Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
Total Program Element	-	143.172	158.158	56.400	-	56.400	-	-	-	-	-	-
BK7: *Robotics for Engineer Operations Technology*	-	9.889	6.037	1.228	-	1.228	-	-	-	-	-	-
BL1: *Materials and Manufacturing Research Technology*	-	7.792	10.030	9.374	-	9.374	-	-	-	-	-	-
BL2: *Explosives Forensics Technology*	-	1.478	1.514	1.582	-	1.582	-	-	-	-	-	-
BL4: *Countermine Technology*	-	4.070	-	-	-	-	-	-	-	-	-	-
BL5: *Expedient Passive Protection Technology*	-	4.106	1.413	1.906	-	1.906	-	-	-	-	-	-
BL7: *Power Projection in A2AD Environments Technology*	-	2.757	1.843	3.151	-	3.151	-	-	-	-	-	-
BL9: *Protection from Advanced Weapon Effects Technology*	-	4.380	3.812	4.344	-	4.344	-	-	-	-	-	-
BN8: *Ground Technology Materials(CA)*	-	108.700	131.000	-	-	-	-	-	-	-	-	-
CA9: *Predictive Maintenance*	-	-	2.509	-	-	-	-	-	-	-	-	-
CG5: *Ground Vehicle Sensor Concepts and Technologies*	-	-	-	4.146	-	4.146	-	-	-	-	-	-
CG6: *Ground Vehicle Power and Energy Concepts and Tech*	-	-	-	2.681	-	2.681	-	-	-	-	-	-
CG7: *Ground Protection Concepts and Technologies*	-	-	-	14.565	-	14.565	-	-	-	-	-	-
CG8: *Human Autonomy Teaming*	-	-	-	8.599	-	8.599	-	-	-	-	-	-
CI2: *Ground Enabling University Applied Research*	-	-	-	4.824	-	4.824	-	-	-	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army	Date: May 2021
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*

A. Mission Description and Budget Item Justification

This PE researches efforts that support and enable the Army's modernization priority for the Next Generation of Combat Vehicles including systems for the deployment and sustainment of ground movement and maneuver. This PE designs and validates technologies that are necessary and foundational for legacy and future ground movement, maneuver and protection of Soldiers and systems.

All FY20 adjustments align program financial structure to Army Modernization Priorities in support of the National Defense Strategy

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

Work in the Project supports the Army Science and Technology Ground portfolio.

Work is performed by the United States (U.S.) Army Futures Command and the U.S. Army Engineer Research and Development Center.

Work in this PE complements PE 0602145A (Next Generation Combat Vehicle Technology), PE 0603119A (Ground Advanced Technology), PE 0603462A (Next Generation Combat Vehicle Advanced Technology), PE 0602143A (Soldier Lethality Technology) and PE 0603118A (Soldier Lethality Advanced Technology).

B. Program Change Summary ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Previous President's Budget	143.899	28.047	31.666	-	31.666
Current President's Budget	143.172	158.158	56.400	-	56.400
Total Adjustments	-0.727	130.111	24.734	-	24.734
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	131.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.727	-0.889			
• Adjustments to Budget Years	-	-	24.734	-	24.734

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Project: BN8: *Ground Technology Materials(CA)*		
Congressional Add: *Environmental Quality Enhanced Coatings*	5.000	-
Congressional Add: *Environmental Friendly Coatings Technology*	3.000	-
Congressional Add: *Additive Manufacturing for Artificial Intelligence and Machine Learning*	5.000	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army	Date: May 2021
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Congressional Add: *Earthen Structures Soil Enhancement*	4.000	-
Congressional Add: *M1 Abrams Tank Track System*	2.200	-
Congressional Add: *High Performance Polymers*	5.000	-
Congressional Add: *Materials Manufacturing Processes*	6.000	-
Congressional Add: *Highly Durable Advanced Polymers for Lightweight Armor*	8.000	-
Congressional Add: *Cellulose Nanocomposite Research*	5.000	-
Congressional Add: *Countermine Program*	5.000	-
Congressional Add: *Materials Research*	17.500	-
Congressional Add: *Additive Manufacturing and Materials Processing*	15.000	-
Congressional Add: *Cold Weather Military Research*	3.000	-
Congressional Add: *Cold Spray Technologies*	15.000	-
Congressional Add: *Center for Research in Extreme Batteries*	10.000	-
Congressional Add: *Program increase: Ice engineering research facility modernization*	-	5.000
Congressional Add: *Program increase: Center for research in extreme batteries*	-	10.000
Congressional Add: *Program increase: Cellulose nanocomposites research*	-	5.000
Congressional Add: *Program increase: Advanced polymers for force protection*	-	8.000
Congressional Add: *Program increase - advanced concrete*	-	4.000
Congressional Add: *Program increase - robotic RTCH*	-	5.000
Congressional Add: *Program increase - military waste stream conversion*	-	5.000
Congressional Add: *Program increase - high performance polymers*	-	5.000
Congressional Add: *Program increase - integrity of transparent armor*	-	5.000
Congressional Add: *Program increase - environmental quality enhanced coatings*	-	5.000
Congressional Add: *Program increase - autonomous digital design and manufacturing*	-	5.000
Congressional Add: *Program increase - materials recovery technologies for defense supply resiliency*	-	10.000
Congressional Add: *Program increase - materials manufacturing processes*	-	10.000
Congressional Add: *Program increase - additive manufacturing machine learning initiative*	-	10.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army	Date: May 2021
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Congressional Add: *Program increase - rapid advanced deposition*	-	10.000
Congressional Add: *Program increase - defense resiliency against extreme cold weather*	-	10.000
Congressional Add: *Program increase - counter UAS technology research*	-	5.000
Congressional Add: *Program increase - cell-free expression for biomanufacturing*	-	10.000
Congressional Add: *Program increase: Earthen structures soil enhancement*	-	4.000
Congressional Add Subtotals for Project: BN8	108.700	131.000
Congressional Add Totals for all Projects	108.700	131.000

Change Summary Explanation

FY22 increase related to the realignment of 5 Projects from 0602145A Next Generation Combat Vehicle Technology to focus on mid to far term deliverables for the ground portfolio

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) BK7 / *Robotics for Engineer Operations Technology*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
BK7: *Robotics for Engineer Operations Technology*	-	9.889	6.037	1.228	-	1.228	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This research investigates and develops standoff robotic capabilities for Combat Engineers to reduce Soldier/Engineer risks and fatalities while conducting activities essential to shaping the environment. It will close the gaps between commercial construction equipment and the requirements of the future Engineer Force to support maneuver, movement, and sustainment. This research will develop the capability to generate a near real-time site model with appropriate engineering details to allow unmanned shaping of the environment through physical interaction (e.g. push, pull, lift, or dig). This effort will also develop the requisite mission planner and task execution controller that accepts input from the user and provides suggestions and feedback based on updates to the site model, reporting from hardware agents, and resource allocation logic. The end state goal is the development of beyond visual line of sight teleoperation and semiautonomous capabilities allowing Engineer robotic support to match pace in near term and future combat environments. This effort will support the development, testing, and evaluation of prototypical robotic Combat Engineer equipment. This Project develops modeling and simulation tools that represent realistic states for Engineer robotic operations and develops and assesses semi-autonomous and autonomous construction equipment technologies needed for remote control Engineer operations.

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

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

Work in this Project is conducted by the United States (U.S.) Army Engineer Research and Development Center and coordinated with U.S. Army Futures Command.

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

Work in this Project is related to, and fully coordinated with, PE 0603119A (Ground Advanced Technology) / Project BK8 (Robotics for Engineer Operations Adv Tech).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Dynamic Site Characterization ***Description:*** This effort develops the capability to dynamically characterize the environment in which robotic Engineer equipment will operate through implementation of multi-modal sensing, sensor data fusion, and object detection and classification.	2.150	-	-
Title: Mission Planning and Task Execution Control	3.100	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BK7 / *Robotics for Engineer Operations Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort develops a mission planning and task execution control capability to enable unmanned robotic Engineer equipment operations. This capability will provide a near real time operational view of the area of interest and will convert mission planning directives into commands for the robotic equipment.			
Title: Integration Prototype Model Development ***Description:*** This effort develops remote control protocols and processes for testing of construction equipment to assess suitability for use during engineer operations; assesses commercially available autonomy solutions from transportation and construction industries to develop enhanced semi-autonomous and autonomous equipment technology; and develops simulation tools for coordinated, multi-equipment operations.	4.639	-	-
Title: Beyond-Visual-Line-of-Sight Teleoperated Engr Ops ***Description:*** This effort develops site characterization technologies, equipment localization technologies, equipment tools, and controls protocols to support remote control and semi-autonomous engineering operations and develops modeling and simulation tools to support remote operations. ***FY 2021 Plans:*** Develop Combat Engineer specific library for object classification and identification to allow for greater fidelity in semi-autonomous site characterization; develop site localization technologies for Engineer equipment operating in Global Positioning System denied environments; develop machine learning and artificial intelligence protocols unique to construction equipment tool manipulation and execution; develop equipment controls and control interfaces to allow multiple pieces of equipment to be operated/overseen by one operator. ***FY 2022 Plans:*** Will investigate operator assist capabilities and operator interface aids for remote tool control; and refine components to the Engineer specific library for object classification, site localization technologies, and site change and manipulation monitoring. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding decrease reflects the planned lifecycle progression to advanced technology development PE 0603119A Project BK8.	-	6.037	1.228
Accomplishments/Planned Programs Subtotals	9.889	6.037	1.228

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BK7 / *Robotics for Engineer Operations Technology*

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) BL1 / *Materials and Manufacturing Research Technology*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
BL1: *Materials and Manufacturing Research Technology*	-	7.792	10.030	9.374	-	9.374	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project links materials research, manufacturing processes, and design to enable higher quality additive manufacturing products for Army applications through the development of high performance feedstock materials (polymers, metals, and ceramics), physics-based process models, and in-situ process monitoring. Integration of these tools with process models enables real-time control and manipulation of materials structure and properties to produce three-dimensional hybrid electronics packaging, power and energy sources and converters and new materials/structures for protection. The goal of this work is to develop robust physics-based models to optimize material properties, structures, and manufacturing processes for Army applications in protection, maneuver, power, sensing, and signature management necessary to rapidly respond to emerging and unknown threats in a battlefield environment.

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

Work in this Project supports the Army Science and Technology Ground and Next Generation Combat Vehicle.

Work in this effort is performed by the United States (US) Army Futures Command.

This work is done in coordination with PE 0602145A (Next Generation Combat Vehicle Technology), 0602143A (Soldier Lethality Technology) and 0603118A (Soldier Lethality Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Agile Expedient Manufacturing	2.227	-	-
Description: This effort researches developing manufacturing processes to accelerate the rate of innovative material adaptations (protection, power, sensing, and signature management) necessary to rapidly respond to emerging and unknown threats in a battlefield environment. Efforts include the development of innovative materials technologies through combinations of additive and subtractive manufacturing, direct write processes, coupled electro-magnetic fields, and other hybrid processes, as well as the development of robust predictive modeling and simulation tools linking manufacturing processes with materials structure, properties, and performance to enable the design and production of optimal materials at the point of need using available materials, energy sources, etc.			
Title: Power and Energy	1.609	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BL1 / *Materials and Manufacturing Research Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort focuses on the design and characterization of chemistries, materials, and components for advanced batteries, fuel reformers, and fuel cells. Potential Army applications include hybrid power sources, smart munitions, hybrid electric vehicles, and soldier power applications. This effort also investigates the applicability of photosynthesis to provide fuel and electricity for soldier power applications, and investigate silicon carbide power module components that could enable compact, high-efficiency, high-temperature, and high-power density converters for motor drive and pulse power applications.			
Title: Additive Manufacturing Research	3.956	8.240	8.471
Description: This effort researches new additive manufacturing (AM) capabilities that enable production of lightweight materials for protection, lethality, and maneuverability that cannot be produced through traditional manufacturing methods. Efforts include the development of new feedstock materials engineered specifically for low-volume additive processes to produce net-shape materials with desired properties and functionalities; integrated process models and real-time monitoring for closed-loop control and production of lightweight materials with optimal architectures, property gradients, and interfaces; and design optimization capabilities that connect materials and manufacturing to access the full design space enabled by additive manufacturing. ***FY 2021 Plans:*** Build upon prior metallic suspension chemistries to demonstrate electrical interconnect deposition capability for ambient reactive extrusion processes; demonstrate high conductivity, high resolution metallic inks to enable chip to chip interconnect and board level integration; demonstrate modified interfaces into three-dimensional hybrid electronics; develop improved performance for the integrated microprocessors, amplifiers, three-dimensional antennas, and sensors for Army applications; investigate use of electromagnetic fields in metal additive manufacturing processes to control specific microstructures in Magnesium alloys for structural and protection uses. ***FY 2022 Plans:*** Will mature a closed-loop AM process control experimental capability across a broad array of AM technologies by applying a set of in-situ process (or "within" process) monitoring techniques; design and develop an AM machine learning (ML) architecture for advancing real-time AM process controls by applying the following two deep ML frameworks: (1) convolutional neural networks (CNN) supervised deep learning framework for automatically detecting in-process defects and rapidly computing predictive models such as a structure-processing-property relations model; (2) generative adversarial networks (GANs) unsupervised deep learning framework for training the in-situ data sets and generating referenced data sets in real-time to compare them against in-situ process data for detecting AM process anomalies and for predicting the geometry-dependent optimized AM process parameters. ***FY 2021 to FY 2022 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BL1 / *Materials and Manufacturing Research Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Funding change reflects planned lifecycle of this effort.			
Title: Energy Sources and Storage	-	1.790	0.903
Description: This effort focuses on the design and characterization of chemistries, materials, and components for advanced batteries, fuel reformers, and fuel cells. Potential Army applications include hybrid power sources, smart munitions, hybrid electric vehicles, and soldier power applications. This effort also investigates the applicability of photosynthesis to provide fuel and electricity for soldier power applications, and investigate silicon carbide power module components that could enable compact, high-efficiency, high-temperature, and high-power density converters for motor drive and pulse power applications. ***FY 2021 Plans:*** Develop electrolytes for high-voltage cathodes with high capacity silicon anode that will enable the transition of next generation high energy dense, safe batteries for Soldier use; synthesize and develop highly active low-cost catalysts for fuel production and to use in fuel cell and power conversion applications; investigate modeling of spin activated liquid reserve batteries to explore the design space as it relates to requirements for energy, activation times, and environmental conditions for future munition systems. ***FY 2022 Plans:*** Will investigate advanced electrolytes to improve safety in ultrahigh energy silicon nanostructured anodes for Soldier-carried batteries including the 3/5 form factor (standard military specification for battery size, with a length over width ratio of 3 to 5) Conformal Wearable Battery (CWB); investigate materials and additives to improving safety in high energy (400 Wh/kg Li-ion); investigate high energy halide intercalation cathodes for transition of metal-free rechargeable batteries (halide intercalation is the reversible inclusion or insertion of a metal hydride molecule or ion into materials with layered structures such as graphite). ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY22, funding was realigned to PE 0602141 (Lethality Technology) / CF7 Solid-state Laser Concepts and Architectures			
Accomplishments/Planned Programs Subtotals	7.792	10.030	9.374

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) BL2 / *Explosives Forensics Technology*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
BL2: *Explosives Forensics Technology*	-	1.478	1.514	1.582	-	1.582	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops analytical methods for military explosives, homemade explosives (HME), HME precursors, and residue analysis for forensics attribution purposes. This project pursues research in signatures and algorithms required to provide improved residue analysis of explosives and precursor materials to enable integration into chemical and explosive hazard detection equipment for the warfighter.

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

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

Work in this effort is performed by the United States (US) Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Forensic Analysis of Explosives Signatures Applied Research	1.478	1.514	1.582
Description: This effort investigates forensics analytical methods for military explosives, HME, HME precursors, and residue analysis for attribution. ***FY 2021 Plans:*** Develop analytical methods for forensic analysis of explosives and other chemical hazards with the objective of assigning attribution to include collection, preparation, instrumental analysis and advanced statistical techniques; provide solutions for analytical problems encountered by expeditionary laboratories based on the research performed in this task. ***FY 2022 Plans:*** Will continue to investigate new technologies (hyperspectral imaging, compressed sensing, augmentation of current technology) for development of advanced concepts and operations of forensic analytical techniques to facilitate chemical and explosive detection and reconnaissance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	1.478	1.514	1.582

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BL2 / *Explosives Forensics Technology*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) BL4 / *Countermine Technology*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
BL4: *Countermine Technology*	-	4.070	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops selectable explosive hazard (EH) (i.e., mine, minefield, improvised explosive device) neutralization technologies combined with detection confirmation sensor capabilities to provide a future integrated detection and neutralization capability in support of both manned and unmanned mounted route clearance and conventional mine breaching operations.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy. Work in this Project supports Army Science and Technology Ground Portfolio and Soldier Lethality modernization priorities.

Work in this effort is performed by the United States (US) Army Futures Command.

This Project is coordinated with PE 0602145A (Next Generation Combat Vehicle Technology), 0602143A (Soldier Lethality Technology), 0603462A (Next Generation Combat Vehicle Technology Advanced Technology) and 0603118A (Soldier Lethality Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Countermine Technology	4.070	-	-
Description: Designs and develops selectable explosive hazard neutralization technologies combined with detection confirmation sensor capabilities to provide a future integrated detection and neutralization capability in support of both manned and unmanned mounted route clearance and conventional mine breaching operations. Products of this effort include sensor components for high reliability confirmation, cueing algorithms that produce repeatable and accurate registration coordinates for neutralization, and trade off analysis of candidate neutralization techniques to achieve a desired neutralization order of magnitude (low or high order detonation).			
Accomplishments/Planned Programs Subtotals	4.070	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) BL5 / *Expedient Passive Protection Technology*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
BL5: *Expedient Passive Protection Technology*	-	4.106	1.413	1.906	-	1.906	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops rapidly deployable passive protective solutions; algorithms for decision support applications and software; and tactics, techniques, and procedures to increase the survivability of personnel, critical assets, and facilities. Through experimental and computational investigation and design, this project develops force protection technologies for complex and urban environments. This Project also develops expedient solutions and decision support applications for protection against advanced energetic threats and large caliber rockets, missiles, and other emerging weapons.

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

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

Work in this Project is conducted by the United States (US) Army Engineer Research and Development Center and coordinated with US Army Futures Command.

Work in this Project complements PE 0603119A (Ground Advanced Technology) / Project BL6 (Expedient Passive Protection Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Integrate Novel Materials for Tone Down Applications ***Description:*** This effort utilizes native vegetation as an unconventional countermeasure for Army concealment. Work includes identification of spectral properties for infrared disruption, and inclusion of additive materials for tone-down applications.	0.333	-	-
Title: Force Protection in the Urban Environment ***Description:*** This effort develops force protection solutions for urban environments and computational test bed capabilities to develop advanced materials and expedient protective solutions; develops rapidly deployable protection systems; decision support applications and software; and tactics, techniques, and procedures to provide protection with consideration for a complex three-dimensional threat.	3.773	-	-
Title: Protection Against High Trajectory Large Caliber Rocket and Missile Threats ***Description:*** This effort investigates high trajectory large caliber rocket and missile weapon effects on critical assets and facilities and develops expedient force protection solutions for these new weapon threats. These solutions include the application of novel	-	1.413	1.906

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BL5 / *Expedient Passive Protection Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
protective materials and designs. This effort develops and validates deployable protection systems against these threats and develops decision support tools to aid the warfighter in selecting protective positions. ***FY 2021 Plans:*** Investigate effects of high trajectory large caliber rockets and missiles on legacy protective systems and new conceptual passive protection designs. ***FY 2022 Plans:*** Will develop new materials and algorithms to protect critical assets in multi-domain operations from emerging threats such as large caliber rockets and missiles, and will develop new design concepts for passive protection against these threats. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase in FY22 will support development of new protective designs against emerging threats (large caliber rockets and missiles).			
Accomplishments/Planned Programs Subtotals	4.106	1.413	1.906

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) BL7 / *Power Projection in A2AD Environments Technology*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
BL7: *Power Projection in A2AD Environments Technology*	-	2.757	1.843	3.151	-	3.151	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops remote assessment technologies to determine entry and maneuver corridors, develops site selection tools and decision support technologies for all climates in all season conditions including aviation site selection tools, enhanced automated route reconnaissance technologies, mobility models for extreme climates, and road capacity assessment technologies. These technologies reduce reliance on manned on-site reconnaissance for projection platform assessments and provide all season capacity predictions to ensure air and ground battlespace entry and maneuver. This Project also designs and develops material solutions to repair, rebuild and construct infrastructure required for movement and maneuver in highly contested, complex operational environments such as Anti-Access/Area Denial (A2/AD).

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

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

Work in this Project is conducted by the United States (U.S.) Army Engineer Research and Development Center and coordinated with U.S. Army Futures Command.

Work in this PE complements PE 0603119A (Ground Advanced Technology) / Project BL8 (Power Projection in A2AD Environments Adv Tech).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Entry and Sustainment in Complex Contested Environments	2.757	0.880	1.375
Description: This effort develops strategic and tactical level planning tools for assessing engineering behavior of ground surfaces as it relates to battlefield maneuver to include factors affecting on-and-off-road vehicle mobility as well as aviation assembly areas; applies new technologies for data acquisition to engineering design factors to rapidly assess vehicle and terrain interaction.			
FY 2021 Plans: Validate remote sensing data analysis algorithms for predicting off-road mobility in arctic regions; design and develop methodology for rapid road and trail classification; and conduct computational experiments for analyzing ground vehicle impact on bound and unbound granular materials.			
FY 2022 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BL7 / *Power Projection in A2AD Environments Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will further develop portions of prediction tools for arctic mobility across snow-covered terrain and in organic soils unique to arctic regions; and will validate methodologies for rapid road and trail classification and determine analytical procedures for estimating capacity of low-volume roads for military vehicles. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase in FY22 will support development of analytical procedures for estimating capacity for low-volume roads.			
Title: Engineering for Battlespace Maneuver ***Description:*** This effort develops the capability to rapidly repair and upgrade damaged infrastructure along mobility corridors and restaging areas to maintain and enhance freedom of maneuver achieving overmatch and tactical advantage in contested complex environments. ***FY 2021 Plans:*** Design and develop techniques for rapid soil stabilization to support military ground vehicle maneuver; conduct experiments to provide stand-off assessments of existing route characteristics; and develop algorithms to support engineer planning for route maintenance to prioritize maneuver corridors based on available engineer assets. ***FY 2022 Plans:*** Will mature materials and refine techniques for rapid ground stabilization and expedient soil hardening to support military vehicles; will enhance techniques for expedient infrastructure upgrades; and will develop planning aids for engineer support to route remediation. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase in FY22 will support development of enhanced expedient infrastructure upgrade techniques and engineer route remediation planning tools.	-	0.963	1.776
Accomplishments/Planned Programs Subtotals	2.757	1.843	3.151

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) BL9 / *Protection from Advanced Weapon Effects Technology*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
BL9: *Protection from Advanced Weapon Effects Technology*	-	4.380	3.812	4.344	-	4.344	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops structural hardening, high-performance computing capabilities, and force protection technologies to enhance survivability of personnel and critical assets. This project investigates and develops advanced materials for protection against blast, fragmentation, and penetration through physical experiments and modeling and simulation. Additionally, this project investigates, designs, and develops passive protection technologies and protective design criteria to mitigate attack from emerging advanced threats.

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

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

Work in this Project is performed by the United States (U.S.) Army Engineer Research and Development Center and coordinated with the U.S. Army Futures Command.

Work in this PE complements PE 0603119A (Ground Advanced Technology) / Project BM1 (Protection from Advanced Weapon Effects Adv Tech).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Materials and Modeling for Force Protection	1.410	1.375	-
Description: This effort develops advanced composite and other protective materials and multi-scale modeling techniques to reduce material weight and increase resistance against blast and penetration threats; develops innovative virtual material design procedures; and optimizes manufacturing processes supported by computational modeling and simulation. ***FY 2021 Plans:*** Develop multi-scale modeling approaches for materials of geological origin and composite material systems. Conduct physical and computational experiments to investigate multiple force protection materials and components against relevant advanced weapon threats. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding decrease in FY22 reflects the planned lifecycle for this effort, ending in FY21.			
Title: Defeat of Complex Attack	2.970	2.437	2.864

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BL9 / *Protection from Advanced Weapon Effects Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort develops passive protection structural hardening designs and solutions against emerging large-caliber advanced weapons; investigates and validates computational models for predicting residual protective capacity for multi-hit threat scenarios; and develops micro-mechanics-based models and material solutions matured by conducting high-rate experiments. ***FY 2021 Plans:*** Refine algorithms and design methods for structural hardening material solutions by conducting advanced high-rate and high-pressure dynamic experiments to improve computational models at the micro-mechanical and macro-continuum scales. ***FY 2022 Plans:*** Will develop a full-scale protection/structural solution with predictive algorithm to mitigate precision strike weapon effects; will design multi-hit composite protection subsystems to validate algorithms and material subsystems through testing; and will develop a model to inform engineers on protective design guidance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase in FY22 supports the development of the predictive algorithm needed to design full-scale protection/structural solutions.			
Title: Advanced Materials and Modeling for Force Protection ***Description:*** This effort develops capabilities in the use of poorly-understood and indigenous materials. This effort develops multi-scale material modeling frameworks incorporating physics of deformation and damage mechanisms; a 3D multi-physics material modeling capability to allow for weapons effects models to be informed by remote sensing; and advanced material technologies for force protection. ***FY 2022 Plans:*** Will develop and refine algorithms for a multi-scale, materials-by-design methodology to model and enhance concrete protective material solutions for weapons effects; and will design and develop metallic, composite, and hybrid material solutions for force protection concepts. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase in FY22 reflects the planned lifecycle for this effort, beginning in FY22, for algorithm development for materials-by-design methodology, and development of material solutions for force protection concepts.	-	-	1.480
Accomplishments/Planned Programs Subtotals	4.380	3.812	4.344

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BL9 / *Protection from Advanced Weapon Effects Technology*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) BN8 / *Ground Technology Materials(CA)*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
BN8: *Ground Technology Materials(CA)*	-	108.700	131.000	-	-	-	-	-	-	-	-	-

Note

Congressional Interest Item funding provided for Ground Technology Materials.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Ground Technology Materials.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Congressional Add: Environmental Quality Enhanced Coatings ***FY 2020 Accomplishments:*** Program Increase supported applied research on Environmental Quality Enhanced Coatings. Work executed by Army Futures Command.	5.000	-
Congressional Add: Environmental Friendly Coatings Technology ***FY 2020 Accomplishments:*** Program Increase supported applied research on Environmental Friendly Coatings Technology. Work executed by Army Futures Command.	3.000	-
Congressional Add: Additive Manufacturing for Artificial Intelligence and Machine Learning ***FY 2020 Accomplishments:*** Program Increase supported applied research on Additive Manufacturing for Artificial Intelligence and Machine Learning. Work executed by Army Futures Command.	5.000	-
Congressional Add: Earthen Structures Soil Enhancement ***FY 2020 Accomplishments:*** Program Increase supported applied research on Earthen Structures Soil Enhancement.	4.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BN8 / *Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Work executed by Army Futures Command.		
Congressional Add: M1 Abrams Tank Track System ***FY 2020 Accomplishments:*** Program Increase supported applied research on M1 Abrams Tank Track System. Work executed by Army Futures Command.	2.200	-
Congressional Add: High Performance Polymers ***FY 2020 Accomplishments:*** Program Increase supported applied research on High Performance Polymers. Work executed by Army Futures Command.	5.000	-
Congressional Add: Materials Manufacturing Processes ***FY 2020 Accomplishments:*** Program Increase supported applied research on Materials Manufacturing Processes. Work executed by Army Futures Command.	6.000	-
Congressional Add: Highly Durable Advanced Polymers for Lightweight Armor ***FY 2020 Accomplishments:*** Program Increase supported applied research on Highly Durable Advanced Polymers for Lightweight Armor. Work executed by Army Futures Command.	8.000	-
Congressional Add: Cellulose Nanocomposite Research ***FY 2020 Accomplishments:*** Program Increase supported applied research on Cellulose Nanocomposite Research. Work executed by Army Futures Command.	5.000	-
Congressional Add: Countermine Program ***FY 2020 Accomplishments:*** Program Increase supported applied research on Countermine Program. Work executed by Army Futures Command.	5.000	-
Congressional Add: Materials Research ***FY 2020 Accomplishments:*** Program Increase supported applied research on Materials Research.	17.500	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BN8 / *Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Work executed by Army Futures Command.		
Congressional Add: Additive Manufacturing and Materials Processing ***FY 2020 Accomplishments:*** Program Increase supported applied research on Additive Manufacturing and Materials Processing. Work executed by Army Futures Command.	15.000	-
Congressional Add: Cold Weather Military Research ***FY 2020 Accomplishments:*** Program Increase supported applied research on Cold Weather Military Research. Work executed by Army Futures Command.	3.000	-
Congressional Add: Cold Spray Technologies ***FY 2020 Accomplishments:*** Program Increase supported applied research on Cold Spray Technologies. Work executed by Army Futures Command.	15.000	-
Congressional Add: Center for Research in Extreme Batteries ***FY 2020 Accomplishments:*** Program Increase supported applied research on Center for Research in Extreme Batteries. Work executed by Army Futures Command.	10.000	-
Congressional Add: Program increase: Ice engineering research facility modernization ***FY 2021 Plans:*** Conduct applied research in Ice Engineering Research Facility Modernization. Work executed by Army Futures Command.	-	5.000
Congressional Add: Program increase: Center for research in extreme batteries ***FY 2021 Plans:*** Conduct applied research in Center for Research in Extreme Batteries. Work executed by Army Futures Command.	-	10.000
Congressional Add: Program increase: Cellulose nanocomposites research ***FY 2021 Plans:*** Conduct applied research in Cellulose Nanocomposites.	-	5.000

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BN8 / *Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Work executed by Army Futures Command.		
Congressional Add: Program increase: Advanced polymers for force protection ***FY 2021 Plans:*** Conduct applied research in Advanced Polymers for Force Protection. Work executed by Army Futures Command.	-	8.000
Congressional Add: Program increase - advanced concrete ***FY 2021 Plans:*** Conduct applied research in Advanced Concrete. Work executed by Army Futures Command.	-	4.000
Congressional Add: Program increase - robotic RTCH ***FY 2021 Plans:*** Conduct applied research in Robotic RTCH. Work executed by Army Futures Command.	-	5.000
Congressional Add: Program increase - military waste stream conversion ***FY 2021 Plans:*** Conduct applied research in Military Waste Stream Conversion. Work executed by Army Futures Command.	-	5.000
Congressional Add: Program increase - high performance polymers ***FY 2021 Plans:*** Conduct applied research in High Performance Polymers. Work executed by Army Futures Command.	-	5.000
Congressional Add: Program increase - integrity of transparent armor ***FY 2021 Plans:*** Conduct applied research in Integrity of Transparent Armor. Work executed by Army Futures Command.	-	5.000
Congressional Add: Program increase - environmental quality enhanced coatings ***FY 2021 Plans:*** Conduct applied research in Environmental Quality Enhanced Coatings.	-	5.000

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BN8 / *Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Work executed by Army Futures Command.		
Congressional Add: Program increase - autonomous digital design and manufacturing ***FY 2021 Plans:*** Conduct applied research in Autonomous Digital Design and Manufacturing. Work executed by Army Futures Command.	-	5.000
Congressional Add: Program increase - materials recovery technologies for defense supply resiliency ***FY 2021 Plans:*** Conduct applied research in Materials Recovery Technologies for Defense Supply Resiliency. Work executed by Army Futures Command.	-	10.000
Congressional Add: Program increase - materials manufacturing processes ***FY 2021 Plans:*** Conduct applied research in Materials Manufacturing Processes. Work executed by Army Futures Command.	-	10.000
Congressional Add: Program increase - additive manufacturing machine learning initiative ***FY 2021 Plans:*** Conduct applied research in Additive Manufacturing Machine Learning Initiative. Work executed by Army Futures Command.	-	10.000
Congressional Add: Program increase - rapid advanced deposition ***FY 2021 Plans:*** Conduct applied research in Rapid Advanced Deposition. Work executed by Army Futures Command.	-	10.000
Congressional Add: Program increase - defense resiliency against extreme cold weather ***FY 2021 Plans:*** Conduct applied research in Defense Resiliency Against Extreme Cold Weather. Work executed by Army Futures Command.	-	10.000
Congressional Add: Program increase - counter UAS technology research ***FY 2021 Plans:*** Conduct applied research in Counter UAS Technology.	-	5.000

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** BN8 / *Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Work executed by Army Futures Command.		
Congressional Add: Program increase - cell-free expression for biomanufacturing ***FY 2021 Plans:*** Conduct applied research in Cell-Free Expression for Biomanufacturing. Work executed by Army Futures Command.	-	10.000
Congressional Add: Program increase: Earthen structures soil enhancement ***FY 2021 Plans:*** Conduct applied research in Earthen Structures Soil Enhancement. Work executed by Army Futures Command.	-	4.000
Congressional Adds Subtotals	108.700	131.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) CA9 / *Predictive Maintenance*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CA9: *Predictive Maintenance*	-	-	2.509	-	-	-	-	-	-	-	-	-

Note

In Fiscal Year 2022 (FY22) this Project was realigned to:
PE 0602180A AI Technologies / Project CN7 Predictive Maintenance Applied Research

A. Mission Description and Budget Item Justification

This Project develops and characterizes artificial intelligence (AI) and machine learning (ML) tools and capabilities to intelligently predict and analyze maintenance status for emerging and legacy ground platforms; extracts maintenance data from existing databases, sensor data and inference of missing data via virtual simulations investigating maintenance concepts that employ AI data capture and integrate AI tools into enterprise resource planning for military ground vehicles. Research enables use of predictive maintenance to increase fleet operational readiness through reduced downtime by preventing critical failure during missions, maximizing availability to combatant commands.

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

Work in this Project supports the Army Science and Technology Ground Portfolio and the Joint Artificial Intelligence Center (JAIC)

Work in this Project is performed by the United States (US) Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Predictive Maintenance	-	2.509	-
Description: This effort performs research on AI, deep learning, and predictive analytics to forecast major issues on platforms and enables services to respond to upcoming failures. Focus will be to identify component failure relationships to principal end items for prediction of critical failure prior to corrective maintenance and reactive supply chain requisitions. Research will increase efficiency, decrease fleet operating and sustainment costs for equipment platforms, and reduce the time and costs associated with repair part requisition, management and transportation.			
FY 2021 Plans: Investigates and develops new capabilities of a standardized end-to-end pipeline for gathering data from maintenance sensors in ground platforms (both manned and unmanned); improves performance failure prediction models for critical components; develops engine health model to predict maintenance events; develops data analytics to categorize failures both off-line (in depot tear-downs) and to aid field maintainers.			
FY 2021 to FY 2022 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** CA9 / *Predictive Maintenance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
In FY22, this Project is administratively restructured to PE 0602180A AI Technologies / Project CN7 Predictive Maintenance Applied Research			
Accomplishments/Planned Programs Subtotals	-	2.509	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) CG5 / *Ground Vehicle Sensor Concepts and Technologies*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CG5: *Ground Vehicle Sensor Concepts and Technologies*	-	-	-	4.146	-	4.146	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this Project was administratively realigned from:
Program Element (PE) 0602145A, Project BI2 Sensor Protection Technology.

A. Mission Description and Budget Item Justification

This Project investigates, designs, fabricates, assesses, and characterizes advanced sensor protection technologies, components, and concepts that will enable the future Soldier to see and operate through a laser directed energy weapon attack. Both active and passive protection technologies will be investigated to protect Army sensors that operate in the visible, short-wave infrared, mid-wave infrared, and long-wave infrared spectra from battlefield laser threats. Areas of research include passive optical limiters such as nonlinear organic dyes, semiconductors, and meta-materials, as well as fast active switches and tunable filters. As new laser technologies are developed, effects of those threats will be studied and assessed to determine vulnerability of Army sensor systems and sensor system materials.

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

Work in this Project supports the Army Science and Technology Ground and Next Generation Combat Vehicle portfolios.

Work in this Project is performed by the United States (US) Army Futures Command.

Work in this Project is coordinated with PE 0602145A (Next Generation Combat Vehicle Technology) and PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Laser Protection Technologies	-	-	4.146
Description: This effort develops new materials and devices for the protection of Army sensors and eyes behind day-view optical sights from a variety of laser threats. This research utilizes a combination of technologies based on the nature of the different threats, as well as the fundamental differences in sensors operating over different frequency ranges. Passive optical limiting materials that block specific frequency bands of light will be investigated and developed for the visible and short-wave infrared (SWIR) spectrum, and active meta- material-based solutions will be investigated for uncooled sensors in the long-wave infrared. Vulnerability of sensors and optical sensor systems will be studied against high-power and ultra-short pulsed laser threats to determine protection requirements.			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** CG5 / *Ground Vehicle Sensor Concepts and Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2022 Plans: Will explore concepts to reduce dazzle from high-power handheld lasers; improve optical system protection concepts from high energy lasers (HEL); reduce the threat of jamming from white light continuum generated by ultra-short pulsed lasers (USPLs): use results from first principles modeling to validate and improve chemical mixtures designed for specific laser light absorption. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort administratively realigned from PE 0602145A Project BI2 Sensor Protection Technology in FY 2022.			
Accomplishments/Planned Programs Subtotals	-	-	4.146

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) CG6 / *Ground Vehicle Power and Energy Concepts and Tech*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CG6: *Ground Vehicle Power and Energy Concepts and Tech*	-	-	-	2.681	-	2.681	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project was administratively realigned from:
Program Element (PE) 0602145A, Project BH5 Platform Electrification and Mobility Tech.

A. Mission Description and Budget Item Justification

This Project researches and develops advanced power and energy technologies for combat ground vehicles that are necessary for parallel hybrid, series hybrid, and all- electric vehicle systems. This effort investigates and develops electric conversion technologies to reduce size and weight of military vehicles while increasing performance and capabilities to support current and future mission loads and provide improved military vehicle mobility.

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

Work in this Project supports the Army Science and Technology Ground and Next Generation Combat Vehicle portfolios.

Work in this Project is performed by the United States (US) Army Futures Command.

Work in this Project is coordinated with PE 0602145A (Next Generation Combat Vehicle Technology) and PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Advanced Distributed Power for Autonomous Systems	-	-	1.423
Description: This effort develops technologies for electrification of both manned and unmanned Next Generation Combat Vehicle platforms. Electrification of these platforms will enable advanced lethality and protection systems, reduced battlefield fuel consumption, and provide new capabilities such as burst acceleration, extended silent mobility, and silent watch. The effort investigates and develops electric conversion technologies to reduce size and weight while increasing performance and capabilities to support current and future mission loads and provide improved military vehicle mobility. Research focuses on high power/ temperature power electronics, magnetic gears, electric drive motors, and adaptive device and component level control that optimized operation in real time. Investigation of advanced control methods at the module and conversion component levels provides an understanding of the impact real time optimization and energy tracking can have on power conversion optimization and mission effectiveness. The research enables the integration of component state and behavior into system level management algorithms that support non-autonomous and autonomous operations while providing modular and scalable electrification			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** CG6 / *Ground Vehicle Power and Energy Concepts and Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
architectures. Efforts will also investigate non-contact magnetic gear technologies coupled with electrical motors and generators to reduce size and weight with an increase in reliability and performance through increased torque and speed operational range. Results of the research inform 0602145A BH5 Platform Electrification and Mobility Tech. ***FY 2022 Plans:*** Will research control algorithms and topologies for power conversion systems with a focus on stability and improved real time maximum power optimization of component operation; explore coupling of decision making methods to increased awareness of tactical energy effectiveness for increased operational-tempo and to support platform operations and battlespace planning and real time energy tracking through standard energy analysis techniques; model high torque magnetic gear components for platform applications and identify additional optimization strategies and use cases. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort administratively realigned from PE 0602145A Project BH5 Platform Electrification and Mobility Tech in FY 2022.			
Title: Power Electronic Components and Materials ***Description:*** This effort investigates and develops electric conversion technologies to reduce size and weight while increasing performance and capabilities to support current and future mission loads and provide improved military vehicle mobility. Research focuses on semiconductor power switches, power switch modules/packaging, and power switch module thermal management. Investigation of high voltage/high frequency power semiconductor materials and devices is concentrated on efficient power switching under militarily relevant temperatures. Development of multi-disciplinary parametric design optimization software tools and multi-functional package structures provides advances in device packaging technology to fully realize device performance improvements. Results of the research inform 0602145A BH5 Platform Electrification and Mobility Tech. ***FY 2022 Plans:*** Will design and model new high performance power module using holistic co-design methods; investigate control and fabrication methods that can enable real time optimization of packaging performance; develop models for power device architectures appropriate for ultra-wide-band gap semiconductors; fabricate and assess initial test structures and devices. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort administratively realigned from PE 0602145A Project BH5 Platform Electrification and Mobility Tech in FY 2022.	-	-	1.258
Accomplishments/Planned Programs Subtotals	-	-	2.681

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** CG6 / *Ground Vehicle Power and Energy Concepts and Tech*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) CG7 / *Ground Protection Concepts and Technologies*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CG7: *Ground Protection Concepts and Technologies*	-	-	-	14.565	-	14.565	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project was administratively realigned from:
Program Element (PE) 0602145A, Project BG6 Advanced Concepts for Active Defense Technology.

A. Mission Description and Budget Item Justification

This Project researches advanced materials and mechanisms to defeat the most common and most dangerous threats that are expected to be encountered by our ground forces in near-, mid-, and far-term. This Project also develops experimental and computational tools and techniques (high resolution instrumentation to observe impact events, theories, and algorithms to explain these phenomena and numerical implementation of these algorithms) for the development of mass-efficient armor mechanisms. This project develops armor mechanisms that will be integrated to create multi-threat armor technologies and form the building blocks for Adaptive and Cooperative Protection Technologies in the Advanced Concepts for Active Defense Project (PE 0602145A Next Generation Combat Vehicle Technology). Additionally, research will focus on subcomponent/component models to predict performance of early concepts and the means to assess effectiveness on ground platforms. The Project will balance developments of active threat defeat measures with the necessary advanced passive and reactive components that will ultimately provide for full system solutions which meet the requirements of current and next generation ground tactical and combat vehicles.

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

Work in this Project supports the Army Science and Technology Ground and Next Generation Combat Vehicle.

Work in this Project is performed by the United States (US) Army Futures Command portfolios.

This Project is coordinated with and transition to Projects in PE 0603462A (Next Generation Combat Vehicle Advanced Technology), PE 0602145A (Next Generation Combat Vehicle Technology), and builds upon weapon target interaction research in PE 0601102A (Defense Research Sciences) / Project AA7 (Mechanics and Ballistics).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Advanced Armor and Protection Technologies	-	-	8.166
Description: This effort enables development of the next generation of lightweight protective concepts and technologies for defeat of current and future threats by utilizing real-time information, combined with threat knowledge, to provide increased protection. This effort researches the fundamental physics of new terminal effects concepts and provides an understanding of interaction			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** CG7 / *Ground Protection Concepts and Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
between the platform's defeat mechanism and the threat . The effort also investigates the ability to analytically simulate complex threat interactions. Experiments will be conducted to validate the efficacy of the designs. ***FY 2022 Plans:*** Will conduct experiments to validate several computationally designed pulsed power mechanisms to defeat a wide range of shaped charge warheads; conduct research into the understanding of energetic material response to ballistic events; validate an optimized notional hull concept that includes adaptive and active protection concepts for a combined threat suite through computational and experimental methods. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort being administratively realigned from PE0602145A Project BG6 Advanced Concepts for Active Defense Technology in FY 2022.			
Title: Computational and Experimental Capability ***Description:*** This effort will develop computational design tools along with diagnostic and experimental capabilities that support the development of advanced protection systems. Such systems include passive, active, and hybrid solutions for defeating (multiple) anti-armor threats and exploit solid-dynamic, explosive-driven, and magneto-hydrodynamic target interactions. This work allows for predicting armor performance and understanding mechanisms, regardless of vehicle platform, with improved and quantified confidence. This effort leverages the Department of Defense and Department of Energy (DOE) Technical Coordination Group Memorandum of Agreement and directly leverages DOE investments in computational platforms for problems in solid dynamics and impact mechanics. ***FY 2022 Plans:*** Will increase computational and material modeling capability to predict performance of hybrid armor protection mechanisms during threat impact; validate improved cineradiography and tomography diagnostic systems in multiple experimental facilities to capture threat interaction with armor mechanisms including multi-energy flash; designs and develops computational capability to couple the blast/fluid/solid/target interactions during threat engagements and reactive models for predicting mass (fragment), momentum (blast), and energy (heat) target effects for non-ideal explosives (a non-ideal explosive's observed detonation velocity is lower than the calculated ideal value from thermo-hydrodynamic theory); explores machine learning methodology for terminal ballistics design applications. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort being administratively realigned from PE0602145A Project BG6 Advanced Concepts for Active Defense Technology in FY 2022.	-	-	6.399
Accomplishments/Planned Programs Subtotals	-	-	14.565

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** CG7 / *Ground Protection Concepts and Technologies*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) CG8 / *Human Autonomy Teaming*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CG8: *Human Autonomy Teaming*	-	-	-	8.599	-	8.599	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project was administratively realigned from:
Program Element (PE) 0602145A, Project BF6 Crew Augmentation and Optimization Tech.

A. Mission Description and Budget Item Justification

This Project performs applied research for capabilities that support teams of Soldier and Artificial Intelligence (AI)-enabled systems to execute missions in complex, dynamic, multi-domain operations environments. Centered on ground vehicle mission planning and operations, this Project is focused on core technologies to enable Soldiers and AI-enabled systems to function as a team, to perform at high levels, and to adapt to adversarial actions and new mission requirements. This Project will enable future Soldiers with AI-enabled systems to perform complex missions with increasingly sophisticated technologies, and in increasingly complex, dynamic, socio-technical environments. The applied research will provide the fundamental technologies to enable scalable Soldier-AI teams and team-centered dynamic tasking to effectively utilize the full capabilities of team and technologies. The research will include considerations to reduce data requirements for AI adaptation, increasing appropriate Soldier trust and use of technology, and ensuring ethical behaviors by teams of Soldier and AI-enabled systems. The capabilities created by this research will lead to increased overall Soldier-AI team mission performance, improved Soldier-centric situation awareness technologies, and units that can effectively integrate within a multi-domain battlefield.

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

Work in this Project supports the Army Science and Technology Ground and Next Generation Combat Vehicle portfolios.

Work in this Project is performed by the United States Army Futures Command.

Work in this Project is coordinated with PE 0602145A (Next Generation Combat Vehicle Technology), PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and PE 0602143A (Soldier Lethality Technology) .

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Soldier?AI Team Mission Planning for Dynamic Complex Environments	-	-	1.264
Description: Planning in multi-domain operations environments is complex and has increased temporal and spatial sensitivities for Soldiers to integrate with AI-enabled systems to plan and execute missions. This effort provides the fundamental concepts and technologies to enable Soldier and AI to team together to plan for multidomain operations from a ground vehicle perspective. This effort focuses on planning enablers to maximize manned-unmanned team performance across squads and platoons and includes mid- to far-term crew station-based emerging technologies in the areas of human- interaction with AI technologies and human-			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** CG8 / *Human Autonomy Teaming*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
guided machine intelligence. Approaches focus on modeling both Soldier and AI capabilities and their limitations as a function of the mission environment and mission requirements, and applying those models to form mission plans. ***FY 2022 Plans:*** Will investigate initial approaches to leverage Soldier feedback to enable mission-to-mission adaptation of intelligent system behaviors to complement crew performance and meet evolving mission needs. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort administratively realigned from PE 0602145A Project BF6 Crew Augmentation and Optimization Tech in FY 2022.			
Title: Dynamic Soldier-AI Team Resource Allocation ***Description:*** This effort focuses on creating the concepts and technologies necessary to dynamically allocate Soldiers and unmanned systems during missions in to adapt mission plans to adversarial actions and other events at a squad and platoon level, including responding to degradation or loss of team capabilities, changes in mission goals or priorities, and responding to adversarial actions. The effort includes the allocation of Soldiers, platforms, and platform sub-system capabilities with the focus to ensure that future AI and automation capabilities are focused on the circumstances and conditions where they are most likely to be successful, and to ensure that the Soldier's cognition is focused appropriately to ensure mission success. ***FY 2022 Plans:*** Will investigate initial algorithms to generate task allocations across a distributed heterogeneous team to enable rapid team reconfiguration and improve team performance in dynamic environments; conduct experiments to examine approaches for Commanders to coordinate actions of a distributed team through a library of preset formations and crew configurations within the Commander?s interface. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort administratively realigned from PE 0602145A Project BF6 Crew Augmentation and Optimization Tech in FY 2022.	-	-	2.458
Title: Soldier Cognition-Centric Interface Technologies ***Description:*** This effort creates cognitive-centric displays that ensure Soldiers are focused on aspects of situational awareness, mobility, target engagements, and communications that are critical to mission performance as future crew stations and displays provide vast amounts of multi-domain information that has the potential to distract, overwhelm, and mislead Soldiers. This effort ensures that our systems do not capture and misdirect Soldier attention and/or cognition, maximizing the utility of AI-enabled systems to the Soldier. This effort also enables Soldiers to better understand the actions, goals, intents, and general reasoning of the AI systems to ensure they are effectively used, but not inappropriately relied upon. ***FY 2022 Plans:***	-	-	1.614

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** CG8 / *Human Autonomy Teaming*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will mature approaches to characterize team cohesion in a distributed Soldier-AI team; continue experiments to investigate approaches to assess and calibrate the crew?s trust in AI-enabled autonomous systems. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort administratively realigned from PE 0602145A Project BF6 Crew Augmentation and Optimization Tech in FY 2022.			
Title: Enabling Soldier-AI Technology Adaptation ***Description:*** This effort develops technologies to rapidly adapt and upgrade AI-enabled system capabilities in response to advancements in AI in the commercial and adversary environments. Focus areas include enabling rapid technology adaption during Soldier experimentation and enabling data to be collected during these events for rapid development of technology updates and modifications. This effort has four goals: 1) increasing the ability of Soldier-AI teams to rapidly adapt to adversarial actions, new technologies, environmental changes, and mission requirements; 2) decreasing the data requirements to train and adapt AI-enabled systems; 3) increasing appropriate Soldier trust and use of technology; and 4) ensuring ethical decisions by using Soldiers to guide the actions and in-field adaptations of Soldier-AI team behaviors. ***FY 2022 Plans:*** Will develop algorithms that learn from natural interactions to allow Soldiers to communicate their intent to adapt and train autonomous systems; investigate novel approaches using interactive machine learning to enhance the robustness of algorithms for assessing effectiveness of Soldier-AI teams; mature novel machine learning approaches to enable Soldiers to rapidly train AI systems in novel situations and environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort administratively realigned from PE 0602145A Project BF6 Crew Augmentation and Optimization Tech in FY 2022.	-	-	3.263
Accomplishments/Planned Programs Subtotals	-	-	8.599

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602144A / *Ground Technology*	Project (Number/Name) CI2 / *Ground Enabling University Applied Research*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CI2: *Ground Enabling University Applied Research*	-	-	-	4.824	-	4.824	-	-	-	-	-	-

Note

In Fiscal Year 2022 (FY22), funding for this Project was realigned from:
Program Element (PE) 0603119A Ground Advanced Technology / BK8 Robotics for Engineer Operations Adv Tech,
PE 0602143A Soldier Lethality Technology / BE8 Synthetic Training Environment (STE) Technology, and
PE 0602145A Ground Technology / BF8 Artificial Intelligence and Machine Learning Tech

A. Mission Description and Budget Item Justification

The Project leverages applied research from academia, in the focus areas of ground autonomy, Artificial Intelligence/Machine Learning (AI/ML) and robotics, occupant/vehicle survivability and other ground platform technologies of importance to the Army. This Project performs discovery research efforts to focus more on mid to far-term Army modernization priorities while also maintaining delivery of near-term technologies critical to the next generation combat vehicles. This Project focuses on employment of research technologies originating from extramural applied research in academia pertaining to navigation/routing, autonomous robotic vehicles with the use of artificial intelligence and machine learning as applied to ground mobility and maneuver, and other innovative ground enabling applied research technologies. This effort conducts applied research and development leading to potential emerging technologies in areas of strategic importance to the Army in autonomy, robotics and AI/ML, protection of both platform and occupant, and other ground platform technologies in propulsion, survivability, powertrain, etc., by bringing competitively selected Universities with research and development teams into Technical Alliances.

Work in this Project supports the Army Modernization Priority Next Generation Combat Vehicle.

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

Work in this Project is performed by the United States (US) Army Futures Command.

This work is done in coordination with PE 0603119A (Ground Advanced Technology), PE 0602145A (Next Generation Combat Vehicle Technology) and PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Robust autonomous capabilities for ground vehicles	-	-	3.220
Description: This effort researches Artificial Intelligence/Machine Learning (AI/ML) and autonomous mobility-enabled ground vehicles to conduct off-road maneuvers to transition from tele-operated to either fully-autonomous, or semi-autonomous			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / *Ground Technology*	**Project (Number/Name)** CI2 / *Ground Enabling University Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
scenarios. Work is conducted in collaboration with university partners to advance autonomous mobility and protection of both occupant and platform in optionally manned and autonomous ground vehicles. ***FY 2022 Plans:*** Will develop AI/ML methods to enable robust, autonomous, tactical behaviors for multi-agent air and ground vehicle teams beyond existing behaviors such as leader-follower (e.g., flanking, occupying); as well as increase the speed of autonomous behavior acquisition through effective navigation and route planning using techniques to extract terrain features from imagery and transfer of simulator-learned behaviors to developmental ground platforms. Develop methods of shared control (between human operators and AI/ML systems) that increase overall autonomous system performance with human input. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY22, funding was realigned from PE 0602145 BF8 Artificial Intelligence and Machine Learning Tech			
Title: Human-robot/AI interactions ***Description:*** This effort develops systems involving physical and cognitive levels of interactions between humans and robots, with the use of reinforcement learning (an area of Machine Learning (ML) research) from human feedback, learning from demonstration, and safe human-aware controllers. Work is conducted in collaboration with university partners to advance autonomous mobility as well as other areas of ground platform technologies in propulsion, survivability, powertrain, etc. ***FY 2022 Plans:*** Will investigate and develop AI/ML methods to improve autonomous systems by capturing and learning from human teleoperation commands, human interventions, and other forms of human interaction (e.g., spoken language). Will develop tactics and algorithms on common software platforms which enable robots to deal with complex environments on the fly while working fully autonomously around humans for extended periods of time. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY22, funding was realigned from PE 0602145 BF8 Artificial Intelligence and Machine Learning Tech	-	-	1.604
Accomplishments/Planned Programs Subtotals	-	-	4.824

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A