Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	163.501	125.537	119.739	-	119.739	118.783	119.365	122.973	127.885	0.000	897.783
221: *Combat Veh Survivablty*	-	60.877	66.436	60.084	-	60.084	57.001	56.439	59.065	60.247	0.000	420.149
441: *Combat Vehicle Mobilty*	-	37.588	33.447	26.508	-	26.508	27.352	29.316	30.090	33.107	0.000	217.408
497: *Combat Vehicle Electro*	-	6.845	7.162	7.215	-	7.215	7.359	7.506	7.662	7.815	0.000	51.564
515: *Robotic Ground Systems*	-	12.191	18.492	25.932	-	25.932	27.071	26.104	26.156	26.716	0.000	162.662
533: *Ground Vehicle Demonstrations*	-	46.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	46.000

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 Army Research Development and Engineering Command (RDECOM)

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army	Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	122.132	125.537	121.013	-	121.013
Current President's Budget	163.501	125.537	119.739	-	119.739
Total Adjustments	41.369	0.000	-1.274	-	-1.274
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	46.000	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-4.573	-			
• Adjustments to Budget Years	-	-	-1.274	-	-1.274
• FFRDC	-0.058	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 533: *Ground Vehicle Demonstrations*		
Congressional Add: *Program Increase*	30.000	-
Congressional Add: *Advanced Water Harvesting Technology*	6.000	-
Congressional Add: *Combat Vehicle Weight Reduction Initiative*	10.000	-
Congressional Add Subtotals for Project: 533	46.000	-
Congressional Add Totals for all Projects	46.000	-

Change Summary Explanation

FY17 Congressional increase in project 533 Ground Vehicle Demonstrations

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
221: *Combat Veh Survivablty*	-	60.877	66.436	60.084	-	60.084	57.001	56.439	59.065	60.247	0.000	420.149

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Vision Protection:	4.800	5.000	-
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 2018 Plans: Complete vulnerability evaluation of current systems against ultra-short pulse laser threats; integrate fabricated components of the ultra-short pulse laser protection concepts onto current systems for performance demonstrations in a relevant environment; improve future protection concepts by reducing optical cross-section, minimizing jamming and dazzling, and increasing damage thresholds.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
The reduction in funding results in reduced scope of effort as a result this effort coming to an end			
Title: Advanced Armor Technologies: ***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; refine 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 2018 Plans:*** Mature subsystem integration study for passive (B-kit) and reactive armor (C-kit); improve integrated subsystem performance while decreasing weight and maintaining cost; demonstrate capabilities of various adaptive armor solutions in relevant environment; down-select between various adaptive armor solution options. ***FY 2019 Plans:*** Will validate integrated subsystem performance for passive (B-kit) and reactive armor (C-kit) against weight and cost objectives; will complete ballistic performance testing of the B-kit and C-kit armor subsystems; will mature adaptive armor solution and optimize for integration with Modular Active Protection System (MAPS) surrogate subsystems into subsystem demonstrator to maximize performance; will verify refined subsystem design through modeling and simulation. Will conduct a demonstration of adaptive armor solutions to verify ballistic performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increased Demonstration for Modular Active Protection System (MAPS) surrogate subsystems into subsystem demonstrator	6.412	12.938	15.364
Title: Occupant Centric Protection (OCP) Technologies: ***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 2018 Plans:*** 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; begin fabrication of hardware	8.261	4.235	-

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
required for subsystem integration of Survive Demonstrator; complete next generation WIAMan device testing based on the previously developed test certification procedures; update WIAMan test capability requirements documentation and materiel solution design specifications based on WIAMan device testing. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Completed OCP and moved to higher priority effort for Combat Vehicle Prototyping			
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 modeling & simulation (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 2018 Plans:*** Mature integration of subsystem technologies into subsystem demonstrator based on blast test results; integrate armor and Modular Active Protection System (MAPS) surrogate subsystems into subsystem demonstrator to maximize performance; verify refined subsystem design through modeling and simulation prior to subsystem fabrication improvements. ***FY 2019 Plans:*** Will conduct component design improvements for seats, restraints, flooring, structures and active blast technologies based on component level test results. Will assess blast technology form, fit and function in an integrated blast mitigation system prior to system level integration. Will fabricate seats, restraints, flooring, structures and active blast components to be integrated into a system demonstrator for vehicle section durability and blast testing. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Reduced demonstration time as a result of prior years investment	9.346	10.565	7.574
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 modeling & simulation (M&S), sensor systems, software, chemical agents, fire-resistant materials, and hardware components. This effort is done in coordination with efforts in PE 0602601A.	2.789	2.838	2.628

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2018 Plans: Improve fire protection technologies performance based on results from modeling and simulation and laboratory testing; evaluate no/low global warming potential (GWP) agents through full scale testing. Evaluate vehicle concepts that support the next generation of combat vehicles for fire protection technology integration feasibility and effectiveness. ***FY 2019 Plans:*** Will continue to evaluate no/low global warming potential (GWP) agents through full scale testing. Will mature vehicle fire protection concepts for the next generation of combat vehicles to improve integration feasibility and effectiveness. Will develop concepts and technologies to conduct fuel containment and fire prevention. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Maturation of technology driving reduced demonstration			
Title: Hit Avoidance Technologies: ***Description:*** This effort matures, integrates, and demonstrates hard-kill (physical countermeasure) and soft-kill (non-kinetic countermeasure such as electronic jamming or spoofing) Active Protection System (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 2018 Plans:*** Complete the design and build steps of the soft-kill and hard-kill modular APS controller (MAC); 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; mature MAPS subsystem integration onto SURVIVE demonstrator in preparation for eventual capability testing. ***FY 2019 Plans:*** Will complete Modular APS Controller (MAC) software updates based on improvements required from previous demonstrations and testing. Will integrate updated software into the MAC. Will complete a virtual demonstration of hard-kill systems integrated on current vehicle platforms. Will complete the integration of the MAC to demonstrate and validate a soft-kill and hard-kill APS configuration on a demonstrator platform against various threats in various environmental conditions; will complete fabrication and integration of soft-kill and hard-kill system with the MAC on a platform demonstrator. Will complete demonstration and testing	26.212	29.079	30.653

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
of a layered soft-kill and hard-kill active protection system integrated on a platform demonstrator to validate MAC modularity and system performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase in funding is a result in need to procure items needed for validation in MAC system performance			
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 2018 Plans:*** Mature and demonstrate lightweighting capabilities through the continued use of virtual modeling and simulation and other lightweighting tools; optimize demonstrator upper hull and lower hull for reduced weight, improved transportability, increased fuel economy, and increased reliability; validate lightweighting capability with demonstrator performance against relevant environment threats. ***FY 2019 Plans:*** Will assess the modeling and simulation data to provide metrics validating the value of Light Weighting to improve transportability, increase fuel economy and increase SWaP-C. Will continue to evaluate advanced materials and their ability to optimize weight while maintaining or improving performance. Will conduct Modeling & Simulation to evaluate the impact of lightweight materials on vehicle subsystem loading. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Demonstration of new materials as the Army continues to look at weight savings in combat vehicles	3.057	1.781	3.865
Accomplishments/Planned Programs Subtotals	60.877	66.436	60.084

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
441: *Combat Vehicle Mobilty*	-	37.588	33.447	26.508	-	26.508	27.352	29.316	30.090	33.107	0.000	217.408

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Onboard Vehicle Electric Power Component Development:	4.042	4.162	2.838
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 integrated electric machines to assist internal combustion engines for propulsion) electric propulsion and high power electric generation. Coordinated work is also being conducted under Program Element (PE) 0602601A.			
FY 2018 Plans: Exploit SIL system optimization, performance, and reliability resulting in a matured, high-voltage integrated OBVP system. Begin integration of advanced OBVP system on combat vehicle advanced propulsion system. Validate strategy for intelligent engine start/stop for the minimization of idle fuel usage.			
FY 2019 Plans: Will continue to exploit SIL system optimization, performance, and reliability pushing components to higher powertrain operating temperatures and finalizing OBVP system communication/ network architecture. Will integrate and optimize advanced OBVP			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
system with an advanced powertrain to include thermal management and define interface with vehicle power management controls. Will optimize control algorithms for intelligent engine start/stop for the minimization of idle fuel usage. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** No hardware purchases needed for demonstration			
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 2018 Plans:*** 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. Fabricate integrated system for future testing. ***FY 2019 Plans:*** Will continue to mature and demonstrate an integrated advanced track and suspension solution for a medium combat vehicle. Will optimize the advanced track and suspension solution to provide increased mobility at a reduced weight. Will demonstrate and improve durability and exploit new design to reduce maintenance tasks as compared to currently fielded track solutions. Will fabricate components to demonstrate an integrated system for design optimization of an advanced medium combat vehicle running gear system. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Reduction in Hardware purchases for demonstration	3.277	3.622	2.140
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	11.570	12.500	8.847

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
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 2018 Plans:*** Complete design of advanced propulsion components such as advanced engine, advanced transmission, and advanced thermal management system. Mature and optimize next generation combat vehicle with advanced technologies and technology concepts to allow for flexible, scalable and modular technologies. 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 2019 Plans:*** Will fabricate advanced propulsion components such as advanced engine, advanced transmission, and advanced thermal management system. Will continue to optimize next generation combat vehicle with advanced technologies and lessons learned to allow for flexible, scalable and modular technologies. Will integrate and optimize components from powertrain to demonstrate advanced technologies, capabilities, and improved performance. Will validate mobility and occupant protection analyses, trade studies, and concepts to inform the advanced combat vehicle survivability demonstrator. Will continue to evaluate and optimize concept platform configurations to reduce gaps in operational capabilities. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Reduction in Hardware purchases for demonstrations			
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 2018 Plans:***	2.950	3.114	3.137

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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. Begin demonstrating safe logistical transportation of Lithium-ion battery packs with the Navy. ***FY 2019 Plans:*** Will continue to optimize advanced form factor (6T) Lithium-ion battery pack system level performance and durability to decrease recharge time, weight, and volume. Will improve the integrated battery management system and demonstrate optimized combat vehicle power management synchronization and safety. Will continue to demonstrate safe logistical transportation of Lithium-ion battery packs with the Navy, improve the Li-ion specification, and inform combat vehicle standardized interfaces to reduce logistics costs. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Inflation			
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, 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.	3.632	-	-
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, reduces logistic burdens, and also 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.	4.632	-	-
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 and range), enhanced mobility (survivability), and reduced cooling system burden (size and 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	4.300	5.000	4.793

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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 2017	FY 2018	FY 2019
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 2018 Plans:*** Complete design and software development of high power density, low heat rejection, fuel efficient opposed piston engine concept, and validate subsystem performance and calibration. Optimize the control strategy for the combat vehicle transmission. Mature and optimize gear set design for integration into combat vehicle transmission. Mature combat vehicle transmission for integration into advanced combat propulsion system. ***FY 2019 Plans:*** Will complete interface and software maturation of opposed piston engine, advanced thermal management, advanced combat transmission for integration into advanced combat propulsion system. Will optimize the control strategy for each component and develop supervisory controls for integration of the advanced propulsion system. Will complete design of components needed to integrate the advanced combat propulsion system into hull for demonstration. Will demonstrate and validate advanced propulsion system controls calibration and efficient operation to meet combat vehicle electrical power and mobility requirements. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Validation of previous demonstration requiring less funding			
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 2018 Plans:*** Continue to demonstrate energy efficient waste water treatment and recycling technologies to support sustainability logistics basing. 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. Validate that the 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. ***FY 2019 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 the fuel efficient gear oils	3.185	5.049	2.206

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
maintain and improve vehicle axle durability and provide extended performance time over current gear oil, as well as limited slip performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Less demonstration time needed in the waste water treatment portion of this effort			
Title: Crew Augmentation ***Description:*** This effort focuses on optimizing crew station technologies while reducing crew sizes that will provide the same overall performance by exploiting human-interaction technologies, automations, machine intelligence and customization to permit soldiers to achieve performance beyond today?s constrained ground vehicle environment. ***FY 2019 Plans:*** Will mature software and demonstrate simulations to provide workload, span of control and mission performance data to show improved soldier performance through customization, machine augmented, information sorting, and weapon engagement software and algorithms. Will continue demonstrating that crew size reduction can provide the same overall performance by validating technical assessments that will provide a strong knowledgebase to support future crew stations efforts. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New Start as result in prioritization of NGCV	-	-	2.547
Accomplishments/Planned Programs Subtotals	37.588	33.447	26.508

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: PB 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
497: *Combat Vehicle Electro*	-	6.845	7.162	7.215	-	7.215	7.359	7.506	7.662	7.815	0.000	51.564

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Vehicle Electronics Integration Technologies:	3.432	2.907	3.025
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 size, weight and power (SWaP) concerns for vehicle electronics. This effort is coordinated with efforts in Program Element (PE) 0602601A.			
FY 2018 Plans: 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.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will validate the matured technology demonstration designs and technologies from the VEA Research SIL in a current combat vehicle platform to validate enhanced performance specifications for open power, data, network interface requirements, standards and architectural design patterns. Will validate integrated Silicon Carbide (SiC) power system functionality. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Slight increase in funding needed for validations and components in the Vehicle Electronics Architectures SIL			
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 2018 Plans:*** Optimize the open data and power architecture capabilities as the VEA Mobile Demonstrator (VMD) component technologies are being integrated. Continue to mature and demonstrate integration of MAPS standard interface definitions which provides guidance to other vehicle electronic subsystems development. ***FY 2019 Plans:*** Will validate the open data and power architecture capabilities as the VMD is prepared for demonstration. Will validate the MAPS standard interface definitions to mature compliant systems that support the efficient integration of electronics components into vehicle systems through the use of open standards. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Slight funding increase needed for MAPS integration into vehicle systems	2.071	2.843	3.015
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.	1.342	1.412	1.175

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2018 Plans: Develop a common system architecture for autonomous vehicles through the exploitation of multiple different pre-existing autonomous vehicle systems architectures. Develop algorithm software modules, vehicle architecture, a common interface, and hardware & software integration within the end-to-end autonomous vehicle architecture. ***FY 2019 Plans:*** Will continue to mature and validate the common system architecture for autonomous vehicles by demonstrating autonomous vehicle architecture, algorithm software modules, a common interface and hardware and software integration across the full spectrum of operational and tactical supply movement operations. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Demonstration of existing prototype -- Reduced hardware purchase			
Accomplishments/Planned Programs Subtotals	6.845	7.162	7.215

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: PB 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
515: *Robotic Ground Systems*	-	12.191	18.492	25.932	-	25.932	27.071	26.104	26.156	26.716	0.000	162.662

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 in Robotics/ Autonomy.. Ground Portfolio investments are greatly improving logistics throughput and surge capability supporting maneuver forces (Leader-Follower technology) and allow experimentation with manned and unmanned teams to develop the advantages that inform/protect the maneuver force (Robotic Wingman JCTD)

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Unmanned Ground Systems Technology:	12.191	12.054	9.443
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 2018 Plans: Continue to mature and develop the modeling and simulation tools to support the design, development, testing, and evaluation of autonomous vehicles. 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. 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. Conduct operational experiments with			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
unmanned Reconnaissance Surveillance and Target Acquisition (RSTA) missions leveraging autonomous ground platforms teamed with tethered unmanned aerial vehicles (UAVs). ***FY 2019 Plans:*** Will mature and develop an improved and optimized distribution system that integrates new and emerging technologies across the full spectrum of operational and tactical supply movement operations. Will continue to optimize common interfaces and open architecture. Will mature hardware-in-the-loop simulators to optimize cargo & vehicle configurations and implementations of autonomous ground resupply on realistic routes. Will continue to improve test & evaluation procedures for robotic systems utilizing modeling and simulation tools that will increase vehicle and pedestrian safety along with robotic control and command. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Previous year was procurement of test and validation equipment, thus the reduced need for identical funding in FY 19			
Title: Autonomous Ground Vehicle Architecture Integration and Demonstration	-	6.438	16.489
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:*** 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. Mature and demonstrate advanced vehicle behaviors for defensive maneuvers and tactical convoy formations built upon the open architecture. Mature and integrate off-road path planning software to enable robotic vehicles to perceive, classify and navigate complex, difficult terrains. Improve advanced vehicle behaviors for sustainment convoy operations to improve leader follower functionality, improved obstacle detection and avoidance, and increased platform speed. ***FY 2019 Plans:*** Will mature and develop an improved and optimized distribution system that integrates new and emerging technologies across the full spectrum of operational and tactical supply movement operations. Will continue to optimize common interfaces and architecture for all future autonomous ground vehicle development. Will mature and define open architecture design, data buses and messages. Will exploit automation software and algorithms to increase platform autonomy in increasing complex			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
environments and mission applications. Will mature & demonstrate scalable autonomy in a single material solution agnostic of platform. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Significant increase in priority in Unmanned Systems Software and autonomy with a strong desire to delivery more capability sooner than was planned in prior years.			
Accomplishments/Planned Programs Subtotals	12.191	18.492	25.932

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: PB 2019 Army				Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
533: *Ground Vehicle Demonstrations*	-	46.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	46.000

Note

Congressional increases for Combat vehicle weight reduction initiative ($10M); Advanced water harvesting technology ($6M); Program increase ($30M)

A. Mission Description and Budget Item Justification

These are Congressional Interest Items

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018
Congressional Add: Program Increase ***FY 2017 Accomplishments:*** N/A	30.000	-
Congressional Add: Advanced Water Harvesting Technology ***FY 2017 Accomplishments:*** N/A	6.000	-
Congressional Add: Combat Vehicle Weight Reduction Initiative ***FY 2017 Accomplishments:*** N/A	10.000	-
Congressional Adds Subtotals	46.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A