot Interaction in Soldier-Robot Teaming effort develops a common scaleable warfighter interface that maximizes soldier performance by minimizing required interactions and workload in the control of unmanned ground/air systems. It develops advanced models and design guidelines and implements model-driven intelligent agents that optimize workload, reduce or automate controlling tasks, support adaptive and dynamic performance, and enable efficient mixed-initiative operations where manned and unmanned systems team to perform missions, to reduce soldier burden and accelerate fielding of soldier-robot teams for FCS and Future Force Warrior (FFW). 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. It is coordinated with the Crew Integration & Automation Testbed (CAT) ATD (described in Project 497). 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 ARL, Adelphi, MD.

Accomplishments/Planned Program	FY 2004	FY 2005	FY 2006	FY 2007
Robotic Follower: In FY04, matured sensor data/map registration and trail detection technologies to obtain following speeds of 40km/hr cross-county; integrated enhanced autonomous mobility algorithms and next generation perception sensor from ARL Semi-autonomous Robotics for FCS effort; matured robotic virtual construction and test environment to enable hardware in the loop modeling and simulation; conducted engineering evaluations and soldier operational testing of follower capability in logistic and tactical mission scenarios. In FY05, 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; conduct urban operations experiment in conjunction with the FFW program. In FY06, will integrate improved obstacle detection algorithms for detection of small positive and negative obstacles; will implement road following traffic avoidance baseline for improved lane maintenance as well as traffic/pedestrian detection and avoidance; will implement improved leader-follower technology with increased mobility and waypoints augmented with terrain intelligent navigation; will demonstrate significant operator workload reduction; will conduct FFW test activities focused on dismounted support and MULE operations in urban areas; perform final engineering evaluations and operational warfighter experiments that test to full ATD exit criteria; create final technical reports/documentation and transfer to FCS and FFW programs.	7126	6973	3000	0

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
Armed Robotic Vehicle (ARV) Robotic Technologies (ART): In FY05, 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 with them; demonstrate tactical behavior suite and maneuverability in a simulated setting prior to the technology being integrated into the surrogate ARV demonstrators. In FY06, will refine semi-autonomous perception to improve operations in fog/dust and reduce frequency of operator interventions; will advance unmanned tactical behaviors in conjunction with the user requirements; will advance UGV mobility to meet the FCS threshold mobility requirements; will increase UGV survivability through addition of anti-tampering, signature reduction, and self-monitoring capabilities; will continue to mature UGV mobility SIL for tactical behavior and maneuverability development; begin to integrate pacing technologies into ARV surrogate platforms; will demonstrate advanced capabilities with interoperability with the Ground Soldier System; will conduct FCS risk reduction demonstrations; will conduct warfighter evaluations and experiments independently and jointly with the Technology for Human-Robot Interaction (HRI), and Command and Control of Robotic Entities programs. In FY07, will continue to mature tactical behavior developments, semi-autonomous perception, intrinsic mobility and survivability technologies, which have deliverables to FCS; will integrate ART subsystems into test platform or demonstrator in preparation for final exit criteria field testing and warfighter experiment in FY08.	0	4577	14056	16319
Technology for HRI in Soldier – Robot Teaming: In FY06, will perform iterative data collection and modeling of Soldier and robot interactions; will develop and transition to FCS and FFW initial Soldier-robot interaction models; will support FCS and FFW unmanned systems experiments. In FY07, will draft guidance for design of Soldier-robot teams interaction and performance; will model Soldier-robot team performance and transition improved and validated Soldier-robot interaction models to FCS and FFW; will integrate hardware/software with existing manned and unmanned platforms in preparation for FY08 exit criteria field testing.	0	0	1955	3997
Totals	7126	11550	19011	20316

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2005

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

COST (In Thousands)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
53G	FUTURE COMBAT SYSTEMS (FCS)	109845	104766	41155	25000	29059	26753	0	0

A. Mission Description and Budget Item Justification: Although the Future Combat Systems (FCS) program transitioned into the System Development and Demonstration phase in May 2003, maturing, demonstrating and transitioning enabling technologies to FCS remains the number one priority for Army S&T. This project funds the Army's share of the Army/ DARPA Enabling Technologies for FCS collaboration. Funds in this project are provided to DARPA for selected collaborative projects, focused on enabling and enhancing FCS capabilities, and are executed by DARPA in accordance with project-specific Memoranda of Agreement. When mature, technologies developed under this project will be available for transition into the FCS acquisition program to enable objective capabilities. NetFires, which demonstrated mobile BLOS capability for precision, loitering munitions and transitioned to the Army in FY04. FCS Communications, which demonstrates high data rate, low probability of detection and anti-jam communications to achieve secure, reliable networked communications transitioned to the Army in FY04. Major efforts include the following: Unmanned Ground Combat Vehicle (UGCV)/PerceptOR Integration (UPI), which matures and demonstrates an Armed Robotic Vehicle (ARV) class vehicle with advanced sensors to enable agile, tactical performance and reduce ARV development risk. Affordable Adaptive Conformal Electronically Steerable Array Radar (AACER), which demonstrates a high resolution Ground Moving Target Indicator/Synthetic Aperture Radar (GMTI/SAR) to provide FCS all weather, tactical surveillance and tracking of ground targets and dismounts. FCS Command and Control (C2), which demonstrates software and handheld C2 situational awareness and decision aid displays and conducts field experiments to demonstrate benefits of real time battlefield awareness. Organic Air Vehicle (OAV), which demonstrates ducted fan technology for Class II unmanned air vehicle (UAV) including a demonstration of Class II mission equipment package. Micro Air Vehicle (MAV) ACTD, which demonstrates the utility of an affordable, man-portable, and responsive reconnaissance and surveillance UAV that fits into a backpack. Jigsaw, which demonstrates three dimensional Laser Radar (LADAR) for day or night detection and identification of hard-to-find targets through foliage or camouflage. Foliage Penetration (FOPEN) Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER), which demonstrates an airborne FOPEN ultra high frequency GMTI radar to detect and track small and medium size moving targets. WolfPack, which demonstrates a small sensor package capable of long duration and having multi- delivery options, for unattended, networked ground sensor/jammer capabilities that will enable signal detection of low power, low probably intercept/low probably detection threat signals and provide for interruption via blanket or precision electronic attack. Mobile Network Multiple Input Multiple Output (MIMO) (MNM), which demonstrates a mobile MIMO radio network in a legacy radio form factor. Sensor DART, which demonstrates earth-penetrating unmanned ground sensors (UGS)-darts that are dispensed from a glider that can be released from an airborne platform or launched from a ground platform. Electromagnetic (EM) Mortar, which demonstrates an EM launch capability for large caliber mortar-type weapons. DP-5X, which demonstrates an alternative Class-III UAV utilizing a multifunctional vertical take off and landing (VTOL) UAV design. Enabled Battle Command for the Unit of Employment (EBC), which demonstrates software decision support tools that can be refined or developed on-the-fly as the campaign unfolds. Air Assault Expeditionary Force Experiment (AAEFE), which demonstrates tactical vertical maneuver of mounted forces enabled by emerging C4ISR and other promising technologies with live forces in a field environment. 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. Expanded description of these efforts may be found in the DARPA R2 Exhibits.

Accomplishments/Planned Program	FY 2004	FY 2005	FY 2006	FY 2007
In FY04: NetFires - completed controlled test vehicle demonstrations and transitioned to PM Tactical Missiles; UPI identified candidate perception sensors and algorithms; FCS Command and Control (C2) - ported software to the FCS UA; FCS Communications - transitioned to FCS Lead Systems Integrator; MAV - conducted critical design review (CDR) and implemented demonstrator build; Jigsaw - conducted a preliminary design review (PDR) and executed system trades; FORESTER - conducted sensor testing to detect dismounts in foliage; AACER - awarded contracts for demonstrators; Sensor Dart initiated preliminary concept studies; WolfPack - performed initial component demonstrations; OAV - initiated concept definition source selection; MNM - demonstrated preliminary mobile network concept; AAEFE - assessed warfighting utility of FCS enabling technologies and concepts; EBC initiated concept development and demonstration of proof of concept; DP-5X - demonstrated flight components in laboratory and test rig; EM Mortar - initiated design and component evaluation of two competing EM technology approaches (rail and coil).	109845	0	0	0
In FY05: UPI - evaluate and test algorithms with a UGCV mounted weapon system; Jigsaw - conduct critical design review (CDR) and initiate demonstrator fabrication; FCS C2 - develop and demonstrate operational and systems C4ISR architectural framework products; FORESTER - design, assess and evaluate a brassboard hardware system; AACER - evaluate preliminary system designs, production cost estimates, and results from critical antenna technology demonstrations and down select to best design(s); Sensor Dart - perform PDR and implement fabrication of demonstrator hardware; MAV - perform demonstrator flight testing and downselect a diesel engine design; WolfPack - refine and improve demonstrator design based on initial demonstrations; OAV - perform PDR for concept downselect and implement demonstrator design; MNM - implement competitive demonstrator hardware fabrication to validate concept with field demonstration of the Mobile Ad Hoc Network and custom wideband RF/signal processing designs; AAEFE - perform detailed analysis and execute pilot demonstration testing; EBC - develop preliminary demonstration software tool set; DP-5X - perform flight test demonstrations with 75lb. payload and waypoint navigation; EM Mortar - perform laboratory demonstrations of EM coil and rail technology.	0	104766	0	0

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
In FY06, UPI - will make the selection of weapon payload and integrator, and conduct initial demonstration testing of two platforms; FCS C2 - will conduct human-in-the-loop experiments; MAV - will conduct flight-testing and experimentation with 25th ID; FORESTER - will design, assess, and evaluate form-fit-and-function demonstrator hardware system for rotorcraft installation and demonstrate end-to-end system performance tests that include aircraft effects under static and dynamic conditions; AACER - will complete fabrication of demonstrator modules and perform subsystem tests, system integration, and rooftop tests; Jigsaw - will complete fabrication of demonstrator equipment and demonstrate active 3-D imaging for hard-to-identify targets; Sensor Dart - will complete demonstrator fabrication and perform flight demonstrations; MAV - will complete diesel powered demonstrator and perform User trials with demonstrator equipment; WolfPack - will demonstrate threat sensor/jammer capabilities as part of the FCS C4ISR structure; OAV - will complete CDR and initiate demonstrator fabrication; MNM - will perform 2-node demonstration tests; AAEFE - will execute a full scale experimental demonstration; EBC - will expand functionality of the demonstration software tool set; DP-5X - will perform flight demonstration tests with weapons payload and demonstrate potential operational scenarios.	0	0	41155	0
In FY07, UPI - will conduct full-up demonstration of enhanced capability sensors on two platforms; AACER - will fabricate optimized integrated airborne system and perform ground performance demonstrations; OAV - will perform demonstrator ground and flight tests; MNM - will perform 10-node demonstration tests on improved MIMO hardware/software demonstrator; AAEFE - will perform operational assessment of warfighting utility of FCS enabling technologies and concepts, in an operational environment, via experimentation with surrogates and mature demonstrator hardware/software; EBC - will transition a robust software tool set capable of providing desired cause/effect prediction and analysis capability to FCS.	0	0	0	25000
Totals	109845	104766	41155	25000