ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2007

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

	COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
	Total Program Element (PE) Cost	212115	204383	131436	108554	86386	85799	84206	86004
221	COMBAT VEH SURVIVABLTY	17726	20484	45414	37659	22185	22938	25507	26089
441	COMBAT VEHICLE MOBILTY	36789	34199	43876	40399	45818	44078	39587	40466
497	COMBAT VEHICLE ELECTRO	8609	9564	13110	7500	7643	7763	7934	8108
515	ROBOTIC GROUND SYSTEMS	12221	17391	9484	10248	10390	11020	11178	11341
533	Ground Vehicle Demonstrations	35757	47124						
53D	NAC Demonstration Initiatives (CA)	63922	53009						
53G	FUTURE COMBAT SYSTEMS (FCS)	34445	20563	14215	12069				
C66	DC66	2646	2049	5337	679	350			

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 for the Future Force vehicles by providing critical technology solutions and spiral opportunities. A significant portion of the FY06-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), combat vehicle electronics (project 497) and robotic ground systems (project 515). These advanced technologies are demonstrated in coordination with Army Acquisition Project Managers and warfighter organizations through vehicle component and system level technology demonstrations. Project 221 matures and demonstrates survivability technologies including advanced armors, Active Protection Systems (APS), and safety devices. Beginning in FY07, a major effort is TWV Survivability, which focuses on maturing and demonstrating viable integrated survivability suites that can be tailored to meet current and future threats when applied to light, medium or heavy tactical vehicles. This effort will provide essential underpinning data to support the mutual effort between the Army and Marines for the next generation Light Tactical Vehicle. While demands for more platform power increase to meet the challenges of network centricity and assured operations, there is also an increased challenge to reduce fuel consumption and increase energy efficiency. Power/energy component and hybrid electric vehicle (HEV) technologies, which can provide power for propulsion, control systems, communications, life support systems, electric weapons, and protection systems, are key enablers for enhancing Current Force and Future Force capabilities. In the near term project 441 focuses on evaluating and demonstrating the maturity of HEVs for military applications and on demonstrating the associated performance benefits and burdens through experimentation and testing against relevant tactical mission duty cycles and environments. Over the longer term, the project focuses on advancing component energy density and system efficiency, while increasing platform capability. Project 441 also demonstrates critical power, propulsion and electric systems including energy storage, power distribution, and Pulse Forming Networks (PFNs). In the mid term Pulse Power technology focuses on enabling Electromagnetic (EM) armor. Over the longer term, this effort focuses on accommodating advanced electric weapons (lasers, high power microwaves, and EM guns) and advanced electric-based protection systems. Project 497 focuses on maturing technologies that enable Soldiers and robotic systems to fight side-by-side. The Robotics Collaboration effort pursues technologies for human-robot interaction in Soldier-robot teams such as: intelligent agents, adaptive automation, augmented

reality for increased local situational awareness, and user-friendly displays to reduce the Soldier's burden in the control of manned and unmanned ground and air systems. In addition, project 515 includes the Near Autonomous Unmanned Systems effort which matures and demonstrates technologies to enable robotic vehicles to act more independently during tactical maneuvers and protect themselves from intruders, thereby enabling the Soldier to perform other mission tasks. Projects 533 and 53D fund congressional special interest items. Project C66 supports programs that are classified. Work in this program element (PE) 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 US Marine Corps, 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 as well as 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) and the Army's Tactical Wheeled Vehicle Fleet Modernization Strategy. Work in this PE is performed by the Tank Automotive Research, Development, and Engineering Center (TARDEC), Warren, MI.

B. Program Change Summary	FY 2006	FY 2007	FY 2008	FY 2009
Previous President's Budget (FY 2007)	242013	109952	124336	96592
Current BES/President's Budget (FY 2008/2009)	212115	204383	131436	108554
Total Adjustments	-29898	94431	7100	11962
Congressional Program Reductions		-5319		
Congressional Rescissions				
Congressional Increases		101250		
Reprogrammings	-29898	-1500		
SBIR/STTR Transfer				
Adjustments to Budget Years			7100	11962

FY06 funds decreased to support higher priority efforts.

Fifty FY07 congressional adds totaling $97045 (after adjustment for Congressional Undistributed Reductions) were added to this PE.

($1247) Tactical Vehicle Design Tools
($1965) Aluminum Lightweight Structures Initiative (ALSI)
($1295) Pacific Rim Corrosian Research Program
($1726) Armored Composite Cab Development
($1151) Lightweight Diesel Engine for Ground Vehicles
($3835) Ltwgt Comp Armor for Blast & Ballistic Protection
($3115) 3-D Advanced Battery Technology (3-D ABT)
($958) Advanced Lightweight Composite Armor
($1917) Antiballistic Windshield Armor (AWA)
($2875) Army Tactical RPG Airbag Protection System (TRAPS)
($958) Battery System Development
($958) Center for Innovative Materials Research (CIMR)
($1246) Cross Cue APS Radar
($1917) Fire Resistant Fuels
($1869) Heat Dissipation for Electr Systems & Enclosures
($3450) High Speed Desel Combustion
($958) LEAN Digital Product Development
($1869) Light Weight Armor Ready Composite Cab
($958) Light Weight Medium Tactical Trailer

($958) Mobile Armor Plant: Battlefild Expedient Armor Mfg
($2300) Purpose Built Armored Tractor Test and Evaluation
($6230) Unmanned Ground Vehicle iInitiative
($958) UGV/UAV Collaborative Operations
($958) Vehicle Information Manager Display for Drivers
($2876) Advanced Thermal Management System
($2301) Battery Charging Technology
($1869) Digital Humans & Virtual Reality
($1630) Dev of Logistical Fuel Processors for TARDEC/TACOM
($3738) Fuel Cell Ground Spt Equipment Demos
($1246) Secure Pervasive Computing for Adv Cbt Vehicles
($1869) Next Gen Non-Tactical Vehicle Propulsion
($1438) Adv Drivetrains for Enhanced Mobility and Safety
($3451) Amphibious Personal Mobility Vehicle
($7764) Center for Military Vehicle Technologies
($958) HAZ-MAT Material Vacuum System
($1246) Solid Oxide Fuel Cell Materials & Manufacturing
($1102) Advanced Tactical Vehicle Safety and Reliability
($1534) Alt Fuels Validation Prog/Military Ground Vehicles
($1390) Battlefield Requirements Management Support System
($958) Compressible Magneto-Rheological (CMR) Fluids
($2971) High Speed Machining of Ceramics for Military Apps
($958) HMMWV Equipment Innovations in Lighting and Towing
($958) Lightweight Road Wheels
($2875) Low Quantity Precision Fabrication
($1198) Mobile Info Distrib & Access-Control Sys (MIDAS)
($958) National Center for Titanium Machining
($958) Segmented Band Track Technology
($1246) Tactical Vehicle Fleet Management
($1390) Vehicle Maintenance Prognostics System
($2492) Versatile Utility Vehicle

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2007

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

COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
221 COMBAT VEH SURVIVABLTY	17726	20484	45414	37659	22185	22938	25507	26089

A. Mission Description and Budget Item Justification: This project matures and demonstrates combat vehicle survivability technologies essential for the Future Force as well as provides technical solutions for enhancing the survivability capabilities of the Current Force. Focus is on advanced armors, Active Protection Systems (APS), safety devices, and integration of these onto Future Force vehicles, Future Tactical Wheeled Vehicles (TWVs) and, where practical, Current Force combat and tactical vehicles. As combat vehicle systems become smaller and lighter and tactical vehicles are more often exposed to combat conditions, one of the greatest technological and operational challenges is providing adequate crew protection without reliance on heavy passive armor. These challenges are being addressed by major efforts in integrated survivability suites comprised of APS coupled with advanced ballistic protection which provides electromagnetic (EM) armor, smart and ceramic armors integrated with advanced composite and laminate structures, and advanced transparent armor formulations. The APS against Kinetic Energy (KE) threats effort conducts essential trade studies, technical evaluations, and demonstrations of APS components/sub-systems including countermeasure warheads and interceptors, detectors, and trackers, and fire control hardware and software required to identify, classify, and defeat KE threats as defined for Future Combat Systems (FCS). Technologies and performance data are transitioned for use in Future Force manned ground vehicles and potential spin-offs to Current Force combat vehicles. This effort is integrated and coordinated with efforts from program elements (PEs) 0602624A (Weapons and Munitions Technology), 0603004A (Weapons and Munitions Advanced Technology), and 060313A (Missile and Rocket Advanced Technology). TWV Survivability focuses on maturing and demonstrating viable integrated survivability suites that can be tailored to meet current and future threats when applied to light, medium, or heavy tactical wheeled vehicles. This effort provides essential underpinning data to support the mutual effort between the Army and Marines for the next generation Light Tactical Vehicle. Lightweight, integrated armor technologies, using components from Program Elements (PEs) 0602601A (Combat Vehicle and Automotive Technology), 0602618A (Ballistics Technology), and 0602105A (Materials Technology), are integrated and demonstrated through ballistic testing to validate performance versus weight against various armor protection requirements. AP systems and signature management treatments are also be integrated and evaluated to determine effectiveness and ability to counter threats in conjunction with armor treatments. Data will be provided to the Program Manager (PM) for Future Tactical Systems (FTS) as input to Technology Readiness Assessment for their next generation Light Tactical Vehicle . Modeling tools that characterize hardware performance of the survivability enhancements are matured and validated and linked to tactical vehicle virtual prototyping tools, enabling more rapid and cost effective adaptations and evaluations of effectiveness in the future. The goal of the Vision Protection effort is to mature and demonstrate treatments to optical systems that provide protection from frequency-agile laser weapons. These technologies are appropriate for transition to Future Force vehicles for spiral integration or to Current Force vehicles such as the Abrams, Bradley, and Stryker. Work in this PE is related to and closely coordinated with work conducted in PE 0602601A (Combat Vehicle and Automotive Technology) and in collaboration with the Army Research Laboratory's PE 0602618A (Ballistics Technologies) as well as with the US Marine Corps and Office of Naval Research. The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, the Defense Technology Area Plan (DTAP), and the Army's TWV Fleet Modernization Strategy. 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 US Army Armaments Research, Development, and Engineering Center (ARDEC), Picatinny, NJ, and the US Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC).

Accomplishments/Planned Program:	FY 2006	FY 2007	FY 2008	FY 2009
APS against close-in threats (Full Spectrum Active Protection Close In Layered Shield (FCLAS)): In FY06, demonstrated FCLAS on a	3600			

both a static and moving HMMWV and evaluated performance; analyzed FCLAS application to rotorcraft and alternate launch mechanisms.				
APS against KE: In FY06, performed system engineering technical trade studies and engineering modeling; conducted test firings of critical components; assessed tracking radar, interceptor, and countermeasure assemblies against tank fired Kinetic Energy (KE) threats; characterized kill radius and warhead effects associated with various candidate system approaches; evaluated and performed engineering tests on high risk KE sensors, fuses, and warheads. In FY07, work with AMRDEC to initiate preliminary design of KE-APS interceptor designs, conduct analysis of interceptor guidance options and downselect guidance scheme and develop detailed design of KE interceptor. In addition, work in concert with ARDEC to mature and characterize blast warhead capable of defeating KE threats and develop and the fuse capable of reacting fast enough to engage hypervelocity threats; develop Systems Engineering Plan (SEP), Test and Evaluation Master Plan (TEMP), systems architecture, initial system and component specifications, and interfaces. In FY08, will provide design support to integrate S&T developed components into FCS vehicle architecture and hardware for the KE AP system; work in concert with ARDEC to weaponize/integrate the warhead and fuse package and begin integration with interceptor being developed at AMRDEC; update the SEP, the TEMP, systems architecture, system and component specifications and interfaces; coordinate and manage and conduct KE APS component testing of warhead, fuze, and interceptor to meet FCS timelines. In FY09, will complete system and component specifications; finalize all system interfaces. Work with ARDEC to complete warhead weaponization & fuse package and integrate into interceptor; build and test warheads in support of KE APS final demonstration; coordinate transition of components for integration into future combat vehicles; and work with AMRDEC to conduct/participate in KE APS interceptor/system testing, demonstration, and analysis.	11326	8658	18461	13876
TWV Survivability: In FY07, use modeling and simulation tools to conduct trade studies and analyses to identify viable candidate integrated survivability suites for one or more TWVs; mature selected safety equipment and APS components and validate ballistic performance, structural capability, and durability of components; assess manufacturability and affordability of candidate solutions; select "best mix" survivability suite for initial demonstration; provide results of assessments and data from performance tests to PM FTS in support of Technology Readiness Assessment. In FY08, will finalize component maturation and fabricate demonstration vehicle(s) while continuing integrated suite design activities and will conduct studies with experimentation to determine the impact of various survivability suites on vehicle weight, volume, and power system. In FY09, will conduct extensive experiments and tests of several integrated survivability suites on demonstration vehicle(s) to verify and validate the level of protection achieved, the durability of the systems and the impact of the added weight, volume, and power on vehicle performance.		6258	11928	10976
Vision Protection: In FY06, developed designs to meet targeting requirements of the electro-optic vision system and demonstrated materials that provide various amounts of protection from laser damage. In FY07, integrate and evaluate nonlinear optical materials that protect the sensors from laser-induced damage; begin construction of a breadboard targeting system using these concepts; and begin design of laser-protected FCS navigation camera system and optical fire control. In FY08, will complete and test the fire control camera breadboard for optical and laser protection performance and fabricate protection system for navigation camera. In FY09, will complete and test agile laser protection in FCS-type navigation camera and optical fire control breadboards.	2800	2824	5556	3823
Armor/Mine Protection: In FY07, investigate lighter weight/more efficient/novel protection technologies in the areas of opaque armor, transparent armor, close-in Rocket Propelled Grenade (RPG) protection, and mine protection for Tactical Wheeled and Combat Vehicles; pursue near-term armor design options to provide increased protection against small arms, surface laid, and buried mines, fragment and Explosively Formed Penetrator (EFP) threats, defeat of close-in RPGs and design guidance for increasing Light Tactical Vehicle (LTV) mine protection; develop initial vehicle-level mine response modeling and simulation (M&S) capability to support vehicle trade studies. In FY08, will mature near-term opaque/transparent/RPG armor designs and develop design guidance for future Medium Tactical and		2481	9469	8984

Combat Vehicles mine protection; will demonstrate initial mine kit designs; will develop and demonstrate candidate spin-out armor/transparent armor/RPG protection; will further develop vehicle-level mine response M&S to include vehicle kinematics response. In FY09, will continue to develop lighter weight armor/mine protection solutions with an emphasis on meeting objective threat defeat levels at reduced weights; will develop design guidance for future Heavy Tactical Vehicles (HTV) mine protection; will demonstrate improved mine kit designs and will further develop vehicle-level mine response M&S to include crew/occupant response.				
Small Business Innovative Research/Small Business Technology Transfer Programs.		263		
Total	17726	20484	45414	37659

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2007

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

COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
441 COMBAT VEHICLE MOBILTY	36789	34199	43876	40399	45818	44078	39587	40466

A. Mission Description and Budget Item Justification: This project matures and demonstrates advanced mobility and electric component and subsystem technologies for next generation ground combat and tactical vehicles and provides demonstrations of increased vehicle performance and capability. It enables lightweight, agile, deployable, fuel efficient, and survivable ground vehicles needed for the Future Force and enhancements to the Current Force. It demonstrates critical propulsion, power, and electrical components and subsystems (advanced engines, lightweight track, energy storage devices, power distribution systems, Pulse Forming Networks (PFNs), and components/subsystems needed to employ alternative fuels) for combat and tactical vehicles. Power/energy component and Hybrid Electric Vehicle (HEV) technologies, which can provide power for propulsion, control systems, communications, life support systems, electric weapons, and protection systems, are key enablers for enhancing capabilities. In the near term a major focus is on evaluating and demonstrating the maturity of HEVs for military applications and on demonstrating the HEV performance benefits and burdens through experimentation and testing against relevant duty cycles and environments in a Power and Energy Systems Integration Laboratory (P&E SIL) and at instrumented test tracks. Over the longer term, the efforts focus advances component energy density and system efficiency while increasing platform capability. The P&E SIL is a reconfigurable hardware-in-the-loop experimentation facility that replicates vehicle power and performance characteristics in a simulated system representing military HEVs (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). The HEV Propulsion effort matures components and sub-systems and demonstrates them in the P&E SIL, which,in the near term, is configured to support HEV designs. The effort also supports development of mission duty cycle profiles critical to evaluations of ground vehicle HEV technologies. The HEV Experimentation and Assessment effort analyzes differences between the demands of commercial, civilian operating environments, and the military operating environments, determines the impact of these differences on the performance of various HEV designs and architectures, evaluates and demonstrates the maturity of HEVs for military applications, and develops modeling and simulation tools that may be used to predict drive cycle fuel economy and performance characteristics (primarily fuel economy but also acceleration, speed, reliability, maintainability, tractive power, and ability to maintain speed on grade) for tactical platforms. The Advanced HEV Components effort seeks significant increases in next generation combat and tactical vehicle mobility, efficiency, and mission capability without increasing vehicle weight and volume through the maturation and demonstration of advanced traction wheel motors, active suspension, high temperature electronic components, regenerative brakes, thermal management, lightweight track, and segmented band track. New designs and packaging concepts are matured and validated in component testing to verify improved performance, reliability, durability. The Pulse Power effort matures component technologies and demonstrates compact components and subsystems that enable revolutionary survivability and lethality applications. The goal is to make significant advances in the maturity of high power density, capacitor-based PFNs that enable advanced electromagnetic (EM) armor, and advanced electric weapons for FCS spiral insertions. The High Power Engine Research (HIPER) effort matures and demonstrates prime power (engine) components and concepts 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 Lightweight Track effort develops new segmented band track and hybrid steel track technologies that are robust, lightweight, exhibit low vibration and acoustic emissions, reduce crew maintenance, and are field supportable. 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 enables fuel cells to be practical for military vehicle power generation. The Fuel Efficiency ground vehicle Demonstrator (FED) is a new effort focused on demonstrating the viability of achieving significant decreases in fuel consumption, without sacrificing the performance or capability, in a tactical vehicle by integrating potentially high-payoff fuel efficient technologies and advanced lightweight materials in new and innovative designs. The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work in this project is performed by Tank Automotive Research, Development, and Engineering Center (TARDEC), Warren, MI, in conjunction with Army Research Laboratory (ARL),

Accomplishments/Planned Program:	FY 2006	FY 2007	FY 2008	FY 2009
HEV Propulsion and P&E SIL: In FY06, evaluated emerging novel hybrid electronics components and integrated them within the P&E SIL to demonstrate operation in a relevant environment at the system level; designed and fabricated onto a chassis in the SIL to address the realistic challenges of integrating HEV system components and operating them in a compact vehicle; lab tested and installed surrogate engine in the chassis; evaluated performance of chassis on inertial dynamometers with realistic duty cycles and terrain input; advanced M&S ability to include real time power and energy vehicle hardware-in-the-loop and man-in-the-loop experiments and analyses; began design of an advanced traction drive system; performed trade-off and performance assessments of spiral upgrade concepts for Future Force and Current Force vehicles; used early power and energy mission profile data to develop duty cycle experiments; and developed advanced thermal management strategy for FCS-like chassis. In FY07, purchase/build, integrate, and evaluate enhanced hybrid electric propulsion components (batteries, switches, controllers, compact engine/generator, thermal management, and power distribution systems) in SIL; begin validation of vehicle emulation model; add instrumentation to enable evaluation of Electromagnetic Interference (EMI) and evaluate EMI on the chassis; and continue to develop and incorporate FCS vehicle duty cycles for use in SIL. In FY08, will integrate advanced traction drive into the chassis; begin optimizing architecture for best thermal management; continue reducing EMI through filtering, shielding, and grounding; and continue to update power and energy mission profiles. In FY09, will complete optimization of architecture for thermal management; complete EMI reduction initiative; finalize power and energy mission profiles; and characterize and quantify performance of optimized architecture over profiles.	10854	8607	7892	7975
HEV Experimentation and Assessment: In FY06, conducted extensive literature search to identify all prior data available on performance of HEVs for military applications, analyzed data to obtain baseline expectations for TWV fuel economy specifications, and identified gaps in knowledge on technology maturity and performance parameters; analyzed User requirements to determine power levels; developed evaluation/test methodology for TWVs designed with HEV drive trains; obtained baseline performance data (including fuel consumption and measures of exportable power availability) on instrumented vehicles at test tracks using existing HEV demonstrators and current non-HEVs. In FY07, develop a set of representative duty cycles for light tactical vehicles for a variety of missions and determine an appropriate test operating procedure to enable direct comparison of HEV performance with that of non-HEVs particularly with respect to fuel economy, sustainability, and overall vehicle performance in tactical missions; provide input to and perform vehicle performance assessments in cooperation with the Future Tactical Truck System military utility assessment; use M&S to explore the variation in performance across various TWV missions/scenarios and various vehicle weights. In FY08, will continue analysis and testing of HEVs, with focus on M&S excursions to expand lessons learned from military utility assessment and conduct additional experiments and performance tests on medium vehicles designed with various HEV architectures. The Demos will also help refine HEV designs and/or applications to TWVs. In FY09, will continue analysis and testing of HEVs and available enhancements with focus on M&S excursions to expand lessons learned; conduct additional experiments and tests on heavy vehicles designed with various HEV architectures.	6000	2485	4832	4779
Advanced Hybrid Electric Vehicle (HEV) Components: In FY06, fabricated, assembled, and demonstrated a 40 kW high temp all-SiC motor inverter, a 10 kW/l traction motor; fabricated and conducted evaluations of enhanced Li-ion batteries from multiple vendors; fabricated and evaluated other advanced battery technologies, including graphite-foam enhanced cells; and advanced HEV system performance and maturity through competitive efforts to fabricate higher energy density traction motor, battery, and power electronic components. In FY07, mature and demo inverter, battery, traction motor, and DC-DC converter component technologies; conduct product evaluations/tests; continue evaluations and laboratory tests of Li-ion and other types of high performance batteries; evaluate advanced	7978	8794	6232	6115

thermal management technologies for maintaining coolant temperatures of 110 degrees C° during system demonstrations using innovative cooling techniques (i.e. spray cooling and hybrid cooling loop); and demonstrate component performance in high power density DC-DC converters and in-vehicle applications. In FY08, will; demonstrate advanced HEV-based modular drive train systems consisting of power sources and energy storage devices under different architectures in the propulsion lab, with focus on developing effective thermal management system architectures and power management control strategies that can be applied to next generation tactical vehicles; and mature and demonstrate system architecture designs for improving reliability, safety, and power consumption strategies. In FY09, will; demonstrate a complete vehicle electrical system designed for tactical vehicle applications implementing an advanced power and energy management/control strategy for both continuous and transient conditions and for pulse power operations; demonstrate built-in prognostics capable of predicting impending failures; and demonstrate exportable power management at different voltages based on realistic demands.				
Pulse Power: In FY06, designed and fabricated improved pulse power components, including faster output switches with 33 percent greater capacity, High Energy Density (HED) capacitors with 12 percent greater energy density (1.8 J/cc) miniturizing the capacitors to fit within the vehicle, and pulse chargers with 30 percent greater power density; inserted advanced components into the first generation HED, dual mode Pulse Forming Network (PFN); integrated and successfully lab tested a second generation dual purpose PFN. In FY07, demonstrate reduced size for critical pulse power components while maintaining the critical electrical performance needed for the dual mode PFN, the Solid State Laser (SSL) PFN and EM Gun switch; evaluate performance of improved HED capacitors in Advanced EM Armor application/vehicle demonstration; integrate and demonstrate transitional switch with improved pulse width for EM Gun at scaled power levels, and complete the design/development of the laboratory version of the a PFN/Battery Box for SSL. In FY08, will complete development of vehicle-ready version of the 100kW power supply for the SSL to include development, integration and test of high power-density batteries with the PFN/Battery Box, will continue to improve EM Gun Switch program with SiC based devices, will increase HED capacitors life by 25 percent and increase energy density of HED capacitors to 2.0J/cc. In FY09, will develop/demonstrate SiC based high-temperature, high power switches/devices and Si- and SiC-based power converters in support of EM Gun, high power microwave, and laser applications; continue to mature and demonstrate HED capacitor with improved DC lifetime as backup to rotating machine technology and HED batteries for other longer pulse applications; integrate and evaluate advanced thermal management techniques to increase efficiency and effectiveness of compact power, pulse power devices, and power converters. This is a collaborative effort between TARDEC/ARL.	5844	4912	6613	7599
HIPER: In FY06, evaluated advanced turbo-machinery and the associated control system and electronics to determine their effect on improving engine power density and efficiency; and completed design studies and trade-off analyses for advanced internal combustion configuration and high speed combustion. In FY07, install turbo-machinery system, including controls, on a high power density 440 kW capable test engine and conduct engineering tests to obtain performance and durability data.	2013	2013		
Advanced Lightweight Track: In FY06, used knowledge, expertise, and technologies gained from band track effort to analyze failures of current track systems. Designed a new segmented band track based on this analysis, combining the lightweight characteristics of band tracks with the higher supportability and robustness of linked steel track. Modeled and analyzed mine blast phenomena to develop survivable lightweight track system; and investigated new approach to the development of advanced elastomers for track applications. In FY07, fabricate prototypes of new segmented band track and a lightweight hybrid steel track, incorporating new bushing elastomers; and evaluate reinforcement and joint structural performance for anti-personnel mine blast survivability, heat transfer, and sprocket/track interfaces and analyze effectiveness. In FY08, will integrate and evaluate performance of the new segmented band track and hybrid steel track on demonstrator vehicles under field conditions with focus on durability and mobility.	4100	4004	3849	
JP-8 Reformation for Alternative Power Sources: In FY07, assess selected reformation and desulphurization technology approaches and		2472	4458	3931

begin initial system integration efforts for future laboratory hardware performance demonstration. In FY08, will begin integration of JP8 reformer to transportable system and interface with fuel cell. Integration will include optimization of key pieces to make the system transportable. This integration will be the first of many steps to making a JP8 reformation/fuel cell combination that will meet the size and signature requirements of the Army. In FY09, will complete integration of JP8 reformer; begin test plan and system integration for endurance test; and begin 1000 hour endurance test on JP8 reformer connected to fuel cell to produce power for a selected tactical vehicle application. At the conclusion of the 1000 hour endurance test, the fuel cell will be sent to TARDEC for an addition 300 hour test that may include extreme cold and/or hot conditions. After meeting TARDEC's environmental tests, planning for the next phase can begin.				
Fuel Efficiency ground vehicle Demonstrator (FED): In FY08, use modeling and simulation that exploits advanced materials and construction techniques to design a tactical wheeled vehicle significantly lighter and more fuel efficient than the HMMWV with comparable or improved mobility and survivability; identify potentially high pay-off lightweight/fuel efficient designs and components (such as electric/hybrid electric propulsion systems, high energy density, high efficiency engines, advanced power units, fuel cells, advanced batteries, lightweight armors, electric motors, lightweight/durable suspensions, and energy efficient tires); select best design and begin physical fabrication/integration effort. In FY09, will complete demonstrator fabrication/integration and conduct comparative performance evaluations, using M1114 Up-armored HMMWV as baseline; analyze test results and make recommendations for future vehicles.			10000	10000
Small Business Innovative Research/Small Business Technology Transfer Programs.		912		
Total	36789	34199	43876	40399

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2007

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

COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
497 COMBAT VEHICLE ELECTRO	8609	9564	13110	7500	7643	7763	7934	8108

A. Mission Description and Budget Item Justification: This project matures, integrates, and demonstrates vehicle electronics hardware (displays, sensors, communications systems, and vehicle command/control/driving mechanisms) and software that result in increased crew efficiencies, performance, and/or reduced crew size for Future Force vehicles and, where practical, for insertion into Current Force vehicles. The project advances open system architectures for ground combat vehicles that allow more efficient crew stations to be adapted for a variety of Future Force ground platforms. Technical challenges include: increased levels of automation for both manned and unmanned systems, advanced user interfaces that support improved/increased span of control for robotic operations, and collaborative vehicle operations, workload management, reliability of driving aids and commander's decision aids, and embedded simulation for battlefield visualization and fully integrated virtual test/evaluation. The Robotics Collaboration effort matures and demonstrates common scaleable user interface software that can reside on multi-screen mounted crewstations, single screen operator control units, or small Soldier portable devices. A major objective is to construct a common scaleable interface that has 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. The interface is designed to allow graceful degradation of the display system, reconfiguring controls and displays in the event of hardware failure and to provide associated functionality to the Soldier upon the discovery of available services. Robotics Collaboration also matures and refines mounted crew and dismounted Soldier task models, combines these in an Intelligent Systems Behavior Simulator (ISBS), and conducts focused experiments that will define key metrics and drive development of embedded intelligent agents that have potential to lessen Soldier workload and reduce and/or automate mounted and dismounted system control tasks. This work is performed in conjunction with Robotics Collaboration effort described in project 515. Force protection measures of the future require the mounted Soldier to operate for extended periods of time under armor with hatches closed. When operating in this mode, the Soldier's local situational awareness and ability to maneuver the vehicle currently are degraded. A portion of this project focuses on Intelligent Secure Mobility (ISM), work that seeks to improve mobility and survivability by collecting and analyzing data from vehicle sensors to provide mounted Soldiers and crew with enhanced local area awareness augmented-reality inside the vehicle. Unmanned assets organic to the platoon expand the local sensing sphere to increase standoff distances and response times. Real-time embedded models predict vehicle system behavior to support safe mobility and weapon operations. The effort supports definition and refinement of requirements based on employment of human factor methodologies and through human-in-the-loop static and ride-motion simulation. The Robotics Collaboration and ISM work is performed in close cooperation with the Army Soldier Battlelab. 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 2006	FY 2007	FY 2008	FY 2009
CAT ATD: In FY06, conducted final operational warfighter experiments in a relevant military environment demonstrating commander's and driver's crew-aiding behaviors and automated planning features; evaluated electronic control architecture and embedded mission planning, rehearsal, and training capabilities.	2000			
Robotics Collaboration: In FY06, developed baseline ISBS began developing relevant intelligent agent software and identifying baseline tasks that may be adaptively automated; initiated designs for common scalable interfaces and evaluated them through simulation and field experiments. In FY07, refine and model additional crew control tasks, display information, and intelligent agents; integrate display	6609	9314	13110	7500

designs and intelligent agents into target hardware; conduct experiments in which Soldiers evaluate the mounted and dismounted scaleable interface; and measure the impact of controlling unmanned (and manned) systems on Soldier task work load during performance of militarily significant combat scenarios. In FY08, will refine task timelines and models in the ISBS environment based on FY07 Soldier evaluations and experimental data; conduct final design and integration of scaleable interface software and intelligent agents into mounted and dismounted system hardware and perform final capstone Soldier operational field experiments in militarily significant combat scenarios in urban environments, capturing all relevant performance data. In FY09, will perform ISM human-in-the-loop simulation experiments to identify best design approaches for augmented reality interface and automation capabilities required for vehicle navigation and local awareness; begin development of augmented reality and automation technology; begin development of predictive models for safe mobility and weapon operations.				
Small Business Innovative Research/Small Business Technology Transfer Programs.		250		
Total	8609	9564	13110	7500

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2007

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

COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
515 ROBOTIC GROUND SYSTEMS	12221	17391	9484	10248	10390	11020	11178	11341

A. Mission Description and Budget Item Justification: This project matures and demonstrates unmanned ground vehicle technologies for the Future Force and explores feasibility for enhancements to the Current Force. The main focus is on integrating and demonstrating in relevant environments sensor technologies, perception hardware and software, and robotic control technologies that enable Unmanned Ground Vehicle (UGV) systems to maneuver on- and off-road at militarily significant speeds with minimal human intervention, thereby enabling the Soldier to perform other mission tasks. Technical challenges addressed include: obstacle avoidance, perception limitations, intelligent situational behaviors, command and control, frequency of human intervention, operations in adverse weather, and robots protecting themselves and their surroundings from intruders. Mature technologies are incorporated in UGV technology demonstrators so that performance can be evaluated for tactical maneuver and sustainment applications. The Near Autonomous Unmanned Systems effort matures a set of automated tactical behaviors and self-security 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. These technologies are 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 Robotics Collaboration effort develops, matures, and demonstrates models that optimize the way Soldier-robot teams perform operations. Models are validated through both man-in-the-loop simulation and field experiments in which Soldier-robot teams perform military relevant scenarios. It develops 3D models and algorithms using colorized ranging with LADAR and visual sensors for safe operations of unmanned systems around humans. In addition, this effort focuses on developing and demonstrating UGV behaviors, including force protection and tactical/reactive/self-security, which provides the ability to consistently operate safely in a semi-autonomous mode in urban environments in the presence of Soldiers, pedestrians, and other vehicles. It also matures technologies that contribute to improved/enhanced navigation. Work done in this project is complementary to the Robotics Collaboration effort described in project 497. The approach builds upon, complements, and does not duplicate previous and ongoing investments conducted under the Joint Robotics Program Office and the Defense Advanced Research Projects Agency, in program element (PE) 0602601A (project H91, Tank and Automotive Technology) and PE 0602618A (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 collaboration with the Army Research Laboratory (ARL), Adelphi, MD.

Accomplishments/Planned Program:	FY 2006	FY 2007	FY 2008	FY 2009
Robotic Follower: In FY06, integrated improved obstacle detection algorithms for detection of small positive and negative obstacles; implemented software to establish road-following, traffic-avoidance baseline for improved lane maintenance as well as traffic/pedestrian detection and avoidance; implemented improved leader-follower algorithms to enable increased mobility using waypoints augmented with terrain-intelligent navigation; demonstrated significant reduction in operator/controller workload; conducted experiments focused on providing dismounted Soldiers support when conducting operations in urban areas; performed final engineering evaluations and operational warfighter experiments that demonstrated program performance exit criteria.	3000			
Near Autonomous Unmanned Systems: In FY06, installed and evaluated performance of a perception suite designed in PE 0602618A (project H03) on a mobile testbed and initiated testing on a tracked skid steer platform; matured algorithms for unmanned tactical behaviors and self-security hardware and software required to meet user needs; began to integrate tactical behavior algorithms and self	7321	12993	5037	4492

security subsystems into testbed platform in preparation for FY07 field evaluations. In FY07, integrate intrusion detection sensors and day/night sensor packages onto testbed and conduct performance evaluations in reconnaissance, surveillance, and target acquisition mission scenarios; integrate and assess tactical behavior algorithms designed to enable maneuver- and formation-based missions; integrate human detection and tracking components associated with self-security suite into testbed and evaluate performance through engineering testing; conduct warfighter field evaluations and experiments to assess maturity and assist in development of tactics, techniques, and procedures; and continue to mature tactical behavior algorithms and self protection technologies using data collected from field experiments. In FY08, will; develop and begin integration of tactical behavior algorithms required for scout missions; and mature entire suite of tactical behaviors and begin integration of human intent analysis algorithms to vehicle self-security system. In FY09, will; complete integration of tactical behavior algorithms and self-security suite; and conduct final capstone Soldier-in-the-loop field experiments in a militarily relevant environment and in a militarily significant scenario.				
Robotics Collaboration: In FY06, conducted simulations and experiments to evaluate performance of a Soldier-portable control device for teleoperation of unmanned systems; and began developing 3D models and algorithms based on LADAR and visual sensor data for safe operations of UGV_s around humans. In FY07, conduct experiments to test and evaluate Soldier-robot teaming models in the performance of militarily significant combat scenarios employing unmanned systems; and conduct engineering evaluations to collect data and refine initial safe operation models. In FY08, will integrate Soldier-robot teaming and safe-operations algorithms into target hardware and perform final capstone Soldier-field experimentation in urban environments to obtain performance data. In FY09, will provide input to support development of requirements for safe operations of UGVs in urban environments in conjunction with users, and initiate development of baseline behaviors that will enable UGVs to navigate around people and other vehicles.	1900	3909	4447	5756
Small Business Innovative Research/Small Business Technology Transfer Programs.		489		
Total	12221	17391	9484	10248

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2007

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

COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
53G FUTURE COMBAT SYSTEMS (FCS)	34445	20563	14215	12069				

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 FCS related combat vehicle and automotive related technologies including armor, active protection, power and energy, and unmanned systems, as well as the Army's share of the Army/DARPA collaboration on Enabling Technologies for FCS. A portion of the 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 DARPA related 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; 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; 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 2006	FY 2007	FY 2008	FY 2009
In FY06, AACER - completed fabrication of demonstrator modules and perform subsystem tests, system integration, and rooftop tests; AAEF - executed a full scale experimental demonstration; FORESTER - designed, assessed, and evaluated 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 - completed fabrication of demonstrator equipment and demonstrate active 3-D imaging for hard-to-identify targets; OAV - conducted critical design review and began demonstrator fabrication; UPI - selected ARV weapon payload and conducted initial demonstration testing of two platforms; WolfPack - demonstrated threat sensor/jammer capabilities as part of the FCS C4ISR structure.	34445			
In FY07, AACER - fabricate optimized integrated airborne system antenna array and perform ground performance demonstrations; AAEF - perform operational assessment of warfighting utility of FCS enabling technologies and concepts, in an operational environment, via		19984		

experimentation with surrogates and mature demonstrator hardware/software. MNM - validated MNM concept with perform 10-node demonstration tests on improved MIMO hardware/software demonstrator; UPI - conduct full-up demonstration of enhanced capability sensors on two UGCV platforms; initiate a redesign and build of the Crusher vehicles to address ARV requirements.				
In FY08, will conduct Armed Robotic Vehicle (ARV) subsystems including software and mission payloads and conduct subsystem design performance tests followed by integrated testing; will integrate and test armor and active protection components and will mature and integrate combat vehicle power and energy components.			14215	
In FY09, will complete integration of FCS ARV software and mission payloads and will conduct developmental and operational testing ARV vehicles. Will conduct integrated testing and demonstration of armor and active protection components on FCS combat vehicles.				12069
Small Business Innovative Research/Small Business Technology Transfer Programs.		579		
Total	34445	20563	14215	12069