ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2006

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

	COST (In Thousands)	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
	Total Program Element (PE) Cost	284720	242013	109952	124336	96592	86706	82086
221	COMBAT VEH SURVIVABLTY	26650	18323	20712	35101	18027	23490	21215
440	ADV CBT VEHICLE TECH	19945	0	0	0	0	0	0
441	COMBAT VEHICLE MOBILTY	28002	51599	34581	34295	30489	41818	39078
497	COMBAT VEHICLE ELECTRO	5331	9353	9671	13212	7513	7643	7763
515	ROBOTIC GROUND SYSTEMS	11545	18740	17585	10158	11266	11490	11720
533	Ground Vehicle Demonstrations	34257	34304	0	0	0	0	0
53D	NAC Demonstration Initiatives (CA)	54407	67227	0	0	0	0	0
53G	FUTURE COMBAT SYSTEMS (FCS)	103218	40568	25331	29442	27117	0	0
C66	DC66	1365	1899	2072	2128	2180	2265	2310

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, to exploit opportunities to enhance Current Force vehicle-related capabilities. Army S&T continues to play an important role in the Future Combat System (FCS) program by providing critical technology solutions for FCS. Supporting FCS remains a high priority for Army S&T and is the primary effort funded in this PE; therefore a significant portion of the FY05-FY07 funding supports the collaborative Army/Defense Advanced Research Projects Agency (DARPA) FCS Enabling Technologies efforts (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 combat vehicle 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 completing Integrated Survivability Advanced Technology Demonstration (ATD) (Project 221) identified the integration issues associated with upgrading FCS baseline survivability capabilities to meet FCS system survivability requirements, while monitoring individual technologies for direct transition opportunities into Current Force systems. The Crew Integration and Automation Testbed (CAT) ATD (Project 497) demonstrates multi-mission crew stations required for the versatility of the Future Force. In the Future Force, Soldiers and robots will be required to fight side by side. Technologies for human-robot interaction in Soldier-robot teams such as: intelligent agents, adaptive automation, and user-friendly displays will be developed to reduce the soldier's burden in the control of manned and unmanned ground and air systems (Project 497). The Robotic Follower ATD (Project 515) matures and demonstrates Unmanned Ground Vehicle (UGV) technologies, including those that enable UGVs to follow manned vehicles and that allow UGVs to be more autonomous for FCS. Additionally, technologies such as tactical behaviors and human detection and deterrent will be developed, matured, and demonstrated for Armed Robotic Vehicles (ARVs) . These technologies will allow robotic vehicles to act more independently during tactical maneuvers and protect themselves from intruders, thereby enabling the soldier to perform other mission tasks (Project 515). 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, electric weapons and protection systems. In the near term, the Tactical Wheeled Vehicle Fleet Modernization and 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 an operational environment. Project 441 demonstrates critical power, propulsion and electric systems including energy storage, power distribution and Pulse Forming Networks (PFNs). In the mid-term, electromagnetic (EM) armor enabled by pulse power technology, developed in Project 441, 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 (lasers, high power microwaves and electric guns) and advanced electric-based protection systems. Work in this program element is related to, and fully coordinated with PE 0602601A (Combat Vehicle and Automotive Technology) and 0602618 (Ballistics Technology). Projects 533 and 53D fund Congressional special interest items. Project C66 supports programs that are classified. Work in this PE is coordinated with the U.S. 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, and 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.

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

B. Program Change Summary	FY 2005	FY 2006	FY 2007
Previous President's Budget (FY 2006)	279260	142866	122661
Current BES/President's Budget (FY 2007)	284720	242013	109952
Total Adjustments	5460	99147	-12709
Congressional Program Reductions		-1410	
Congressional Rescissions		-2443	
Congressional Increases		103000	
Reprogrammings	5460		
SBIR/STTR Transfer			
Adjustments to Budget Years			-12709

FY 07 decrease of -12.7 million attributed to realignment of funding to higher priority requirements.
Forty-nine FY06 Congressional adds totaling $103000 were added to this PE.

FY06 Congressional adds with no R-2A (appropriated amount is shown):
($2500) 3-D Advanced Battery Technology (3-D ABT)
($1300) Advanced Battery Development
($1000) Advanced Drivetrains for Enhanced Mobility and Safety
($1000) Advanced Technology Integration Environment
($4000) Advanced Thermal Management
($4900) All Composite Mil Vehicle
($4000) Alternative Mobility Vehicles for Special Operations Forces
($2600) Amphibious Personal Mobility Vehicle
($2000) Armored Composite Cab Development Program
($1700) Battery Charging Technology
($1500) CCMMC Lightweight Diesel Engine Initiative for Army Ground Vehicles
($1000) Center for Innovative Materials Research (CIMR) at Lawrence Tech University
($8100) Center for Military Vehicle Technologies
($1400) Collaborative Development Approach for Non-line of Sight Cannon and Mortar
($1000) Combat Vehicle Research-Weight Reduction, Survivability & Mobility
($5000) Commercially Based Logistical Support Trucks
($1500) Component Optimization for Ground Systems (COGS)
($2800) Composite Body Parts - Composite Armored Vehicle Technology Transition
($2600) Composite Shelters for the Future Tactical Truck and Retrofit of Current Vehicle Shelters

($1000) Counter Sniper/RPG self protection system
($1800) Development of Logistical Fuel Processors to Meet Army/TARDEC/TACOM Needs
($1400) Digital Humans and Virtual Reality for Future Combat Systems
($1000) Electrochromatics Program
($1400) Fastening and Joining Research
($1000) FREEDOM Software
($2500) Full Spectrum Active Protection Close-In Layered Shield (FCLAS)
($4000) Future Light-weight Military Trailer Chassis
($1700) HAZ-MAT Material Vacuum System
($2500) HEMTT Structural Weight/Cost Reduction and Efficient Armor Integration Initiative
($1000) High Strength Powder Metal Gears for Vehicle Transmissions
($5000) Hydraulic Hybrid Vehicles for the U.S. Army
($2100) Improved Abrams Track
($500) Joint Technology Evaluation and Analysis (JTEA) Program
($2600) Light Weight Structural Composite Armor for Blast and Ballistic protection
($1000) Lightweight Composite Structural Armor for Ground Combat Vehicles
($1400) Liquid Hydrogen Storage System
($500) Mobile Hydrogen Infrastructure (MHI)
($2000) Next Generation Non-Tactical Vehicle Propulsion
($1900) Non-Line of Sight Cannon (NLOS-C) and Mortar (NLOS-M) lightweight technologies including aluminum vehicle design technologies
($3600) N-STEP Enabled Manufacturing Cell for FCS
($1000) On-Board Secure Telematics for Advanced Combat Vehicles
($1700) Pacific Rim Environmental Degradation of Materials Research Program at UH
($1500) PEM Fuel Cell-Based Ground Support Equipment
($1000) Rocket Propelled Grenade Vehicle Protection System
($2800) Secure Pervasive Computing (PvC) for Advanced Combat Vehicles
($900) ShotSpotter Individual Soldier Worn Weapon Detection and Location System
($2100) Solid Oxide Fuel Cell Materials and Manufacturing
($1200) Split-Cycle Engine Technology
($1000) Virtual Explosives Detection-Image Matching (VED-Imatch)

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2006

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

COST (In Thousands)	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	26650	18323	20712	35101	18027	23490	21215

A. Mission Description and Budget Item Justification: This project matures and demonstrates combat vehicle survivability technologies essential for Future Combat System (FCS) and the Future Force. Where practical, it also provides potential technical solutions for enhancing 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. The goal of the AP against Kinetic Energy (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 Program Elements (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 and Sensor/Eye Protection effort 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 Full Spectrum Active Protection Close in Layered Shield (FCLAS) effort demonstrates the defeat of Rocket Propelled Grenades (RPGs) and small Anti-Tank Guided Missiles (ATGMs) on a light, moving platform with a vehicle integrated countermunition. The Signature Management effort improved existing multi-spectral signature modeling tools, characterized hardware performance, and provided inputs to FCS virtual prototyping tools. Multi-spectral combat vehicle signature models are 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 2005	FY 2006	FY 2007
AP and EW against Chemical Energy (CE): In FY05, completed full evaluation of AP system, demonstrated ability to defeat multiple threats while vehicle was On-the-Move (OTM); tested mature OTM algorithms for EW; field tested the multi-function EW countermeasure; and provided design information on the demonstrated components and system to appropriate acquisition program(s).	7143	0	0
AP against KE - In FY05, performed a top level technology evaluation on system and component upgrades necessary to make the CE AP system work against the much faster and heavier KE rod; selected KE AP countermeasure components to be demonstrated; performed laboratory tests to evaluate multiple countermeasure warheads; and completed initial upgrades to AP tracking radar. In FY06, perform system engineering technical trade and engineering modeling of point of departure systems and conduct field test firings of critical components to demonstrate technical feasibility; assess tracking radar, interceptor, countermeasure and launcher assemblies against tank fired KE threats; and characterize kill radius, and warhead effects. Evaluate and test high risk KE components for various approaches,	6093	11423	17788

including to sensors, fuzes and warheads. In FY07, will evaluate AP system performance with candidate warhead designs; will conduct interceptor technology field demonstration in order to select interceptor and warhead design; will mature selected interceptor and warhead through design refinement and sensor redesign as well as by conducting kill mechanism and sensor component evaluations; will conduct lab evaluation of AP system performance with selected interceptor; and will begin detailed design of mature KE interceptor concept for fabrication in support of live fire KE experiments.			
AP against close-in threats (Full Spectrum Active Protection Close In Layered Shield (FCLAS)): In FY05, characterized fragment pattern to determine safe and hazard zones; demonstrated an intelligent controller with dynamic exclusion zones to minimize collateral damage and protect the dismounted Soldier in the vicinity of the vehicle; modified existing sensor to increase effectiveness against RPG's; redesigned reduced size and weight of interceptor and integrated an onboard safe and arm; demonstrated a full-up FCLAS round. In FY06, demonstrate FCLAS on a moving platform and evaluate performance; test alternate FCLAS launch mechanisms for other possible applications.	5500	4000	0
Signature Management - In FY05, developed and validated signature management virtual models; and provided signature modeling capability to Research Development and Engineering Command's Modeling Architecture for Technical and Research Experimentation (MATREX).	4945	0	0
Ballistic Protection for FCS - In FY05, completed integration of armor appliqué solutions for FCS threats; tested advanced frontal armor on the FCS-armor testbed for ability to defeat medium KE threats and improved RPGs.	2469	0	0
Countermine (Lightweight Appliqués and Structures): In FY05, completed evaluation of FCS mine resistant lower hull appliqué concept integrated into FCS prototype designs and used finite element models to evaluate FCS prototype vehicle designs against multiple mine scenarios to assess which capabilities remained beyond the first blast event and to characterize multi-blast performance.	500	0	0
FCS Laser Hardened Vision/ Sensor/Eye Protection from Frequency-Agile Lasers: In FY06, develop and provide designs to meet targeting requirements of the electro-optic visions system and demonstrate the ability to deny passage of the laser beam through the optical system. In FY07, will integrate and evaluate nonlinear optical materials solutions that protect the sensor and eyes from laser-induced damage and begin construction of a brass-board targeting system utilizing these concepts and will design laser protected FCS navigation camera system.	0	2900	2924
Total	26650	18323	20712

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2006

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

COST (In Thousands)	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	28002	51599	34581	34295	30489	41818	39078

A. Mission Description and Budget Item Justification: This project develops and tests advanced mobility and electric component technologies for next generation ground combat and tactical vehicles and demonstrates increased vehicle performance and capability. It enables lightweight, agile, deployable, fuel efficient and survivable ground vehicles needed for the Future Combat System (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, Advanced Engine Technologies, Advanced HEV Technologies, JP-8 Reformation for 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 (Si)/silicon carbide (SiC) 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. HEV technology potentially offers improved automotive performance, 15-25% reduction in fuel consumption, silent watch, silent mobility, and vehicle design flexibility. The P&E SIL demonstrates 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. The project will also assess the performance of hybrid electric vehicles while developing tactical mission duty cycle profiles critical to evaluations of HEV technologies. These cycles will be integrated into the P&E SIL for future technology evaluations. The goal of the Advanced Engine Technology effort is to mature and demonstrate prime power (engines) options for hybrid combat vehicles with a goal to more than double the power density (horsepower per cubic foot (hp/cu.ft.)) of currently fielded combat engines and raise the state-of-the-art from 6 hp/cu.ft to 8-10 hp/cu.ft. The Advanced HEV Technologies efforts will seek further increases in vehicle mobility, efficiency and mission capability without increasing vehicle weight and volume. This effort applies advanced technologies (traction wheel motors, active suspension, high temperature electronic components, regenerative brakes, thermal management, lightweight track and segmented band track) to next generation vehicles and identifies changes in vehicle performance. The objective of the Pulse Power effort is to mature pulse power component technologies and demonstrate compact pulse power components that enable revolutionary survivability and lethality applications. The goal is to make significant advances in the maturity of high power density, capacitor-based Pulse-Forming Networks (PFNs) that enable advanced electromagnetic (EM) armor and advanced electric weapons for FCS spiral insertions. The JP-8 Reformation for Fuel Cells effort matures reformer and desulphurization technologies, which convert battlefield fuels to the hydrogen required for fuel cell operation. This will enable fuel cells to be practical for military vehicle power generation as an alternative to the reciprocating engine for Auxiliary Power Units (APUs) and prime power. The Advanced Lightweight Track program develops a segmented band track to increase maintainability and reliability of tracked vehicles, while incorporating the lower heat signature and inherently lower noise emissions for stealth operations. 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 2005	FY 2006	FY 2007
HEV FCS Propulsion - In FY05, evaluated advanced hybrid electric components in the P&E SIL; demonstrated increased hybrid electric system power density in the P&E SIL; advanced modeling and simulation (M&S) capability to include real time power and energy vehicle analyses; began design of an integrated mobile Dynamic Test Rig (DTR); performed trade-off and performance assessments of spiral upgrade concepts for FCS and Current Force vehicles; developed detailed power and energy mission profile data; and provided vehicle integration support. In FY06, purchase/build, integrate and evaluate enhanced hybrid electric propulsion components (batteries, switches,	7326	15130	8864

motors, controllers, active suspensions and wheel/band track stations) in the P&E SIL; demonstrate significantly increased hybrid electric system power density (i.e., provide same power that now occupies 4 cu.m. in a volume of 3 cu.m.); conduct SIL experiments using various mission profiles to validate propulsion system performance and gather data that can be used to design future combat and tactical vehicles. In FY07, will continue to integrate new component technologies and subsystems that support the creation of a 2 cu.m. sized hybrid electric system power; will implement advanced thermal management system/techniques in the SIL; will conduct SIL experiments and evaluate propulsion system performance across mission scenarios.			
Advanced Engine Technologies- In FY05, fabricated and tested to NATO durability standards an advanced in-line 4-cylinder high power density FCS candidate engine; initiated very high power density design studies for Internal Combustion (IC) engines in preparation for development efforts. In FY06, investigate advanced turbo-machinery systems along with associated control system development and electronics integrated into the engine control system and complete design studies and trade-off analyses for advanced IC configuration and high speed combustion. In FY07, will initiate test engine modifications for high speed combustion and fabrication of a prototype single-bank 8 hp/cu.ft. power density Opposed Piston/Opposed Cylinder (OPOC) engine module; will install Turbo-machinery system, including controls on a high power density capable test engine and evaluate to obtain performance data and durability.	9963	2000	2112
Advanced Hybrid Electric Vehicle (HEV) Technologies - In FY05, demonstrated 30 kW high-temperature all-SiC motor inverter; advanced Lithium-Ion (Li-Ion) battery technology to achieve higher energy/power densities; demonstrated improved traction motor and active electric suspension for FCS; advanced the performance and maturity of hybrid electric component technologies to allow integration and characterization at the subsystem and system level; and provided upgrades to power and energy modeling and simulation efforts. In FY06, demonstrate a 40 kW high temperature all-SiC motor inverter, a 100 kW/cu.ft. traction motor and enhancements to Li-Ion battery technology (up to 120 Wh/kg); advance HEV component performance and maturity via multiple competitive efforts in motor, battery and power electronics development; procure long lead items for and initiate assessment of HEV tactical mission profiles. In FY07, will complete maturation of inverter, battery, traction motor and DC-DC converter component technologies; complete assessment of HEV's by using tactical mission profiles; will integrate and validate component performance in the P&E SIL; and will evaluate advanced thermal management technologies for coolant temperatures in the range of 110 degrees Centigrade during system demonstrations.	5576	14872	11554
Pulse Power: In FY05, incorporated high energy density capacitors, high power density/high temperature Si/SiC pulse chargers, and high action/fast rise-time output switches into high-energy density, dual mode PFN for EM Armor/Electrothermal Chemical Gun and evaluated the PFN in the P&E SIL; fabricated and demonstrated modular, high-action solid state output switches in support of EM Gun development; designed and developed higher energy density PFN circuit boards in support of the Solid State Laser (SSL); and provided Operational Effectiveness. In FY06, improve component characteristics and performance ranges, to include producing faster output switches with greater capacity, HED capacitors with greater energy density, and pulse chargers with greater power density and insert these into the high-energy density, dual mode PFN, and integrate and evaluate the performance of the SSL PFN/Power Supply/Diode Load in P&E SIL; demonstrate and transition PFN required for Electromagnetic Armor. In FY07, will demonstrate and validate the technical maturity and size reduction for all components (60% for switches, 50% for capacitors and 30% for switches while 33% faster) over previous state-of-the-art components for the high-energy density, dual mode PFN, the SSL PFN and EM Gun switch, validating performance in the P&E SIL.	3937	11252	5258
JP-8 Reformation for Fuel Cells: In FY05, completed power studies and selected a JP-8 reformation approach, and initiated plan for laboratory hardware fabrication, performance demonstration, and durability maturation to achieve future tactical and combat vehicle power generation system requirements. In FY06, mature and verify selected reformation technology approach refining system models and simulations. In FY07, will assess selected reformation and desulphurization technology approaches; and will begin initial limited system integration efforts for future laboratory hardware performance demonstration.	1200	4245	2593

Advanced Lightweight Track: In FY06, leverage technology from the continuous band track program into the design of new hybrid segmented band track technology, combining these lightweight characteristics with the higher supportability and robustness of linked steel track; model and analyze mine blast phenomena to develop survivable lightweight track system; investigate new approach to the development of advanced elastomers. In FY07, will fabricate prototypes of new segmented band track and lightweight steel track, incorporating new bushing elastomers; and will conduct analyses on reinforcement and joint structural performance for AP mine blast survivability, heat transfer, and sprocket/track interfaces.	0	4100	4200
Total	28002	51599	34581

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2006

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

COST (In Thousands)	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	5331	9353	9671	13212	7513	7643	7763

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 Future Combat System (FCS) vehicles with potential spin-outs to 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 Crew Integration and Automation Testbed (CAT) Advanced Technology Demonstration (ATD) focuses on automation of crew functions and integration of advanced electronic architectures compatible with automotive and system platform requirements. Products include simplified, user friendly, responsive controls for unmanned ground and air systems improved electronic and power architectures, and reusable software modules. The CAT ATD, in cooperation with the Robotic Follower ATD (Project 515), evaluates 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 full mission rehearsal via an embedded simulation for 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 matures and demonstrates a common scaleable user interface that maximizes the mounted/dismounted Soldier's primary mission performance by automating robotic control tasks, to include efficient operations of multiple unmanned assets through scalable interface designs and intelligent agent software. A common scaleable interface has the potential to reduce platform unique training requirements by providing intuitive interfaces with a common look, feel, and function across a range of devices for the control of unmanned ground and air systems. HRI will mature, through a robust systems engineering approach, advanced models, metrics, and user validated interface design recommendations for mounted and dismounted soldier-robot 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 lessen 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 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 2005	FY 2006	FY 2007
CAT ATD: In FY05, investigated technology enablers for on-the-move embedded simulation and mission rehearsal; implemented and demonstrated autonomous capability using an upgraded autonomous mobility sensor suite; and matured a distributed workload management system across manned/unmanned assets that supports the FCS network centric concept by incorporating weapon/target pairing algorithms and components from the FC-NET project PE 63313/704. In FY06, conduct final operational warfighter experiments in a relative military environment; demonstrate commander's and driver's crew aiding behaviors and automated planning features for both manned and unmanned systems; evaluate electronic control architecture and embedded mission planning, mission rehearsal, and training capabilities; and create final technical reports and deliver to FCS.	4000	2000	0

HRI: In FY05, determined baseline workload levels for intelligent agent functionality that will reduce and automate Soldier tasks associated with controlling ground and air unmanned assets and established platform baselines of interfaces for scaling and the reduction of mounted and dismounted soldier training burden. In FY06, begin software development of intelligent agents and baseline task identification for application of adaptive automation; initiate design for common scalable interface that will reduce unique training requirements between mounted and dismounted operations; demonstrate initial interface designs in simulation and experimentation in a relative field environment and provide deliverables to FCS; refine and validate requirements for FCS-compatible interfaces. In FY07, will determine optimal workload levels for selected relevant FCS mission scenarios and continue refinement of intelligent agent software to reduce soldier control workload; will develop adaptive automation algorithms to assess Soldier workload and employ intelligent agents when required; will validate adaptive automation and intelligent agent software and scalable interface through simulation and joint Soldier operational field experimentation with the Armed Robotic Technologies (ART) program; will transition experimentation data, algorithms and documentation to FCS.	1331	7353	9671
Total	5331	9353	9671

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February 2006

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

COST (In Thousands)	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	11545	18740	17585	10158	11266	11490	11720

A. Mission Description and Budget Item Justification: This project matures and demonstrates unmanned ground vehicle technologies for Future Combat System (FCS) and the Future Force, and explores feasibility for enhancements to 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, so that 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 operations in adverse weather. The Robotic Follower ATD focuses on UGVs that follow other vehicles directly at user definable separation times and distances, or that follow a designated path requiring little human intervention. An experimental UGV (XUV) and a converted Stryker Infantry Carrier variant serve as demonstration vehicles. This program provides critical information on design and performance of robotic technologies and demonstrations of "Follower" UGVs for FCS. The project also advances UGV technologies to enable semi-autonomous and near autonomous operation and to expand the missions in which UGVs contribute to Future Force operations. The Armed Robotic Vehicle (ARV) Robotic Technologies (ART) effort matures a set of automated tactical behaviors and intruder detection and deterrence systems that allow unmanned vehicles to perform intelligent tactical maneuvers in a semi-autonomous mode and enable self-protection through the identification and deterrence of human threats, which are consistent with the unmanned platform missions in the FCS Brigade Combat Team. These technologies will be integrated with sensor hardware, appropriate mission modules, and integrated onto a demonstration platform. Potential missions/functions include perimeter security, medical supply and evacuation, scout/reconnaissance and remote weapons delivery. The Technology for Human-Robot Interaction (HRI) in Soldier-Robot Teaming program will optimize the way Soldier-robot teams perform mixed-initiative operations by validating through FCS-relevant scenarios and experimentation, both simulated and fielded collaboration of manned and unmanned ground and air systems. It will optimize warfighter-machine interfaces for maximum span of control with minimal task loading across a broad range of control devices. It will address safe operations of unmanned systems around humans and other vehicles. The approach builds upon previous and ongoing investments such as the Demo III program, conducted under the Joint Robotics Program Office, and the ongoing DARPA UGCV program. It is coordinated with the Crew Integration & Automation Testbed (CAT) ATD (described in Project 497). The work in this project is fully coordinated with and complements efforts conducted in PE 0602601A (Project H91, Tank and Automotive Technology) and PE 06026118A (Ballistic Technology). 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 the Army Research Laboratory (ARL), Adelphi, MD.

Accomplishments/Planned Program	FY 2005	FY 2006	FY 2007
Robotic Follower: In FY05, matured/incorporated intelligent situational behaviors to enable significant increase in time and distance separation between the leader and follower vehicles and to assist vehicles in performing safely in case of loss of vehicle communication; matured/integrated vehicle tracking capability to enable operation within traffic; matured pedestrian detection capability to enable safe operation among pedestrian traffic; and conducted engineering evaluations and Soldier operational evaluations of follower performance in logistic and tactical mission scenarios. In FY06, integrate improved obstacle detection algorithms for detection of small positive and negative obstacles; implement road following traffic avoidance baseline for improved lane maintenance as well as traffic/pedestrian detection and avoidance; implement improved leader-follower technology with increased mobility and waypoints augmented with terrain	6979	3000	0

intelligent navigation; demonstrate significant operator workload reduction; conduct experiments focused on dismounted support and MULE operations in urban areas; perform final engineering evaluations and operational warfighter experiments that demonstrate ATD performance exit criteria; and create final technical reports/documentation to transfer to FCS.			
ARV Robotic Technologies: In FY05, initiated design of a tactical behavior suite that allows unmanned systems to act decisively while maneuvering around the battlefield; initiated design of a non-lethal intruder detection and deterrence system for increased UGV survivability; began evaluating tactical behavior, intruder detection suites and maneuverability in a simulated environment and a System Integration Laboratory (SIL) prior to the technology being integrated into the ART platform; modified ART platform to accept mission packages and subsystems. In FY06, integrate a perception suite designed in PE 0602618A (Project H03) on a highly instrumented mobile demonstrator to validate improved semi-autonomous operations; update algorithms in the perception suite to improve operations in fog/dust and reduce frequency of operator interventions; mature concepts and technologies for unmanned tactical behavior, intruder detection and analysis, and self-monitoring to meet user requirements; continue to mature UGV SIL for tactical behavior maneuverability and intruder detection and analysis maturation; begin to integrate tactical behavior, intruder detection and deterrence suite, and self monitoring subsystems into ART platform in preparation for field evaluations; conduct warfighter operational field evaluations and experiments in conjunction with user community. In FY07, will complete integration of tactical behavior, intruder analysis and deterrence suite, and self monitoring subsystems into ART platform in preparation for field evaluations; will conduct warfighter operational field evaluations and experiments in conjunction with user community; will continue to mature tactical behaviors and intruder analysis technologies using data collected from field experiments, semi-autonomous perception, intrinsic mobility; and will begin integration of ART subsystems into test platform or demonstrator in preparation for final exit criteria field evaluations.	4566	13785	13526
Technology for HRI in Soldier - Robot Teaming: In FY06, through simulation and field experimentation, perform iterative data collection and modeling of Soldier and robot interactions; conduct simulation and experimentation for handoff of mounted to dismounted unmanned systems control; begin addressing safe operations around humans for UGV's; transition models, data and documentation to FCS. In FY07, based on FY06 experimentation results, will draft guidance for design of Soldier-robot teaming interaction and performance; will model Soldier-robot team performance and improved and validated Soldier-robot interactions; will integrate developed hardware/software onto existing manned and unmanned platforms to include ART program and conduct simulation and field experimentation to validate teaming and safe operations models and software algorithms; will transition models, algorithms, data and documentation to FCS.	0	1955	4059
Total	11545	18740	17585

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2006

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

COST (In Thousands)	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)	103218	40568	25331	29442	27117	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 a priority for Army S&T. This project funds the Army's share of the Army/DARPA collaboration on Enabling Technologies for FCS. Funds in this project are executed in collaboration with 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. Major efforts include the following: Unmanned Ground Combat Vehicle (UGCV)/PerceptOR Integration (UPI), which matures and demonstrates an Armed Robotic Vehicle (ARV) with advanced sensors to enable agile, tactical performance and reduce ARV development risk; Affordable Adaptive Conformal Electronically Scanned 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; Multi-cell and Dismount (M&D) 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) Advanced Concept Technology Demonstrator (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 sensor (UGS)darts that are dispensed from a glider 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; and Air Assault Expeditionary Force experiment (AAEF), 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 2005	FY 2006	FY 2007
In FY05: AACER - evaluated preliminary system designs, production cost estimates, and results from critical antenna technology demonstrations and selected best design(s); AAEF - integrated enhanced surrogate network technologies (sensors, battle command tools, robotic elements) into live combat environment; DP-5X - performed flight test demonstrations with 75lb. payload and waypoint navigation; EM Mortar - conducted exploratory laboratory demonstrations of EM coil and rail technology; FORESTER - designed, assessed and evaluated a brassboard hardware system; Jigsaw - conducted critical design review and began demonstrator fabrication; MAV - conducted demonstrator flight tests and selected a diesel engine design; MNM - fabricated competitive demonstrator hardware,	103218	0	0

validated concept with field demonstration of the Mobile Ad Hoc Network and custom wideband RF/signal processing designs; OAV - conducted preliminary design review for concept and began design of demonstrator; Sensor Dart - performed preliminary design review and fabricated demonstrator hardware; UPI - evaluated and tested algorithms with a UGCV mounted weapon system; WolfPack - refined and improved demonstrator design based on initial demonstrations.			
In FY06, AACER - complete fabrication of demonstrator modules and perform subsystem tests, system integration, and rooftop tests; AAEF - execute a full scale experimental demonstration; DP-5X - will perform flight demonstration tests with weapons payload and demonstrate potential operational scenarios; FORESTER - 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; Jigsaw - complete fabrication of demonstrator equipment and demonstrate active 3-D imaging for hard-to-identify targets; MAV - complete flight-testing and experimentation with 25th ID; MNM - perform 2-node demonstration tests; OAV - conduct critical design review and begin demonstrator fabrication; Sensor Dart - complete demonstrator fabrication and perform flight demonstrations; UPI - select ARV weapon payload and conduct initial demonstration testing of two platforms;; WolfPack - demonstrate threat sensor/jammer capabilities as part of the FCS C4ISR structure.	0	40568	0
In FY07, AACER - will fabricate optimized integrated airborne system and perform ground performance demonstrations; AAEF - 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. MNM - will perform 10-node demonstration tests on improved MIMO hardware/software demonstrator; OAV - will perform demonstrator ground and flight tests; UPI - will conduct full-up demonstration of enhanced capability sensors on two UGCV platforms.	0	0	25331
Total	103218	40568	25331