Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603005A *I Combat Vehicle and Automotive Advanced Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	136.624	122.132	125.537	-	125.537	121.013	116.716	117.184	112.935	-	-
221: *Combat Veh Survivablty*	-	53.300	63.269	66.436	-	66.436	65.084	57.001	56.439	59.065	-	-
441: *Combat Vehicle Mobilty*	-	41.673	39.067	33.447	-	33.447	29.398	30.943	32.550	34.160	-	-
497: *Combat Vehicle Electro*	-	6.396	7.118	7.162	-	7.162	7.215	7.359	7.506	7.662	-	-
515: *Robotic Ground Systems*	-	12.755	12.678	18.492	-	18.492	19.316	21.413	20.689	12.048	-	-
533: *Ground Vehicle Demonstrations*	-	22.500	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) matures, integrates and demonstrates combat and tactical vehicle automotive technologies that enable a lighter, more mobile and more survivable force. This PE executes the Army's Combat Vehicle Prototyping (CVP) program to mature, integrate and demonstrate ground vehicle leap ahead technologies in support of future combat vehicles. Project 221 matures, integrates and demonstrates protection and survivability technologies such as active protection systems (APS), advanced vehicle armors, blast mitigation and occupant safety devices to address both current and emerging advanced threats to ground vehicles. Project 441 matures and demonstrates advanced ground vehicle power and mobility technologies such as powertrains, power generation and storage, water and fuel logistics, and running gear subsystems for military ground vehicles to enable a more efficient, mobile and deployable force. Project 497 matures, integrates, and demonstrates vehicle electronics hardware (computers, sensors, communications systems, displays, and vehicle command/control/driving mechanisms) and software that result in increased crew efficiencies, vehicle performance, reduced size, weight, and power (SWaP) burdens and vehicle maintenance costs. Project 515 matures and demonstrates unmanned ground vehicle (UGV) technologies with a focus on sensors, perception hardware and software, and robotic control algorithms that enable UGV systems to maneuver on- and off-road at speeds which meet mission requirements with minimal human intervention.

Work in this PE is coordinated with, PE 0602105A (Materials), 0602120A (Sensors and Electronic Survivability, Robotics Technology), 0602601A (Combat Vehicle and Automotive Technology), 0602618A (Ballistics Technology), 0602624A (Weapons and Munitions Technology), 0602705A (Electronics and Electronic Devices), 0602784 (Military Engineering Technology), 0603001A (Warfighter Advanced Technology), 0603004A (Weapons and Munitions Advanced Technology), 0603005 (Combat Vehicle and Automotive Advanced Technology), 0603125A (Combating Terrorism Technology Development), 0603270A (Electronic Warfare Technology), 0603313A (Missile and Rocket Advanced Technology), 0603734 (Military Engineering Advanced Technology), 0604115A (Technology Maturation Initiatives), and 0708045A (Manufacturing Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this PE is performed by the Tank Automotive Research, Development, and Engineering Center (TARDEC), Warren, Michigan.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army	Date: May 2017
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603005A *I Combat Vehicle and Automotive Advanced Technology*

B. Program Change Summary ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	135.571	122.132	126.724	-	126.724
Current President's Budget	136.624	122.132	125.537	-	125.537
Total Adjustments	1.053	0.000	-1.187	-	-1.187
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	5.500	-			
• SBIR/STTR Transfer	-4.447	-			
• Adjustments to Budget Years	0.000	0.000	-0.609	-	-0.609
• Civ Pay Adjustments	0.000	0.000	0.165	-	0.165
• Other Adjustments 2	0.000	0.000	-0.743	-	-0.743

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 533: *Ground Vehicle Demonstrations*		
Congressional Add: *Program Increase*	22.500	-
Congressional Add Subtotals for Project: 533	22.500	-
Congressional Add Totals for all Projects	22.500	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 3	R-1 Program Element (Number/Name) PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	Project (Number/Name) 221 / *Combat Veh Survivablty*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
221: *Combat Veh Survivablty*	-	53.300	63.269	66.436	-	66.436	65.084	57.001	56.439	59.065	-	-

A. Mission Description and Budget Item Justification

This Project matures, integrates and demonstrates protection and survivability technologies such as active protection systems (APS), advanced vehicle armors, blast mitigation and occupant safety devices to address both current and emerging advanced threats to ground vehicles. This Project integrates complimentary survivability technologies to enable advanced protection suites, providing greater survivability and protection against emerging threats. This Project executes the Army's APS program to mature and demonstrate APS technologies in order to increase protection against current and emerging advanced threats while maintaining or reducing vehicle weight by reducing reliance on armor through the use of other means such as sensing, warning, hostile fire detection and active countermeasures. This Project develops an APS Common Architecture that defines the component interface standards and component specifications enabling adaptable APS solutions that can be integrated across Army vehicle platforms as required.

Work in this Project supports the Army Science and Technology Ground Maneuver Portfolio.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Tank Automotive Research, Development, and Engineering Center (TARDEC), Warren, Michigan in collaboration with the Army Research Laboratory (ARL), Adelphi and Aberdeen Proving Grounds, MD, Armament Research, Development and Engineering Center (ARDEC), Picatinny, NJ, Aviation and Missile Research, Development and Engineering Center (AMRDEC), Huntsville, AL and Communications-Electronics Research, Development and Engineering Center (CERDEC), Aberdeen Proving Grounds, MD and Fort Belvoir, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Vision Protection:	2.842	5.000	5.052
Description: This effort matures and integrates devices to protect occupant's eyes, vehicle cameras and electro-optic fire control systems against anti-sensor laser devices as well as reduces the sensor's optical signature. Anti-sensor laser devices can deny vision either temporarily by flooding the sensor with too much light (jamming) or permanently by damaging the sensor. These jamming or damaging effects can slow our battle tempo, disrupt fire control solutions, or prevent vehicles from completing their mission. This effort focuses on demonstrating the effectiveness of optical systems that protect sensors and Warfighter vision from pulsed, continuous wave and future laser threats to maintain fire control capability and situational awareness. Coordinated work is also being performed in Program Elements (PEs) 0602120A, 0602705A, 0602712A, and 0602786A.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 221 / *Combat Veh Survivablty*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Matured optical power-limiting materials to improve protection of camera sensors from laser energy. Evaluated the power-limiting materials protection capability against low-powered continuous wave and short-pulsed laser threats. Integrated the power-limiting material onto a current fire-control sensor and determined the improved survivability of the sensor against near term laser threats. ***FY 2017 Plans:*** Will begin vulnerability evaluation of current systems against ultra-short pulse laser threats; will evaluate high energy laser threats to determine their threat parameters for testing sensors against the threats; using the threat parameters will improve the experiment and performance validation methodology for sensors and protection concepts against high energy laser threat weapons; and will fabricate components of the ultra-short pulse laser protection concepts that will be integrated into current systems for performance demonstrations. ***FY 2018 Plans:*** Will complete vulnerability evaluation of current systems against ultra-short pulse laser threats; will integrate fabricated components of the ultra-short pulse laser protection concepts onto current systems for performance demonstrations in a relevant environment; will improve future protection concepts by reducing optical cross-section, minimizing jamming and dazzling, and increasing damage thresholds.			
Title: Advanced Armor Technologies:	8.332	6.679	13.120
Description: This effort matures, fabricates, integrates and evaluates advanced ground vehicle armor systems such as advanced passive kinetic energy armor, explosive reactive armor, electromagnetic armor, and adaptive armor. The goal is to optimize armor system technologies and integration methodologies to reduce overall armor system weight; create and mature scalable / modular / common armor system integration standards for the advanced armor technologies; create armor system test & evaluation standards for advanced armor technologies and leverages the standards for armor component and armor system maturation; refines armor modeling and simulation system engineering process to incorporate advances in armor technologies. This effort is done in coordination with efforts in PEs 0602105A, 0602601A, 0602618A, and 0708045A. ***FY 2016 Accomplishments:*** Began armor integration approaches to help achieve an overall ground vehicle armor subsystem weight reduction of 10-15%. Demonstrated advanced passive and explosive reactive armor technologies and designed approaches for defeat of kinetic energy threats, chemical energy threats, and improvised explosive devices. Demonstrations included environmental testing followed by ballistic testing of advanced armor components. Matured advanced passive armor system design for integration of the armor technology components and attachment schemes. Matured advanced explosive reactive armor system design for integration of the armor component technologies. Matured weight optimization methods for holistic vehicle lightweighting that supports and complements the vehicle armor systems. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 221 / *Combat Veh Survivablty*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will complete environmental and ballistic performance testing of the advanced passive (B-kit) and explosive reactive armor (C-kit) technologies; will complete the demonstration of advanced passive (B-kit) and explosive reactive armor (C-kit) attachment schemes; will leverage the demonstration results to define the design approach for follow-on integration and testing of the B-kits and C-kits. ***FY 2018 Plans:*** Will mature subsystem integration study for passive (B-kit) and reactive armor (C-kit); will improve integrated subsystem performance while decreasing weight and maintaining cost; will demonstrate capabilities of various adaptive armor solutions in relevant environment; will down-select between various adaptive armor solution options.			
Title: Occupant Centric Protection (OCP) Technologies:	9.873	5.934	4.263
Description: This effort matures and validates design philosophies, guidelines, military standards, handbooks, etc. that embody a focused, systems engineering approach to occupant-centric protection in vehicle design. This is accomplished using tools such as modeling and simulation (M&S), full vehicle and subsystem demonstrators, evaluations and component optimizations. This effort addresses and validates the products from requirements generation through design and build to incorporate occupant-centric philosophies. This effort is done in coordination with efforts in PEs 0602601A and 0602618A. ***FY 2016 Accomplishments:*** Matured passive and active levels of occupant-centric protection technologies for combat vehicle survivability. Optimized combat vehicle survivability demonstrator designs using modeling and simulation to include the integration of a lightweight structure design, and occupant protection component technologies. Conducted optimization to balance weight, mobility and performance goals. Verified occupant-centric design guidelines and procedures/processes. Evaluated the performance of the initial Warrior Injury Assessment Manikin Project (WIAMan) test device in a simulated test environment. ***FY 2017 Plans:*** Will validate the design of advanced flooring, advanced seating, lightweight hulls and structures, and active blast technologies that minimize weight impact while maximizing performance capability provided through modeling and simulation and component technology performance testing in both the laboratory and in blast tests; will use knowledge gained through testing of the initial WIAMan test device to mature and fabricate a next generation WIAMan test device; conduct WIAMan device testing based on the test certification procedures developed in PE 0602601A to inform updates to the WIAMan test capability requirements documentation and materiel solution design specifications. ***FY 2018 Plans:*** Will refine integration of advanced flooring, advanced seating, lightweight hulls and structures, and active blast technologies using results from laboratory and blast tests to improve system performance and minimize weight; will begin fabrication of hardware required for subsystem integration of Survive Demonstrator; will complete next generation WIAMan device testing based on the			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 221 / *Combat Veh Survivablty*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
previously developed test certification procedures; will update WIAMan test capability requirements documentation and materiel solution design specifications based on WIAMan device testing.			
Title: Blast Mitigation: ***Description:*** This effort fabricates and matures advanced survivability and protection components, tools and subsystems for enhanced protection against vehicle mines, improvised explosive devices (IEDs) and other underbody blast threats, and vehicle collision and rollover events that result from blast events. This effort also integrates and improves occupant protection technologies such as seats and restraints. This effort creates the laboratory capability needed to enable expeditious performance evaluation through M&S, experimentation and instrumented test of blast-mitigating technologies in such areas as active and passive exterior/hull/cab/kits, interior energy absorbing capabilities for seats, floors, restraints, and sensors for active blast mitigating technologies. This effort is done in coordination with efforts in PE 0602601A. ***FY 2016 Accomplishments:*** Matured and integrated the next generation of seats, restraints, and flooring technologies to mitigate underbody blast effects to the occupant in Combat Vehicle Prototyping (CVP) program concepts. Demonstrated the CVP concepts' performance using modeling and simulation along with sub-system level blast tests. Validated integration methods for blast mitigation technologies onto a combat vehicle platform. Exploited technologies to increase neutralization effectiveness rates against anti-tank mines while maintaining host platform mobility and reliability characteristics. ***FY 2017 Plans:*** Will complete the integration analysis of advanced seats and restraints, advanced flooring, lightweight hulls, and active blast technologies to identify the optimized integrated design approach; will integrate the optimized technologies into the subsystem demonstrator design and leverage the design approach to maximize performance while minimizing subsystem weight; will conduct modeling and simulation on the subsystem design to verify performance prior to subsystem fabrication; will improve technologies to increase neutralization effectiveness rates against anti-tank mines based on the exploitation previously conducted. ***FY 2018 Plans:*** Will mature integration of subsystem technologies into subsystem demonstrator based on blast test results; will integrate armor and Modular Active Protection System (MAPS) surrogate subsystems into subsystem demonstrator to maximize performance; will verify refined subsystem design through modeling and simulation prior to subsystem fabrication improvements.	4.143	9.633	10.090
Title: Vehicle Fire Protection: ***Description:*** This effort matures, integrates and demonstrates technologies to minimize vehicle and crew vulnerabilities to fires in current and future military ground vehicles. Supporting technologies include M&S, sensor systems, software, chemical agents, fire-resistant materials and hardware components. This effort is done in coordination with efforts in PE 0602601A.	2.234	2.903	1.915

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 221 / *Combat Veh Survivablty*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Improved designs and technologies to minimize vehicle and crew vulnerabilities to fires. Evaluated next generation materials, components and system level technologies to address emerging military ground vehicle thermal threats. Validated automatic fire-extinguishing system (AFES) designs using M&S and testing to improve integration for current and new vehicle configurations. ***FY 2017 Plans:*** Will evaluate fire protection technologies through modeling and simulation and laboratory testing; will complete validation of AFES designs and a common fire extinguisher; will begin concept evaluation of crew compartment protection through the use of advanced fire protection technologies. ***FY 2018 Plans:*** Will improve fire protection technologies performance based on results from modeling and simulation and laboratory testing; will evaluate no/low global warming potential (GWP) agents through full scale testing. Will evaluate vehicle concepts that support the next generation of combat vehicles for fire protection technology integration feasibility and effectiveness.			
Title: Hit Avoidance Technologies:	25.876	29.924	29.331
Description: This effort matures, integrates and demonstrates hard-kill (physical countermeasure) and soft-kill (non-kinetic countermeasure such as electronic jamming or spoofing) APS components and integrated systems to verify the APS Common Architecture and reduce integrating risk on current systems. In demonstrating hard-kill and soft kill-active protection technologies, requirements and specifications will be matured for future integration onto tactical and combat vehicle platforms. This effort is coordinated with efforts in PEs 0602601A, 0602618A, 0603004A, 0603270A, 0603313A, and 0604115A. ***FY 2016 Accomplishments:*** Continued maturation of the modular APS common architecture, and maturation of the modular APS common controller. Continued software and hardware maturation for the APS common controller, enabling integration of active protection components that accommodate varying performance and vehicle needs. Enhanced soft-kill and hard-kill simulation and laboratory capability to exercise and test software and hardware components against design requirements and determine trade space for APS configurations. Continued to mature a modular architecture APS configuration with soft-kill and hard-kill capabilities by integrating sensors and countermeasures that are matured and compliant with the APS common architecture interfaces and protocols. Conducted virtual and physical demonstrations of a modular architecture APS soft-kill configuration defeat capability against anti-tank guided missiles at the subsystem level. ***FY 2017 Plans:*** Will continue the design and build of the soft-kill and hard-kill modular APS common controller; will complete integration of a soft-kill APS configuration on a demonstrator platform to conduct performance and safety testing of the soft-kill demonstrator against			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 221 / *Combat Veh Survivablty*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
anti-tank guided missiles in various environmental conditions; will conduct hard-kill sensor and countermeasure component testing to validate component performance; will complete integrated hard-kill and soft-kill APS configuration laboratory simulation and component hardware-in-the-loop testing to verify component and system-level performance; will conduct integrated subsystem virtual and physical testing to evaluate integrated system performance; will begin the design of the hard-kill and soft-kill APS configuration to be integrated onto a demonstrator. ***FY 2018 Plans:*** Will complete the design and build of the soft-kill and hard-kill modular APS controller (MAC); will validate MAC capability to ensure that it is configurable for the Army Vehicle Fleet and compliant with Army Safety Standards; demonstrate and validate soft-kill APS configuration on a demonstrator platform against anti-tank guided missiles in various environmental conditions; mature soft-kill and hard-kill system/platform demonstrator integration design and begin fabrication of hardware required for integration; will mature MAPS subsystem integration onto SURVIVE demonstrator in preparation for eventual capability testing.			
Title: System Design Optimization for Lightweighting: ***Description:*** This effort will focus on optimization of platform design to reduce weight in both traditional and novel methods. This effort will demonstrate best practices in cost-conscious, multi-material design for components to reduce ground vehicle weight, as well as demonstrate holistic weight reduction with informed system and component-level design decisions. This will be accomplished by using and evaluating design tools, advanced materials, manufacturing processes and assembly technologies to design lightweight systems, develop lightweight components and enhance the ability to use novel approaches for lightweighting. This effort leverages lessons learned from prior and ongoing individual component efforts within industry, academia and Department of Defense (DoD). This effort is done in coordination with efforts in PEs 0602601A, 0602618A, 0603005A, and 0708045A. ***FY 2017 Plans:*** Will use the Computer Aided-Design for Fabrication of Advanced Materials (CADFAM) tools to develop new or re-engineer existing components such as floors, engine housing, turret with geometric and loading constraints out of advanced materials (e.g. composites) in order to save weight while maintaining or increasing performance. Will mature non-structural lightweight techniques and implement into a lightweighting process; will begin to apply to components to optimize their design for lightweighting. ***FY 2018 Plans:*** Will mature and demonstrate lightweighting capabilities through the continued use of virtual modeling and simulation and other lightweighting tools; will optimize demonstrator upper hull and lower hull for reduced weight, improved transportability, increased	-	3.196	2.665

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
fuel economy, and increased reliability; will validate lightweighting capability with demonstrator performance against relevant environment threats.			
Accomplishments/Planned Programs Subtotals	53.300	63.269	66.436

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 3	R-1 Program Element (Number/Name) PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	Project (Number/Name) 441 / *Combat Vehicle Mobilty*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
441: *Combat Vehicle Mobilty*	-	41.673	39.067	33.447	-	33.447	29.398	30.943	32.550	34.160	-	-

A. Mission Description and Budget Item Justification

This Project matures and demonstrates advanced mobility and onboard electrical power technologies for combat and tactical vehicles to enable lightweight, agile, deployable, fuel efficient and survivable ground vehicles. Technologies include advanced propulsion, engines, transmissions, power, and electrical components and subsystems. This Project will also mature and demonstrate advanced mechanical and electrical power generation systems to increase available onboard electrical power to enable future capabilities such as next generation communications and networking, improvised explosive device (IED) jamming systems and next generation sensor devices can be supported on combat and tactical vehicles. This Project also matures and demonstrates water and fuel logistics technologies.

Work in this Project supports the Army Science and Technology Ground Maneuver Portfolio.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Onboard Vehicle Electric Power Component Development:	4.227	4.701	4.162
Description: This effort focuses on meeting the Army's demand for more onboard vehicle electric power to enable technologies such as advanced survivability systems, situational awareness systems and the Army network. This effort matures, integrates and demonstrates onboard vehicle power (OBVP) components to include electrical power generation machines and associated power converters such as high temperature inverters and converters, advanced control algorithms, and high efficiency power conversion (mechanical to electrical) components. Additionally, it matures and integrates advanced electric machines such as Integrated Starter Generator (ISG) and their controls for mild hybrid (system that integrates electric machines to assist internal combustions engines for propulsion) electric propulsion and high power electric generation. Coordinated work is also being conducted under Program Element (PE) 0602601A.			
FY 2016 Accomplishments: Matured and demonstrated OBVP technologies to include inverters and generators for high temperature operation capability, power quality and the ability to provide more compact, power dense electrical power generation. Demonstrated power			

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Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 441 / *Combat Vehicle Mobilty*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
technologies to enable application of advanced technologies to vehicles including electromagnetic armor, communications and other technologies enhancing combat vehicle lethality, survivability and situational awareness. ***FY 2017 Plans:*** Will fabricate and evaluate at a subsystem level, the integrated starter generator (ISG), inverter power conversion box and control strategy for an advanced OBVP system that provides 10 times more electrical power onboard combat vehicles than is available today. Will begin to integrate the components into a system integration laboratory (SIL) for system optimization testing and initial performance and reliability evaluation. ***FY 2018 Plans:*** Will exploit SIL system optimization, performance, and reliability resulting in a matured, high-voltage integrated OBVP system. Will begin integration of advanced OBVP system on combat vehicle advanced propulsion system. Will validate strategy for intelligent engine start/stop for the minimization of idle fuel usage.			
Title: Advanced Running Gear: ***Description:*** This effort matures and demonstrates running gear components and advanced suspension technologies to increase vehicle mobility and durability in response to increased ground vehicle platform weights. Components and subsystems include new elastomer compounds, lightweight, survivable track systems and road wheels, advanced compensating track tensioners, advanced damping suspension technologies, Electronic Stability Control (ESC) systems, and preview sensing technologies linked to advanced suspension designs. Coordinated work is also being conducted under PE 0602601A. ***FY 2016 Accomplishments:*** Improved elastomer materials and road wheels to demonstrate improved combat vehicle track system durability. Continued fabrication, integration and optimization of external suspension unit system for 60-70 ton combat vehicle application. Matured suspension control architectures for system control of vehicle dynamics, ride height and handling. Characterized combat vehicle external suspension unit functionality, durability and system performance relative to performance metrics. Executed track and suspension maturation efforts in support of the Combat Vehicle Prototyping program. ***FY 2017 Plans:*** Will integrate improved elastomer components and lessons learned from previous track system evaluations to create an advanced track system design for a medium combat vehicle application that reduces system weight while increasing durability. Will design and build an external suspension unit based on results of previous system characterizations to increase durability, provide ride height control and improve ride quality performance for medium combat vehicles. Will begin the integration of advanced track and	4.806	4.576	3.622

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
suspension for a medium combat vehicle running gear solution to provide superior off-road performance at a reduced weight and improved durability to currently fielded solutions ***FY 2018 Plans:*** Will continue integration of advanced track and suspension for a medium combat vehicle running gear solution to provide superior off-road performance at a reduced weight and improved durability to currently fielded solutions. Will fabricate integrated system for future testing.			
Title: Combat Vehicle Subsystem Demonstrations ***Description:*** This effort contributes to the Army's ground platform risk reduction efforts which seek to address technical and integration challenges in the areas of mobility, survivability, and vehicle architecture and systems integration. The primary focus of this activity is to mature and demonstrate a series of subsystem demonstrators building off of previous investment in ground combat acquisition and technology programs with the purpose of maturing key technologies to refine and inform future platform requirements and reduce risks in critical ground combat vehicle technology areas. Specifically, this effort focuses on maturing and demonstrating ground combat vehicle mobility technologies such as powertrain subsystems and systems integration technologies such as vehicle structures and concept demonstrators. This effort seeks to optimize platform efficiency and growth potential to ensure the combat fleet is able to accept new technologies as they are developed to bring advanced capability for the Warfighter. This effort is executed in coordination with PEs 0602601A, 0602618A, 0603004A, and 0603125A. ***FY 2016 Accomplishments:*** Matured the design of a unique high power density, low heat rejection, fuel efficient opposed piston engine concept through the use of advanced lightweight materials and optimization of in-cylinder combustion performance and efficiency to inform future combat vehicle concept development and analyses and its future powertrain subsystem demonstrator. Optimized engine fuel efficiency and increase commonality of engine components to reduce engine logistical and life cycle costs. Developed novel future combat vehicle concepts for the Combat Vehicle Prototyping (CVP) program leveraging leap-ahead technologies and technology concepts. Conducted capability analyses and trade studies on the integration of vehicle mobility and occupant protection technologies into the CVP concepts, in order to optimize the platform configuration. ***FY 2017 Plans:*** Will continue to mature novel future combat vehicle concepts leveraging advanced technologies and technology concepts to include requirements excursions to mature innovative combat vehicle design approaches. Will continue to conduct capability analyses and trade studies on the integration of vehicle mobility and occupant protection technologies into combat vehicle concepts, in order to evaluate and optimize concept platform configurations. ***FY 2018 Plans:***	14.439	5.200	12.500

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will complete design of advanced propulsion components such as advanced engine, advanced transmission, and advanced thermal management system. Will mature and optimize next generation combat vehicle with advanced technologies and technology concepts to allow for flexible, scalable and modular technologies. Will continue to conduct capability analyses and trade studies on the integration of vehicle mobility and occupant protection technologies into combat vehicle concepts, in order to evaluate and optimize concept platform configurations.			
Title: Energy Storage Systems Development: ***Description:*** The goal of this work is to mature energy storage systems to both enable silent watch capability and increased survivability through power brick energy storage components for pulse power electromagnetic armor. This is accomplished through the maturation and demonstration of advanced ground vehicle energy storage devices such as advanced chemistry batteries, high energy density capacitors and power brick batteries for pulse power. This effort leverages commercial industry battery development efforts to reduce battery volume and weight while improving their energy and power densities. This effort also matures and optimizes a common specification for battery management systems to improve the battery state of charge indicator accuracy and battery state of health information to reduce the frequency of battery replacement and optimize starting, lighting, and ignition functions. Coordinated work is also being conducted under PEs 0602601A and 0602705A. ***FY 2016 Accomplishments:*** Matured standardized low voltage battery systems to improve fuel efficiency and support vehicle lightweighting. Matured control electronics and battery management system for advanced, standardized, military specific batteries to improve durability and reliability. Optimized advanced, standardized, military specific battery system for increased energy density and reliability. ***FY 2017 Plans:*** Will leverage the cell-level durability and performance testing in PE 0602601A to mature the advanced Lithium-ion battery system-level design to meet military vehicle form factor (6T) in order to improve energy storage capacity while reducing battery system weight on platforms. Will leverage ongoing battery cell level development to begin battery module (system-level) integration and evaluation focusing on interconnects, packaging design and control strategies. ***FY 2018 Plans:*** Will optimize advanced form factor (6T) Lithium-ion battery pack system level performance and durability testing to decrease recharge time, weight and volume while integrating a battery management system Will begin demonstrating safe logistical transportation of Lithium-ion battery packs with the Navy.	2.811	3.050	3.114
Title: Pulse Power: ***Description:*** This effort matures and demonstrates high energy, compact pulse power components, subsystems and systems that enable significantly improved survivability and lethality applications components to include Direct Current (DC) to DC chargers,	3.672	4.632	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 441 / *Combat Vehicle Mobilty*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
high energy batteries, pulse chargers, high density capacitors, solid state-switches, control systems and electromagnetic armor panels. Coordinated work is also being conducted under PEs 0602601A, 0602618A, and 0602705A. ***FY 2016 Accomplishments:*** Integrated energy storage and high-voltage power electronic components into a power system to support electromagnetic armor development weight reduction goals of 10% to 15%. Demonstrated and validated pulse power system and electromagnetic armor module in relevant environments. Began integrated demonstration of pulse power and electromagnetic armor systems, including durability and environmental testing, Validated ballistic performance of the integrated pulse power and electro-magnetic armor system. ***FY 2017 Plans:*** Will complete testing of the integrated pulse power and electromagnetic armor system. Will complete durability and environmental evaluations of the integrated system to demonstrate overall performance in relevant environments. Will complete verification of the ballistic performance of the system. Will complete electromagnetic interference testing to evaluate the ability of the system to operate with other vehicle equipment. Will conduct testing of the pulse power recharge capability and ballistic multi-hit performance of the system.			
Title: Non-Primary Power Systems: ***Description:*** This effort exploits, matures, and demonstrates Auxiliary Power Unit (APU) technologies such as a small modular/ scalable engine-based APUs, a fuel cell reformer system to convert JP-8 to hydrogen, a sulfur tolerant JP-8 fuel cell APU, and novel engine-based APUs for military ground vehicles and unmanned ground systems. This effort also establishes interface control documents for simplified integration of current and future APUs, improves reliability to reduce logistic burdens, as well as reduces acoustic signature for silent operation. Additionally, this effort exploits Jet Propellant 8 (JP-8) fuel cell and engine APUs to optimize prime power in unmanned ground systems. Coordinated work is also being conducted under PE 0602601A. ***FY 2016 Accomplishments:*** Matured power dense, heavy fuel engine, such as JP-8, rotary engine and electrical generator technologies to significantly increase under armor power generation capability for combat vehicles. Integrated and optimized rotary engine-based auxiliary power unit system for increased fuel efficiency and improved packaging of rotary engine, electrical generator and other components to decrease acoustic signature.	2.974	-	-
Title: Propulsion and Thermal Technologies: ***Description:*** This effort matures high power density engines and transmission systems needed to offset increasing combat vehicle weights (armor), increased electrical power generation needs (onboard communications, surveillance and exportable power), improved fuel economy (fuel cost & range), enhanced mobility (survivability), and reduced cooling system burden (size,	4.804	12.808	5.000

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 441 / *Combat Vehicle Mobilty*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
heat dissipation). This effort also matures thermal management including heat energy recovery, propulsion and cabin thermal management sub-systems to utilize waste heat energy and meet objective power and mobility requirements on combat and tactical vehicles. Lastly, this effort maximizes efficiencies within propulsion and thermal systems to reduce thermal burden on the vehicle while providing the same or greater performance capability. This effort is executed in coordination with PE 0604115A. ***FY 2016 Accomplishments:*** Matured combat vehicle mechanical automatic transmission design and increased transmission efficiency by targeting the optimal efficiency through all vehicle operating ranges. Optimized powertrain system mobility and steering performance by delivering increased engine power to the vehicle track system while reducing heat rejection. Validated model of advanced powertrain system. Matured transmission quality, reliability and durability to reduce lifecycle costs. ***FY 2017 Plans:*** Will conclude single-cylinder engine component optimization of a unique high power density, low heat rejection, fuel efficient opposed piston engine that will dramatically improve the power density and reduce fuel consumption for combat vehicles. Will begin maturation of multi-cylinder engine components by exploiting the single-cylinder engine component optimization. Will mature advanced engine control strategies to optimize fuel efficiency and enable precise control of the new combat engine. Will fabricate proof of concept hardware and conduct component level testing of a combat vehicle mechanical automatic transmission that will increase propulsion system efficiency by targeting the optimal efficiency through all vehicle operating ranges. Will mature the control strategy for the combat vehicle transmission that will optimize the gearing ratios for desired torque parameters and ensure transmission ride quality, reliability and durability to reduce powertrain lifecycle costs. ***FY 2018 Plans:*** Will complete design and software development of high power density, low heat rejection, fuel efficient opposed piston engine concept and validate subsystem performance and calibration. Will optimize the control strategy for the combat vehicle transmission. Will mature and optimize gear set design for integration into combat vehicle transmission. Will mature combat vehicle transmission for integration into advanced combat propulsion system.			
Title: Force Projection: ***Description:*** This effort focuses on reducing the logistics footprint, improving fuel efficiency, and ensuring mobility by maturing and demonstrating technologies in areas such as water purification, generation, quality monitoring, storage and distribution and wastewater treatment and reuse; petroleum quality monitoring, filtration, storage and distribution, hydraulic fluids; alternative fuels and fuel additives; lubricants, oil, powertrain fluids and coolants. This effort is done in coordination with efforts in PE 0602601A. ***FY 2016 Accomplishments:***	3.940	4.100	5.049

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 441 / *Combat Vehicle Mobilty*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Performed modeling and analysis of waste water treatment and recycling technologies to assess the scalability of technologies and optimize system designs. Evaluated and qualified synthetic fuels made from non-petroleum sources against performance requirements for use in military ground systems. Matured and demonstrated fuel sensor technologies and a portable fuel analyzer for contaminate detection. Validated performance of gear oils and hydraulic fluids using a new test methodology and performance based specification, demonstrating increased vehicle fuel efficiency with limited equipment/hardware modifications. ***FY 2017 Plans:*** Will demonstrate optimized waste water treatment and recycling technologies to support sustainability logistics basing. Will continue to validate physical property characteristics and demonstrate performance of select synthetic fuel blends made from non-petroleum sources to determine suitability for military ground systems. Will assess performance of gear oils used in limited slip differentials and transfer cases, and will mature and demonstrate hydraulic fluid formulations to increase vehicle fuel efficiency and reduce maintenance burden. ***FY 2018 Plans:*** Will continue to demonstrate energy efficient waste water treatment and recycling technologies to support sustainability logistics basing. Will continue to optimize performance of synthetic fuel blends made from non-petroleum sources to determine suitability for military ground systems that will allow for an increase in energy security. Will validate that fuel efficient gear oils maintain and improve vehicle axle durability and provide extended performance time over current gear oil, as well as limited slip performance.			
Accomplishments/Planned Programs Subtotals	41.673	39.067	33.447

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 3	R-1 Program Element (Number/Name) PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	Project (Number/Name) 497 / *Combat Vehicle Electro*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
497: *Combat Vehicle Electro*	-	6.396	7.118	7.162	-	7.162	7.215	7.359	7.506	7.662	-	-

A. Mission Description and Budget Item Justification

This Project matures, integrates, and demonstrates vehicle electronics hardware such as computers, sensors, communications systems, displays, and vehicle command/control/driving mechanisms as well as vehicle software to enhance crew performance, increase vehicle fuel efficiency, reduced Size, Weight, and Power (SWaP) burdens and reduce vehicle maintenance costs. This Project also advances open system architectures (power and data) for military ground vehicles to enable common interfaces, standards and hardware implementations. The overall vehicle system architecture is known as the Vehicle Integration for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance / Electronic Warfare (C4ISR/EW) Interoperability (VICTORY), which is a long term technology effort that provides an open architecture that will allow platforms to accept future technologies without the need for significant re-design as new technologies are developed and integrated. Additionally this Project matures autonomy architectures that enable the ease of integration of autonomous subsystem technologies into future and existing tactical and combat vehicle architectures. Technical challenges include: software and algorithm development for increased levels of automation for both manned and unmanned systems, secure vehicle data networks, interoperability of intra-vehicle systems, and implementation of advanced user interfaces. Overcoming these technical challenges enables improved and increased span of collaborative vehicle operations, efficient workload management, commander's decision aids, embedded simulation for battlefield visualization and fully integrated virtual test/evaluation.

Work in this Project supports the Army Science and Technology Ground Maneuver Portfolio.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Tank Automotive Research, Development, and Engineering Center (TARDEC), Warren, MI.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Vehicle Electronics Integration Technologies:	4.308	3.532	2.907
Description: This effort matures, demonstrates and implements next generation military ground vehicle electronics and electrical power open architectures for future ground combat and tactical vehicle systems. Mature and demonstrate technologies to include: next generation video/data networking and computing equipment, Silicon Carbide (SiC) high voltage power electronics and low voltage smart power distribution. Technologies will reduce currently fielded vehicle overall SWaP concerns for vehicle electronics. This effort is coordinated with efforts in Program Element (PE) 0602601A.			
FY 2016 Accomplishments: Matured and demonstrated vehicle electronics architecture to facilitate rapid integration of card-based communication equipment into combat and tactical systems. Continued all maturation and integration activities of the next generation power and data architecture and corresponding system design in a System Integration Laboratory (SiL). Verified and validated the next generation			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 497 / *Combat Vehicle Electro*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
power and data architecture through testing traced to power, network and SIL designs and requirements. Enhanced the data transport mechanism for VICTORY, leveraging the next generation power and data architecture and incorporating electronics and electrical power open architecture requirements for future combat vehicles. Exploited the existing VICTORY data architecture to demonstrate future combat vehicle functions and components. ***FY 2017 Plans:*** Will provide an integrated vehicle electronics architectural depiction of the Vehicle Electronics & Architecture (VEA) Mobile Demonstrator that incorporates the use of open power, data, and network interface standards. Will exploit the VEA Research SIL technology demonstration findings to optimize performance specifications for open power, data, and network interface requirements, standards, and architectural design patterns for future tactical and combat vehicles. Will continue to exploit VICTORY (Vehicular Integration for C4ISR/EW Interoperability) data architecture to mature data interface standards for future combat vehicle functions and components. Will provide one-wire architectural depictions, vehicle security engineering improvements, and power design concepts for Radio Frequency (RF) Convergence SIL demonstrator to improve C4ISR modularity, maintainability, and mission pack configurability. ***FY 2018 Plans:*** Will transition matured technology demonstration designs and technologies (such as optimized performance specifications for open power, data, and network interface requirements, standards, and architectural design patterns) from the VEA Research SIL into a current combat vehicle platform for future test and evaluation activities.			
Title: Vehicle Electronics Architecture and Standards: ***Description:*** This effort matures technologies and standards for existing and future combat and tactical ground vehicles. Open commercial standards will be evaluated and modified for use in military ground vehicles and possible inclusion in the Army's open, non-proprietary intra-vehicle data network e.g., VICTORY. This effort will also evaluate standards and components for suitability of integration into vehicle platforms. This effort also supplements the design of electronic architectures to support the efficient integration of electronic components into vehicle systems through the use of open standards. Additionally, this effort matures and expands the VICTORY effort to interface with the Modular Active Protection System (MAPS) Architecture. This effort is coordinated with PEs 0602601A and 0603005A. ***FY 2016 Accomplishments:*** Continued to mature and validate the VICTORY specification through demonstration in the VICTORY SIL. Completed the VICTORY SIL update to standard version 1.7, which adds capabilities for Logistics and Training systems and demonstrated component compliance to standard version 1.7. Began the VICTORY SIL update to VICTORY standard version 1.8, providing the	2.088	2.174	2.843

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 497 / *Combat Vehicle Electro*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
capability to demonstrate component compliance to the VICTORY standard version 1.8, which adds capabilities for weapons and sensor systems. ***FY 2017 Plans:*** Will continue to optimize the VICTORY specification by exploiting VICTORY SIL technology demonstration results for application in vehicle system level demonstration that matures and demonstrates implementations of electronic, data, and power standards that enable better interoperability and fault tolerance technology. Will continue to mature and demonstrate integration of MAPS using standard interfaces to improve MAPS interoperability with the other vehicle electronic subsystems. ***FY 2018 Plans:*** Will optimize the open data and power architecture capabilities as the VEA Mobile Demonstrator (VMD) component technologies are being integrated. Will continue to mature and demonstrate integration of MAPS standard interface definitions which guide other vehicle electronic subsystems development.			
Title: Autonomous Vehicle Architecture: ***Description:*** This project matures, integrates and demonstrates an improved, optimized autonomy-enabled distribution architecture that eases integration of new and emerging technologies across the full spectrum of operational and tactical supply movement operations. This project addresses systems integration challenges by providing the appropriate fault tolerant architecture design artifacts that will allow ease of integration for autonomy enablement kits, autonomy enablement software, and end-to-end sustainment and tactical ground resupply capability through use of open systems interfaces. This effort is coordinated with efforts in PEs 0602120A, and 0602601A. ***FY 2017 Plans:*** Will exploit and optimize the Autonomous Mobility Applique System (AMAS) fault-tolerant architecture to gain better understanding of system of system impacts and system level requirements for an end-to-end autonomous vehicle architecture design implementation. Will provide and refine a reference autonomous vehicle architecture, and initial integration & demonstration of behavior algorithm software modules within the end-to-end autonomous vehicle architecture. ***FY 2018 Plans:*** Will develop a common system architecture for autonomous vehicles through the exploitation of multiple different pre-existing autonomous vehicle systems architectures. Will develop algorithm software modules, vehicle architecture, a common interface, and hardware & software integration within the end-to-end autonomous vehicle architecture.	-	1.412	1.412
Accomplishments/Planned Programs Subtotals	6.396	7.118	7.162

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 497 / *Combat Vehicle Electro*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 3	R-1 Program Element (Number/Name) PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	Project (Number/Name) 515 / *Robotic Ground Systems*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
515: *Robotic Ground Systems*	-	12.755	12.678	18.492	-	18.492	19.316	21.413	20.689	12.048	-	-

A. Mission Description and Budget Item Justification

This Project matures and demonstrates technologies to enable Unmanned Ground Vehicles (UGV) including sensor technologies, perception hardware and software, and control technologies that allow the Soldier to perform mission tasks more efficiently. Challenges addressed include: obstacle avoidance, overcoming perception limitations, intelligent situational behaviors, command and control by Soldier operators, frequency of human intervention, operations in adverse weather, and autonomy enabled vehicles protecting themselves and their surroundings from intruders. Mature technologies are incorporated onto existing, Army-owned UGV technology demonstrators so that performance of the enabling technologies can be evaluated.

The approach builds upon, complements, and does not duplicate previous and ongoing investments conducted under the Joint Robotics Program Office.

Work in this Project supports the Army Science and Technology Ground Maneuver Portfolio.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

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 and Aberdeen Proving Ground, MD, Army Engineer Research and Development Center (ERDC), Vicksburg, MS, Army Natick Soldier Research, Development, and Engineering Center (NSRDEC), Natick, MA, and Army Armament Research, Development, and Engineering Center (ARDEC), Picatinny Arsenal, NJ.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Unmanned Ground Systems Technology:	12.755	12.678	12.054
Description: This program matures, integrates and demonstrates advanced robotic and autonomous technologies for the tactical and combat vehicle fleets. Unmanned ground systems technologies can be employed to overcome critical Army challenges to include automated resupply and sustainment, and reduced physical and cognitive burden. Challenges can be met by utilizing relevant technologies such as behavior algorithms, autonomy kits, sensor integration, advanced navigation and planning, object and local environment manipulation, local situational awareness, advanced perception, vehicle and pedestrian safety, and robotic command and control. This effort is coordinated with efforts in Program Elements (PEs) 0602120A, 0602601A, 0602784A, 0603001A, and 0603734A.			
FY 2016 Accomplishments: Matured, integrated and demonstrated advanced scalable autonomous technologies onto tactical vehicles to automate driving tasks and reduce logistics support requirements. Matured and integrated software and behavior algorithms to enable autonomous			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 515 / *Robotic Ground Systems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
convoy and autonomous vehicle loading/unloading operations to improve the effectiveness of unit resupply and sustainment operations. Matured and demonstrated platform autonomy in increasingly complex environments and mission applications ranging from urban terrain to cross country maneuvers. ***FY 2017 Plans:*** Will continue to mature and integrate state-of-the-art autonomous technologies such as Light Detection and Ranging (LIDAR), Global Positioning System (GPS), and cameras into advanced autonomy-enabled tactical vehicles and material handling equipment (MHE) to demonstrate the reduction of the logistics support and manpower requirements. Will mature and verify scalable autonomous software and behavior algorithms agnostic of the platform and autonomous vehicle loading/unloading operations to improve the effectiveness of unit resupply and sustainment operations. Will mature and demonstrate modeling & simulation (M&S) tools to support the design, development, testing, and evaluation of autonomous vehicles in tactical terrain and weather conditions. Will demonstrate hardware-in-the-loop / software–in-the-loop integrations of physics-based simulations of initial development increment of autonomous vehicle technologies. Will mature and demonstrate initial increment prototype hardware and software capability. ***FY 2018 Plans:*** Will continue to mature and develop the modeling and simulation tools to support the design, development, testing and evaluation of autonomous vehicles. Will continue to mature and demonstrate hardware-in-the-loop / software-in-the loop integrations of the physics-based simulations with prototype hardware and software autonomous vehicle technologies. Will begin to mature technologies for manned-unmanned teaming to further extend Autonomous Ground Resupply in a tactical environment and perform sustainment mission operational experiments to get Warfighter feedback on system performance. Will conduct operational experiments with unmanned Reconnaissance Surveillance and Target Acquisition (RSTA) missions leveraging autonomous ground platforms teamed with tethered unmanned aerial vehicles (UAVs).			
Title: Autonomous Ground Vehicle Architecture Integration and Demonstration	-	-	6.438
Description: This project matures, integrates, and demonstrates advanced robotic and autonomous foundational architecture and the technologies to enable tactically relevant unmanned ground systems. Technologies focused on creating an open Autonomous Ground Vehicle Reference Architecture for all future unmanned platforms, improved tactical and maneuver intelligence and behavior algorithms based off the architecture, sensor integration and advanced perception for off road, manned and unmanned teaming for the tactical environment, and enabling the integration of weapons and vehicle self-protection capabilities. This effort is coordinated with efforts in PEs 0602120A, 0602601A, 0602784A, 0603001A, and 0603734A. ***FY 2018 Plans:*** Will publish and demonstrate modularity of an open Autonomous Ground Vehicle Reference Architecture (AGVRA) which will be the foundational architecture for all future autonomous ground vehicle development. Will mature and demonstrate advanced			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 3	**R-1 Program Element (Number/Name)** PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	**Project (Number/Name)** 515 / *Robotic Ground Systems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
vehicle behaviors for defensive maneuvers and tactical convoy formations built upon the open architecture. Will mature and integrate off-road path planning software to enable robotic vehicles to perceive, classify and navigate complex, difficult terrains. Will improve advanced vehicle behaviors for sustainment convoy operations to improve leader follower functionality, improved obstacle detection and avoidance, and increased platform speed.			
Accomplishments/Planned Programs Subtotals	12.755	12.678	18.492

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 3	R-1 Program Element (Number/Name) PE 0603005A / *Combat Vehicle and Automotive Advanced Technology*	Project (Number/Name) 533 / *Ground Vehicle Demonstrations*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
533: *Ground Vehicle Demonstrations*	-	22.500	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

These are Congressional Interest Items

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017
Congressional Add: Program Increase	22.500	-
FY 2016 Accomplishments: Program increase.		
Congressional Adds Subtotals	22.500	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A