Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Army											Date: February 2020	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2019**	**FY 2020**	**FY 2021 Base**	**FY 2021 OCO**	**FY 2021 Total**	**FY 2022**	**FY 2023**	**FY 2024**	**FY 2025**	**Cost To Complete**	**Total Cost**
Total Program Element	-	0.000	263.547	217.565	2.000	219.565	237.850	236.099	253.416	278.222	0.000	1,488.699
BF1: *Autonomous Ground Resupply Tech*	-	0.000	11.301	11.018	-	11.018	0.000	0.000	0.000	0.000	0.000	22.319
BF3: *Combat Vehicle Robotics Tech*	-	0.000	11.658	9.182	-	9.182	17.456	12.914	8.728	7.473	0.000	67.411
BF6: *Crew Augmentation and Optimization Tech*	-	0.000	23.027	19.022	-	19.022	21.765	22.263	22.693	20.626	0.000	129.396
BF8: *Artificial Intelligence & Machine Learning Tech*	-	0.000	18.651	19.894	2.000	21.894	28.578	40.888	64.387	78.379	0.000	252.777
BF9: *Sensors for Autonomous Operations and Surv Tech*	-	0.000	15.283	38.154	-	38.154	38.927	26.697	26.996	26.997	0.000	173.054
BG2: *Modeling and Simulation for MUMT Technology*	-	0.000	3.966	3.397	-	3.397	11.054	11.277	7.846	7.846	0.000	45.386
BG6: *Advanced Concepts for Active Defense Technology*	-	0.000	53.469	45.983	-	45.983	43.081	47.203	47.651	49.626	0.000	287.013
BG8: *Obscuration Technology*	-	0.000	4.070	2.620	-	2.620	2.675	2.729	2.758	2.786	0.000	17.638
BH2: *C4ISR Modular Autonomy Technology*	-	0.000	4.874	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.874
BH5: *Platform Electrification and Mobility Tech*	-	0.000	10.024	21.275	-	21.275	19.989	16.221	13.580	18.689	0.000	99.778
BH7: *Enhanced VETRONICS Technology*	-	0.000	3.603	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.603
BH9: *Protection for Autonomous Systems Tech*	-	0.000	2.548	1.499	-	1.499	1.499	1.998	2.098	2.098	0.000	11.740
BI2: *Sensor Protection Technology*	-	0.000	10.584	10.340	-	10.340	10.599	10.822	10.952	10.953	0.000	64.250
BI4: *Materials Application and Integration Tech*	-	0.000	8.313	7.689	-	7.689	7.819	7.972	8.057	8.058	0.000	47.908

Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Army												Date: February 2020
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*							
BI6: *All-Electric Combat Powertrain Technology**	-	0.000	0.000	0.000	-	0.000	0.000	2.498	5.595	9.992	0.000	18.085
BI9: *Vehicle System Security Technology*	-	0.000	2.951	2.777	-	2.777	2.827	2.253	2.125	3.572	0.000	16.505
BJ2: *Tactical and Navigation Lasers Sensors Technology*	-	0.000	4.990	5.453	-	5.453	5.562	5.673	5.737	5.794	0.000	33.209
BJ3: *Hydrogen Based Combat System Technology*	-	0.000	7.127	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.127
BJ7: *Detection of Explosive Hazards Technology*	-	0.000	11.882	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.882
BJ9: *Autonomous Mobility Tech*	-	0.000	3.060	2.498	-	2.498	3.996	0.000	0.000	0.000	0.000	9.554
BK2: *Virtual Prototyping Technology*	-	0.000	5.426	8.609	-	8.609	8.482	8.608	8.292	8.316	0.000	47.733
BK3: *Next Gen Intelligent Fire Control (NG-IFC) Tech*	-	0.000	1.050	4.196	-	4.196	0.999	0.999	0.000	0.000	0.000	7.244
BK5: *Adv Direct In-Direct Armament Sys (ADIDAS) Tech*	-	0.000	1.190	3.959	-	3.959	12.542	15.084	15.921	17.017	0.000	65.713
BP5: *Ground Vehicle Technology (CA)*	-	0.000	44.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	44.500

*This project's R-2a exhibit has been suppressed due to funding not beginning until after FY 2021

Note

In Fiscal Year (FY) 2020, this Program Element (PE) is realigned with continuity of effort from the following PEs:
* 0602105A Materials Technology
* 0602120A Sensors and Electronic Survivability
* 0602308A Advanced Concepts and Simulation
* 0602601A Combat Vehicle and Automotive Technology
* 0602618A Ballistics Technology
* 0602622A Chemical, Smoke and Equipment Defeating Technology
* 0602624A Weapons and Munitions Technology
* 0602705A Electronics and Electronic Devices
* 0602709A Night Vision Technology
* 0602712A Countermine Systems

Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Army	Date: February 2020
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*

* 0602716A Human Factors Engineering Technology
* 0602783A Computer and Software Technology
* 0602784A Military Engineering Technology

A. Mission Description and Budget Item Justification

This PE executes research for the Army's modernization priority for the Next Generation of Combat Vehicles. This PE researches, designs, and evaluates combat vehicle technologies that enable the Army to have a smarter, faster, more lethal, more precise, more protected, and more adaptable force. The focus is on building upon the foundational vehicle architectures to support the Next Generation of Combat Vehicles, to include autonomy architecture, power architecture, vehicle electronic architecture, physical architecture, lethality architecture and vehicle protection architecture. The research conducted will provide technologies to enable leap ahead capabilities for manned, optionally manned and unmanned vehicles that deliver decisive lethality.

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

Work in this PE complements PE 0602141A (Lethality Technology), PE 0602144A (Ground Technology), PE 0602146A (Network C3I Technology), PE 0602782A (Command, Control, Communications Technology), PE 0603116A (Lethality Advanced Technology), PE 0603119A (Ground Advanced Technology), PE 0603462A (Next Generation Combat Vehicle Advanced Technology), and PE 0603463A (Network C3I Advanced Technology).

Work in this PE will transition to PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

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

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

B. Program Change Summary ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	219.047	230.179	-	230.179
Current President's Budget	0.000	263.547	217.565	2.000	219.565
Total Adjustments	0.000	44.500	-12.614	2.000	-10.614
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	44.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	-12.614	2.000	-10.614

Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Army	Date: February 2020
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2019**	**FY 2020**
Project: BP5: *Ground Vehicle Technology (CA)*		
Congressional Add: *Prototyping Energy Smart Autonomous Ground Systems*	-	10.000
Congressional Add: *Highly Electrified Vehicles*	-	5.000
Congressional Add: *Additive Metals Manufacturing*	-	3.000
Congressional Add: *RPG and IED Protection*	-	3.000
Congressional Add: *Modeling and Simulation*	-	3.000
Congressional Add: *Structural Thermoplastics*	-	3.000
Congressional Add: *Advanced Materials Development for Survivability*	-	10.000
Congressional Add: *Autonomous Vehicle Mobility*	-	7.500
Congressional Add Subtotals for Project: BP5	-	44.500
Congressional Add Totals for all Projects	-	44.500

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BF1 / *Autonomous Ground Resupply Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BF1: *Autonomous Ground Resupply Tech*	-	0.000	11.301	11.018	-	11.018	0.000	0.000	0.000	0.000	0.000	22.319

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602601A Combat Vehicle and Automotive Technology:
* Project H91 Ground Vehicle Technology
PE 0602784 Military Engineering Technology:
* Project T40 Mob/Wpns Eff Tech

A. Mission Description and Budget Item Justification

Autonomous Ground Resupply (AGR) will design and develop modeling and simulation tools and advanced software behaviors to inform future ground supply distribution system requirements across multiple levels of strategic and tactical sustainment operations. The modeling and simulation software tools will be incorporated into a suite of products designed to support every phase of AGR and used to develop and refine AGR concepts, test vehicle designs, evaluate design changes, determine technology performance, and predict outcomes in a wide variety of terrain, weather, and environmental conditions. The effort will utilize the modeling and simulation software tools to design, develop and mature software; and conduct experiments to increase future autonomy capabilities. Increased capabilities will transition to PE 0603462 (Next Generation Combat Vehicle Advanced Technology) to be integrated into a Soldier evaluation to obtain user feedback and inform and transition to the Leader/Follower Program of Record. The architecture and safety work under this Project also lays the groundwork for Army Modernization Priority Next Generation Combat Vehicle (NGCV).

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 Modernization Priority NGCV.

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

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and the Leader/Follower Program of Record.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Software for Autonomous Systems	-	9.544	10.023	-	10.023

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF1 / *Autonomous Ground Resupply Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: Develop and implement advanced system behaviors to address leader follower capabilities, including algorithms for dynamic route planning, world modeling that feature system cues and collaboration to minimize the cognitive load placed on soldiers managing groups of unmanned systems. ***FY 2020 Plans:*** Will develop advanced software behaviors to address Leader Follower capabilities; including the integration of trailers (forward and reverse), convoy reverse capabilities, and convoy formations. Will investigate and develop new advanced convoy behaviors to enable autonomous convoy operations. Will develop algorithms for dynamic route planning and world modeling that feature system cues and collaboration to minimize the cognitive load placed on soldiers managing groups of unmanned systems. ***FY 2021 Base Plans:*** Will continue to develop advanced software behaviors and algorithms for integration into the fail-safe autonomous ground vehicle architecture and conduct field testing to validate increased robotic capabilities, which include: the integration of trailers (forward and reverse), convoy reverse capabilities, convoy formations, dynamic route planning and world terrain modeling to minimize the cognitive load placed on Soldiers managing groups of unmanned systems. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: Autonomous System Modeling and Simulations	-	1.243	-	-	-
Description: This effort matures a real-time, hardware-in-the-loop simulation environment for rapid autonomous system design and development and for robust autonomy algorithm development; investigates novel analyses methods for Modeling and Simulation enhanced demonstrations of autonomous ground vehicles to include adverse environmental conditions. ***FY 2020 Plans:*** Will mature simulation environments and will improve algorithms to predict autonomous vehicle system performance in adverse environmental conditions; will provide improved analytical tools to investigate the benefits of autonomous ground resupply and optimize sensor configurations for autonomous maneuver. ***FY 2020 to FY 2021 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF1 / *Autonomous Ground Resupply Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
In FY21 work in this effort is realigned to the Simulation Tools for AGR effort in this Project.					
Title: Simulation Tools for AGR ***Description:*** This effort designs and develops real-time and high-fidelity, hardware and software-in-the-loop simulators capable of rapid design and assessment of ground vehicle autonomous behaviors through integration with autonomy solutions. ***FY 2021 Base Plans:*** Will investigate simulation design, development, and performance as well as develop tools to explore autonomous system performance; develop simulation-enabled analysis methods for Autonomous Ground Resupply capstone events; and investigate integration of additional sensors and algorithms into simulation tools. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 work in this effort was realigned from the Autonomous System Modeling and Simulations effort in this Project.	-	-	0.995	-	0.995
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.514	-	-	-
Accomplishments/Planned Programs Subtotals	-	11.301	11.018	-	11.018

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BF3 / *Combat Vehicle Robotics Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BF3: *Combat Vehicle Robotics Tech*	-	0.000	11.658	9.182	-	9.182	17.456	12.914	8.728	7.473	0.000	67.411

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602601A Combat Vehicle and Automotive Technology / H91 (Ground Vehicle Technology

A. Mission Description and Budget Item Justification

This Project designs, develops, and evaluates a variety of innovative technologies that enable scalable integration of multi-domain robotic and autonomous system capabilities teamed within Army formations supporting all combat warfighting functions (close combat, reconnaissance, targeting and acquisition, etc.). This Project focus areas include autonomous architecture, autonomous behaviors and perception, and soldier machine Interface.

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 Modernization Priority Next Generation Combat Vehicle (NGCV).

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

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and transitions to PE 0604017A (Robotics Development).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Autonomous Behaviors and Perception	-	5.054	3.555	-	3.555
Description: This effort contributes to the NGCV Robotic Autonomous Strategy (RAS) to advance the mobility performance of autonomous systems within complex environments/ operations to allow for the completion of mission goals in separate and teaming configurations at varying levels of autonomy.					
FY 2020 Plans: Will develop the semi-autonomous on-road and off-road mobility technology to focus on the rules of the road and begin to establish behaviors for tactical formations and operationally relevant speeds. Will develop algorithms and capabilities for obstacle detection/avoidance, mounted/dismounted following, dynamic route planning, manned/unmanned teaming, and individual/coordinated learning and environmental modeling.					
FY 2021 Base Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF3 / *Combat Vehicle Robotics Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Will develop the dynamic obstacle detection and avoidance capability and integrate with advanced off-road autonomous navigation and conduct experiments for defined missions with tactical formations at operationally relevant speeds. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding in this effort is realigned to PE 0603462A (Next Generation Combat Vehicle Technology), Project BF4 (Combat Vehicle Robotics Advanced Technology) to better reflect the work being performed.					
Title: Autonomous Architecture ***Description:*** This effort contributes to the NGCV RAS to implement an open autonomous architecture for an inclusive military library of behaviors that are non-proprietary and in a modular format to allow for design and development of payloads across the enterprise. This effort builds upon architecture activities under the autonomous ground resupply activity, further expanding the Autonomous Ground Vehicle Robotics Architecture for increased complexity of military maneuvers as well as the Robotic Operating Systems ? Military (ROS-M) framework. ***FY 2020 Plans:*** Will develop a set of guidelines to enable the robotics community to fulfill the Army?s NGCV RAS commonality objectives with an affordable means to deliver advanced capability to the Warfighter by utilizing architectural best practices and standards. Will develop military repositories and an ecosystem for the sharing of robotic vehicle software to help reduce the cost of developing software for autonomous robotic platforms and increase the overall reliability, security, maturity, and interoperability of the software. ***FY 2021 Base Plans:*** Will continue to develop and establish ROS-M framework of reusable and adaptable software developed in collaboration with other Government Agencies and industry to align the robotics community to a common architecture. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	-	1.973	1.680	-	1.680
Title: Human Robotic Interaction ***Description:*** This effort contributes to the NGCV RAS to implement a focused approach to deliver optimized unmanned system and manned-unmanned system team performance through reduced cognitive burden for	-	4.101	3.947	-	3.947

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF3 / *Combat Vehicle Robotics Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
the Soldier while maintaining real-time unmanned system status/activity, overall mission effectiveness, and predictive capability of the system's intended activity. ***FY 2020 Plans:*** Will design and develop a multi-vehicle asset control approach that will have the capability to interface with multiple robotic assets on an interface either at a command mission planning level or directly to each asset that will allow for multi-user connection with different levels of authority. Will investigate multi-modal communications interface techniques for soldier interaction that will have the capability to interface with a robotic asset with multiple modes of communication either separately or all combined into one multi-modal mission command system. ***FY 2021 Base Plans:*** Will mature the operator-directed voice recognition for command and control of the robotic ground system maneuver. Will assess the performance of how naturally the robotic system interacts with human operators through experiments or experimentation to improve manned-unmanned system teaming. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.530	-	-	-
Accomplishments/Planned Programs Subtotals	-	11.658	9.182	-	9.182

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BF6 / *Crew Augmentation and Optimization Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BF6: *Crew Augmentation and Optimization Tech*	-	0.000	23.027	19.022	-	19.022	21.765	22.263	22.693	20.626	0.000	129.396

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602601A Combat Vehicle and Automotive Technology / H91 Ground Vehicle Technology
PE 0602716A Human Factors Engineering Technology / H70 Human Fact Eng Sys Dev
PE 0602308A Advanced Concepts and Simulation / C90 (Advanced Distributed Simulation

A. Mission Description and Budget Item Justification

This Project designs capabilities for reduced vehicle crew sizes to successfully operate a larger number of closed-hatch manned and remote unmanned vehicles in a complex multi-domain operations environment. This Project will enable future crews 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 integrated performance-improving Learning - Warfighter Machine Interfaces (WMIs) that are scalable to multiple crew hardware and functional configurations; reconfigurable frameworks and simulation for concept experimentation and exploration; and team-centered dynamic tasking by machine intelligence to effectively utilize full capabilities of crew and technologies. The research will generate soldier-informed data, reports, and analysis to support operational use in future vehicles through soldier experimentation and assessment of technical concepts in simulation and in-field WMIs. The capabilities created by this research will lead to increased overall crew and team performance; improved soldier safety due to fewer soldier per vehicle, closed-hatch operations, and improved standoff from effective control; and vehicles that can effectively perform across multiple domains of battle.

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 Modernization Priority Next Generation Combat Vehicle (NCVG).

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

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and PE 0602143 (Soldier Lethality Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Crew Station / Closed Hatch Operations	-	3.856	-	-	-
Description: This effort focuses on crew size reduction and crew stations tailored to mission and soldier needs through the utilization of emerging human-interaction technologies, automations, machine intelligence and the					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 / *Crew Augmentation and Optimization Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
provision of cohesive domain personalization to permit soldiers to achieve leap-ahead performance beyond today's constrained ground vehicle environment. ***FY 2020 Plans:*** Will develop baseline crew station technology for a seven soldier vehicle in both Manned Fighting Vehicle and Infantry Carrier Vehicle configurations to optimize task effectiveness, investigate and adapt helmet mounted display functionality for ground vehicle applications and incorporate rudimentary driving automations to validate utility of artificial intelligence as a soldier task enabler. Will assess motion effects on crew station utilizing motion based simulation. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 funding in this effort was realigned to the Crew & Robotic Mission with Agent Technology and Platoon Teaming Capability efforts in this Project to better describe the work being performed.					
Title: Crew Understanding Agents ***Description:*** This effort focuses on increasing the crew's comprehension of physical and virtual intelligent agent actions, intentions, goals, and general reasoning in order to increase the effectiveness of human-agent teaming. The effort will increase soldiers situational awareness and team resilience as well as inform effective use of intelligent assets. ***FY 2020 Plans:*** Will create first of its kind machine-learning based Learning - Warfighter Machine Interfaces (L-WMI) technology to enhance crew?s ability to plan missions. Apply theoretical approaches to increase a crew's comprehension of unmanned vehicle actions, intentions, goals, and general reasoning to operationally relevant, multi-tasking, team crew software-in-the-loop environments; integrate with L-WMI technology to improve planning based on crew?s improved comprehension of crew interactions with unmanned vehicles. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned to the Enabling Soldier-AI Technology Adaptation, Crew Capability Enhancement and Human Augmentation for Collective Training efforts in this Project.	-	7.847	-	-	-
Title: Agents Understanding Crew ***Description:*** This effort focuses on increasing intelligent agent ability to understand crew actions, intentions, goals, and general reasoning in order to increase the effectiveness of human-intelligent agent teaming. The	-	5.924	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 / *Crew Augmentation and Optimization Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
effort will enable effective adaptation by intelligent agents, increase appropriateness of intelligent agent actions, increase manned/unmanned team resilience, and is critical for intelligent approaches to dynamic team tasking. ***FY 2020 Plans:*** Will generate and enhance real-time algorithms to enhance ability of intelligent agents to understand vehicle crew behaviors, states, and intentions; integrate with L-WMI technology to improve planning based on crew?s ability to predict crew dynamics and capability changes over mission. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned to the tasks Dynamic Soldier-AI Team Resource Allocation, Soldier Cognition-Centric Interface Technologies and Characterize Soldier-Adaptive AI Interactions efforts in this Project.					
Title: Joint Human-Agent Teamwork ***Description:*** Will design and develop Commander?s interface to enable dynamic task reassignment across crew members and unmanned platforms to provide capability of crew members to manually share critical tasks as capabilities and mission needs change; Will investigate novel algorithms and communication protocols for developing, maintaining and sharing situational awareness across a distributed heterogeneous team to enable improved decision making and rapid team reconfiguration; Will develop novel machine learning approaches to enable Soldiers to rapidly train artificial intelligence systems on simulated and physical platforms ***FY 2020 Plans:*** Will create novel technologies to identify gaps in common situational awareness between and among vehicle crew and intelligent agents. Perform soldier-based assessment of simulated technology concepts and soldier-focused experimentation. Assessment and experimentation will be performed in an operationally relevant, crew teaming environment. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned to the Soldier?AI Team Mission Planning for Dynamic Complex Environments and Human Augmentation for Collective Training efforts in this Project.	-	4.354	-	-	-
Title: Crew & Robotic Mission with Agent Technology ***Description:*** This effort focuses on the design, development and validation of hardware and software for establishing crew to robotic mission operator interactions to address full vehicle performance. Included are simulation tools and hardware for Soldier-in-the-loop testing including the Learning Warfighter Machine Interface (L-WMI), a seven-Soldier vehicle crew configuration command vehicle simulator; personalization of crew and	-	-	1.498	-	1.498

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 / *Crew Augmentation and Optimization Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
robotic operator configurations to permit reconfiguration for role, mission requirements and Soldier monitoring; optimization of vehicle crew interactions to permit sharing, reallocation and management of tasks, as well as situational awareness and data management. ***FY 2021 Base Plans:*** Will validate enhancements to the crew?s ability to plan missions and optimization of crew?s comprehension of crew interactions with unmanned systems by integrating the L-WMI onto a motion-based simulation platform. Will validate behavioral and communications-based Soldier state assessment approaches in an operationally-relevant, motion-based simulation environment. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the Crew Station / Closed Hatch Operations efforts in this Project.					
Title: Crew Capability Enhancement ***Description:*** This effort focuses on the dynamic interaction of Soldiers, responsible for both manned and unmanned ground vehicles, working together within a platoon formation. Research focuses on the simultaneous use of multiple technologies by Soldiers including transparent multi-modal user interfaces, commander?s tools for maintaining and enhancing situation awareness, decision aids for enabling dynamic resource allocation and orchestration, and tools to interact with and adapt vehicle based autonomy. Products will include artificial intelligence algorithms, information display technologies, and team-centric design principles. ***FY 2021 Base Plans:*** Will develop a concept for a Commander?s interface to demonstrate dynamic task reassignment across crew to enable crewmembers to manually share critical tasks as capabilities and mission needs change; investigate novel algorithms and communication protocols for developing, maintaining, and sharing situational awareness across a distributed Soldier-Artificial Intelligence team to enable improved decision making and rapid team reconfiguration. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the Crew Understanding Agents effort in this Project.	-	-	2.877	-	2.877
Title: Characterize Soldier-Adaptive AI Interactions ***Description:*** This effort develops approaches for characterizing Soldier interactions and overall human-system performance of mixed Soldier and intelligent-agent teams to enable robust human system performance for manned and unmanned teams. This effort will focus on flexible, tailorable methodologies for laboratory-grade,	-	-	2.443	-	2.443

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
high-resolution characterization of joint Soldier and Artificial Intelligence (AI) enabled intelligent-agent adaption in complex environments. ***FY 2021 Base Plans:*** Will create algorithms for characterizing crew behavior and adaptations; create algorithms for characterizing AI behavior and adaptations; develop initial advanced techniques for integrating subject matter expertise with machine learning approaches for characterizing intelligent-agent behaviors and adaptations. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the Agents Understanding Crew effort in this Project.					
Title: Human Augmentation for Collective Training ***Description:*** This effort investigates assessment techniques of crew performance to inform the development of individual and collective training for military vehicles. Assessment techniques will be applicable across a wide-variety of vehicle platforms, training tasks and vehicle crew roles. This effort will support training and increased force readiness of vehicle crews in complex environments by developing accurate and efficient performance assessment techniques evaluated in complex Operational Environments (OE) enabled by the latest advances in simulation and training technology. ***FY 2021 Base Plans:*** Will design and conduct laboratory experiments to investigate training and visual display concepts that improve coordination and communication in manned-unmanned teaming operations in experimental crew station environments. Will investigate and validate training methods using reconfigurable unmanned system command vehicle representative training system testbeds to support improved individual and crew adaptation to dynamic task-changing events and inform training system design for embedded and non-embedded training capabilities. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the Crew Understanding Agents and Joint Human-Agent Teamwork efforts in this Project.	-	-	2.254	-	2.254
Title: Platoon Teaming Capability ***Description:*** This effort focuses on the design, development and validation of intelligent, real-time, within-vehicle task management; data-driven allocation of situational awareness (SA) across platforms within the platoon; coordinated platoon-level manned-unmanned teaming (MUM-T) semi-autonomous maneuver with complex formations; and on-the-fly, platoon-level task optimization. This effort includes WMI modification to	-	-	1.339	-	1.339

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
evaluate these capabilities in application of intelligent task management and data-driven prediction of crew to support changing mission goals. ***FY 2021 Base Plans:*** Will validate interface for manual, pre-planned, cross-vehicle task reassignments by the team leader in order to enhance team performance based on crew status and mission objectives. Will conduct experiment utilizing limited semi-autonomous maneuver for unstructured off-road operations in a motion-based simulation environment. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 work in this effort is realigned from the Crew Station / Closed Hatch Operations effort in this Project.					
Title: Soldier?AI Team Mission Planning for Dynamic Complex Environments ***Description:*** Planning in multi-domain operations environments is complex and has increased temporal and spatial sensitivities for Soldiers to integrate with AI systems to plan missions. This effort provides the fundamental concepts and technologies to enable Soldiers and AI systems to team together to plan for multi-domain operations from a ground vehicle perspective. This effort focuses on planning enablers to maximize manned-unmanned team performance across squads and platoons and includes crew station-based emerging technologies in the areas of human- interaction with AI technologies and human-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 forming mission plans. ***FY 2021 Base Plans:*** Will conduct experiments to augment Learning Warfighter-Machine Interface capabilities to include enhanced mission planning capabilities that account for the relationship between terrain and environmental features as well as crew performance across multiple manned and unmanned ground vehicles. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the Joint Human-Agent Teamwork effort in this Project.	-	-	1.251	-	1.251
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	-	-	2.434	-	2.434

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
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 resources of the Soldier-AI team are focused appropriately to ensure mission success. ***FY 2021 Base Plans:*** Will design and develop Commander?s interface to enable dynamic task reassignment across crew to provide capability of crew members to manually share critical tasks as team capabilities and mission needs change; investigate novel algorithms and communication protocols for developing, maintaining, and sharing situational awareness across a distributed heterogeneous team to enable improved decision making and rapid team reconfiguration. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the Agents Understanding Crew effort in this Project.					
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 systems to the Soldier. This effort 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 2021 Base Plans:*** Will investigate novel approaches to characterize overall team cohesion in a distributed Soldier-AI team; and conduct experiments to examine approaches for quantifying a crew?s trust in AI-enabled autonomous systems. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the Agents Understanding Crew effort in this Project.	-	-	1.598	-	1.598
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. Two focus areas include enabling 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	-	-	3.328	-	3.328

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 / *Crew Augmentation and Optimization Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
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 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 2021 Base Plans:*** Will leverage data from multiple sensor systems and sensing approaches to improve robustness of real-time algorithms for understanding crew status, actions, intentions, and goals; investigate the ability for using information regarding crew behavior, physiology and interaction with intelligent agents to inform the development of novel approaches for assessing effectiveness of Soldier-AI teams; develop novel machine learning approaches to enable Soldiers to rapidly train AI systems on simulated and physical platforms. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the task Crew Understanding Agents effort in this Project.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	1.046	-	-	-
Accomplishments/Planned Programs Subtotals	-	23.027	19.022	-	19.022

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BF8 / *Artificial Intelligence & Machine Learning Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BF8: *Artificial Intelligence & Machine Learning Tech*	-	0.000	18.651	19.894	2.000	21.894	28.578	40.888	64.387	78.379	0.000	252.777

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602705 Electronics and Electronic Devices / EM8 High Power And Energy Component Technology
PE 0602120A Sensors and Electronic Survivability / TS2 Robotics Technology
PE 0602783A Computer and Software Technology / Y10 Computer/Info Sci Tech

A. Mission Description and Budget Item Justification

This Project develops and characterizes artificial intelligence and machine learning software and algorithms to team with soldiers in support of fully autonomous maneuver of the Next Generation Combat Vehicle (NGCV)and other autonomous systems, both physical and non-embodied. Efforts develop capabilities for NGCV and other autonomous agents that increase autonomy, unburdening the soldier operator, with a high degree of survivability and lethality in a highly contested environment. This work also investigates power distribution and conversion technologies to provide compact, efficient, and high power capabilities for electrical and electro-mechanical loads supporting both mobile and stationary unmanned platforms. Research enables combat vehicles to rapidly learn, adapt, and reason faster than the adversary; accomplish missions in contested, austere and congested environments, characterized by lack of structure, adversarial actions, and minimal a priori knowledge; and provide force reduction through self-learning vehicles that can operate in complex militarily relevant environments. This Project also matures emerging research leading to potential technology development in areas of strategic importance to the Army by bringing competitively selected Universities with research 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 Army Futures Command.

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Advanced Distributed Power for Autonomous Platforms	-	1.395	-	-	-
Description: The effort investigates power distribution and conversion technologies to provide compact, efficient, and high power capabilities for electrical and electro-mechanical loads supporting both mobile and					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
stationary platforms. High voltage and intelligent control methods will be coupled with the ongoing research in autonomy technologies to provide advanced performance enhancements in mobility and capabilities for these platforms. Research on innovative electric machines covering both electrical generation and motor technologies will focus on providing efficient, power dense, fault tolerant generation and mobility capabilities. Research addresses current and future Army-unique power delivery challenges in compact autonomous air and ground platforms and provides increased mission effectiveness with reduced cognitive burden. ***FY 2020 Plans:*** Will investigate optimization methods and analytical techniques to provide mission effective energy management at the tactical unit level; will investigate control methods and circuitry that enable intelligent power control at the module and component levels within the power distribution system; will develop power-dense direct current (DC)-DC distribution hardware and software that autonomously manages power conversion and distribution. Methods to be considered include embedded sensors, machine learning, and energy flow analysis. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort is realigned in FY21 to PE 0622145A (Next Generation Combat Vehicle Technology) / BH5 (Platform Electrification and Mobility Tech) to better align the work being performed.					
Title: Scalable, Adaptive, and Resilient Autonomous Systems ***Description:*** This effort develops and matures emerging research in Artificial Intelligence/Machine Learning (AI/ML), human agent teaming, scalable and collaborative behaviors, embodied and embedded intelligence, and autonomous operations for next generation Army platforms in dynamic Army relevant environments, architectures, and missions. Specific focus will be on application of AI/ML to autonomous systems and human-intelligent agent teaming; scalable and collaborative behaviors in support of heterogeneous air and ground manned-unmanned teaming (MUM-T) operations; methods for embodied and embedded intelligence for increased understanding, manipulation, and reflexive maneuver through and interaction with dynamic environments; techniques for improved perception, decision making, and adaptive behaviors in contested environments for MUM-T; and new methods for testing and evaluating emerging technologies for intelligent and autonomous systems under Army relevant constraints and environments and in Army relevant architectures. ***FY 2020 Plans:*** Will develop architectures, algorithms, data sharing approaches, and control methodologies to enable scalable numbers of heterogeneous, air and ground intelligent systems to collaboratively perform (autonomous and semi-autonomous) maneuver foroperations. Will investigate methods, metrics, and tools to facilitate, simulate, and	-	7.194	4.505	-	4.505

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF8 / *Artificial Intelligence & Machine Learning Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
enable testing and evaluation of emerging approaches for individual and collaborative intelligent systems in Army relevant constraints and environments. ***FY 2021 Base Plans:*** Will investigate and develop methods for metric- and semantic-based world models as well as small unmanned aerial system and unmanned ground system coordinated maneuver; will validate AI/ML methods to enable tactically-informed behaviors and maneuver of autonomous systems under Army-relevant constraints and environments. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding is realigned in FY21 to Predictive Maintenance Project in PE 0622144A (Ground Technology) to represent application of AI/ML technology.					
Title: Context-Based Information Dynamics ***Description:*** This effort investigates techniques that integrate on-board and external information sources, and it applies ML analytic approaches to support automated intelligence analysis and decision making. The goal is to enable tactical agents to cooperatively share relevant and timely tactical information within a distributed environment. ***FY 2020 Plans:*** Will investigate intelligent approaches that are resilient to adversarial threats and to continuous learning threats and maximize soldier and agent situational awareness; investigate methods and models for complex or social event processing, with compact representations, efficient pattern evaluation, and mission-centric focus to accelerate reasoning and decision making; study self-aware characteristics of intelligent or non-stationary agents. ***FY 2021 Base Plans:*** Will investigate methods for using machine learning approaches to provide information mediation and transformation to identify approaches that address tactical dynamics and challenges of distributed intelligent command and control system interoperation. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Adjustment to economic assumptions.	-	2.248	2.149	-	2.149
Title: Heterogeneous Computing and Computational Sciences	-	1.620	1.508	-	1.508

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF8 / *Artificial Intelligence & Machine Learning Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: This effort researches and develops software algorithms to allow information processing across different computing hardware platforms. The goal of this research is to provide high performance computing and processing capabilities to the Soldier on the battlefield. ***FY 2020 Plans:*** Will develop resource constraints-aware heterogeneous adaptive computing abstractions, optimizations, and algorithms. Will develop AI/ML algorithms and models to build local decision making framework to enable intelligent computational off-loading and distributed computing under resource constrained and contested environments. Preliminary design and construction of an adaptive heterogeneous computing testbed that combines processors with varying capabilities and size, weight and power footprints to allow for exploration and optimization of Army tactical application processing. ***FY 2021 Base Plans:*** Will continue to develop adaptive computation algorithms for AI/ML processing at resource-constrained tactical edge for NGCV platforms, and to build local decision making framework to enable intelligent computational off-loading and distributed computing under resource constrained and contested environments. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Adjustment to economic assumptions.					
Title: Machine Learning with Constrained Resources ***Description:*** This effort will research new ML and reinforcement learning methods to address issues of statistically mismatched and incomplete information which must be annotated, collected, classified, and used for rapid decisions by joint intelligent agent- Human teams. In addition, multi-modal human interaction approaches will be investigated to ensure effective Soldier interactions and understanding of intent. The goal of this research is to enable joint human-intelligent agent decision making, optimizing the strengths of each in the decision process and creating an adaptive, agile team. This work applies research conducted in PE 0611102A (Defense Research Sciences) / AA6 (Robotics and Mobile Energy) and AA9 (Information and Networking). ***FY 2020 Plans:*** Will investigate novel on-line ML approaches that enable high-speed (similar to human speed) mobility of autonomous ground vehicles in complex environments on which the vehicle has not been previously trained	-	3.993	3.926	-	3.926

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
and by teaming with the soldier to accelerate algorithm training and provide dynamically changing goals for the autonomous ground vehicle. ***FY 2021 Base Plans:*** Will investigate novel machine learning approaches that allow trained models to be transferred between autonomous ground vehicles operating in similar domains; investigate algorithms that allow learned models to be developed from synthetic or offline training data; develop algorithms that allow autonomous ground vehicles to use semantic representations of the environment to navigate in complex environments; extend surrogate models for use of physical self-awareness for autonomous flight of unmanned aerial systems (UASs) to incorporate differing, static weather conditions, including pressure, wind-speed, and direction incorporating uncertainty in weather conditions; investigate the use of cyber agility and deception algorithms and methodologies as well as additional evasion defensive algorithms against Adversarial Machine Learning (AML) techniques in order to make tactical and enterprise systems resistant to attacks on their cyber defenses that rely on ML. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Adjustment to economic assumptions.					
Title: Ground Robotic Vehicle Mobility & Propulsion Technology ***Description:*** Applied research in ground robotic vehicle mobility and propulsion technologies to enhance intelligent vehicle performance (speed, acceleration, mobility, maneuverability, adaptability, etc.) and enable Army robotic platform maneuverability in complex terrain and environments. ***FY 2020 Plans:*** Will establish a novel AI/ML algorithm framework to improve vehicle maneuver performance in complex terrains, environments, and damage conditions. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned to the Intelligence for High Operational Tempo Maneuver effort within this Project.	-	1.354	-	-	-
Title: Intelligence for High Operational Tempo Maneuver ***Description:*** Applied research on intelligence for cognitive learning and control architectures to enable efficient and full use of embodied physical capabilities and create the machine intelligence required of autonomous systems to understand physical limitations. Investigates the means through which robotic physical performance attributes (e.g. speed, agility) will be coupled with artificial intelligence to enable resilient maneuver in high operational tempo missions in complex environments.	-	-	1.237	-	1.237

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF8 / *Artificial Intelligence & Machine Learning Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
FY 2021 Base Plans: Will investigate efficient algorithms that respond quicker to increase maneuver speed, agility, and adaptability of autonomous systems over complex terrain. Will establish cognitive and control architectures that enable closed-loop self-aware and resilient tactical teaming behaviors at high operational tempos. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the Ground Robotic Vehicle Mobility & Propulsion Technology effort within this Project.					
Title: Autonomous Mobility NGCV Challenge ***Description:*** Develop novel behaviors and algorithms for autonomous off-road mobility in tactical environments to meet capability needs of the Next Generation Combat Vehicle (NGCV). ***FY 2021 Base Plans:*** Will investigate novel algorithms for autonomous off-road navigation behaviors in complex environments at more operationally relevant speeds. Approaches will include learning from Soldier experimentation events to enable more tactically relevant behaviors with improved resiliency over current approaches. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This work is realigned in FY21 from PE 0602145A (Next Generation Combat Vehicle Technology) / BF6 (Crew Augmentation and Optimization Tech), BJ3 (Hydrogen Based Combat System Technology), and BI2 Sensor Protection Technology.	-	-	3.368	-	3.368
Title: Operational Assessment of Artificial Intelligence Developmental Systems ***Description:*** This effort supports the Combatant Commander's needs by performing operational assessments of AI-intense developmental weapon systems. ***FY 2021 Base Plans:*** None ***FY 2021 OCO Plans:*** Will begin an operational assessment of Artificial Intelligence developmental systems in support of a Combatant Commander identified need. ***FY 2020 to FY 2021 Increase/Decrease Statement:***	-	-	0.000	2.000	2.000

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
This effort is realigned from support to the Combatant Commanders.					
Title: Army Universities and Technical Alliances Collaboration ***Description:*** This effort conducts research leading to potential emerging technology development in areas of strategic importance to the Army in AI/ML and Robotics by bringing competitively selected Universities with research teams into Technical Alliances. The Technical Alliance collaborations consist of large collaborative hubs focused on developing and transitioning research in Army critical areas. Technical Alliances will be used to exploit opportunities to advance new capabilities through a sustained long- term multidisciplinary research effort. The primary focus of the Technical Alliances is expanding the frontiers of knowledge in research areas where the Army has enduring needs, and integrates state-of-the-art research programs at academic institutions to increase the supply of scientists and engineers to advance and optimize research within Army laboratories. ***FY 2021 Base Plans:*** Will investigate and research technologies for ground vehicles focusing on autonomy, AI/ML and robotics. Will research geospatially-enabled, autonomy-related machine learning technologies, advanced teaming, and navigation/routing necessary for the Ground Portfolio, NGCV and the Army Modernization Priorities. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding for this effort is realigned in FY21 to support Army Modernization priority efforts.	-	-	3.201	-	3.201
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.847	-	-	-
Accomplishments/Planned Programs Subtotals	-	18.651	19.894	2.000	21.894

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
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D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BF9 / *Sensors for Autonomous Operations and Surv Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BF9: *Sensors for Autonomous Operations and Surv Tech*	-	0.000	15.283	38.154	-	38.154	38.927	26.697	26.996	26.997	0.000	173.054

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602709A Night Vision Technology / H95 Night Vision and Electro Optic Technology

A. Mission Description and Budget Item Justification

This Project designs, and develops modular and adaptive sensor components, algorithms and machine learning/artificial intelligence tools which provide improved manned and unmanned ground vehicle situational understanding and enable aided target recognition (AiTR) and autonomous navigation in all environments.

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 Next Generation Combat Vehicle (NGCV), Soldier Lethality (SL), and Future Vertical Lift (FVL) Modernization priorities.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Sensors for Autonomous Operations and Survivability	-	14.589	-	-	-
Description: This effort will deliver sensor component technologies which greatly improve current and future uncooled thermal sensor performance through novel materials, new pixel designs and enhanced image processing, compression, and analysis capabilities. Research into novel multi-function digital read-out integrated circuits and other sensor components will provide embedded on-chip, non- uniformity correction, dynamic motion compensation, on-chip stabilization of infrared imagery and data compression with a significant reduction in data transmission requirements, greatly increased sensitivity of low size, weight, power and cost thermal sensors, and imaging capabilities through natural and manmade obscurants. This effort will research and develop threat cueing algorithms for unmanned aerial sensor borne electro-optic/infrared and ground penetrating radar sensors, and for ground vehicle based 360 degree sensors. This effort will investigate, develop and validate target detection and recognition algorithms with low false alarms rates and high probability of detection while on-					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF9 / *Sensors for Autonomous Operations and Surv Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
the-move. These components will enable sensor systems to provide vehicle borne and dismounted soldier situational understanding in all environments and improve lethality by reducing decision making timelines. ***FY 2020 Plans:*** Will develop on-chip non-uniformity correction to enable on-chip calibration pre-processing. Will mature digital read out integrated circuits with on-chip compression, enabling high resolution imaging within bandwidth constricted environments. Will design and develop dynamic on-chip compression of thermal imagery to allow for 10x reduction in data rate. Will investigate novel pixel designs using advanced Micro Electro-Mechanical Systems with low thermal mass and high thermal isolation to increase sensitivity. Will mature fabrication techniques and pixel design to reduce thermal mass to enable the read-out integrated circuit to read entire focal plane array (FPA) at once (snapshot) and enable increased frame rate. Will validate novel high sensitivity uncooled longwave infrared FPAs for low size, weight, power and cost applications and to address 360-degree situational awareness requirements. Will design and develop compact high resolution thermal imaging sensors with three-dimensional imaging algorithms to enable compact navigation and threat detection capabilities. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort is realigned in FY21 to the Advanced Sensors with Embedded Processing, Multi-Mission Payload, and Automated Threat Cueing efforts in this same Project.					
Title: Advanced Sensors with Embedded Processing ***Description:*** Designs and develops advanced, automated multi-spectral and multi-function sensor components, and image processing techniques with improved performance in all environments and against all threats to include low-contrast targets in camouflage or in degraded conditions to enable combined arms maneuvers in complex environments for NGCV via manned, optionally manned, and robotic platform applications. ***FY 2021 Base Plans:*** Will validate Digital Readout Integrated Circuit (DROICs) with high dynamic range and on-chip compression to enable high resolution imaging within bandwidth constricted environments. Will mature on-chip non-uniformity correction for electro-optical / infrared (EO/IR) sensor components. Will mature and demonstrate dynamic on-chip compression of thermal imagery to allow for up to 10x reduction in data rate. Will begin development of pixel designs using advanced Micro-Electro Mechanical System (MEMS) to increase sensitivity. Will mature compact high resolution uncooled thermal imaging sensors with integrated three-dimensional imaging algorithms to enable compact navigation and threat detection capabilities. Will investigate exploitable scene features and target signatures throughout visible to long wave infrared portions of the spectrum to aid in robust threat	-	-	26.495	-	26.495

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF9 / *Sensors for Autonomous Operations and Surv Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
detection through experiments during various times-of-day/night, sky irradiance, targets and backgrounds. Will investigate the environmental parameters and target properties governing target detectability by EO/IR sensors operating at differing wavelengths to identify optimal sensor configurations. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 funding from the Sensors for Autonomous Operations and Survivability effort is realigned to the Advanced Sensors with Embedded Processing effort in this Project as well as being increased to support Army Modernization Priorities.					
Title: Multi-Mission Payload ***Description:*** Investigates, designs and develops sensor payloads for ground vehicle based unmanned aerial system to detect line of sight, and beyond line of sight threats and complex obstacles such as personnel and vehicles in all environments. ***FY 2021 Base Plans:*** Will investigate and design unmanned aerial system (UAS) mountable polarized EO/IR sensors. Will conduct experiments co-registering EO/IR, and other modalities to determine design impact to detection performance. Will investigate various polarized sensor designs for vehicular, dismounted Soldier, and UAS mountable configurations enabling wider field of regard terrain coverage. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 funding from the Sensors for Autonomous Operations and Survivability effort is realigned to the Multi-Mission Payload effort in this Project.	-	-	5.988	-	5.988
Title: Automated Threat Cueing ***Description:*** Investigates, matures and validates novel image processing and threat recognition and detection methods to enable automated search and detection of open and concealed threats for cueing and target hand-off to maintain overmatch via speed in cluttered environments. ***FY 2021 Base Plans:*** Will develop threat cueing algorithms utilizing EO/IR, novel compact ground penetrating radar, and position sensors for on-the-move target detection and tracking. Will research novel two-dimensional and three-	-	-	5.671	-	5.671

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF9 / *Sensors for Autonomous Operations and Surv Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
dimensional based algorithms utilizing exploitable features and signatures of threats in close combat open terrain scenarios. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 funding from the Sensors for Autonomous Operations and Survivability effort is realigned to the Automated Threat Cueing effort in this Project.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.694	-	-	-
Accomplishments/Planned Programs Subtotals	-	15.283	38.154	-	38.154

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army										Date: February 2020		
Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*				Project (Number/Name) BG2 / *Modeling and Simulation for MUMT Technology*			
COST ($ in Millions)	**Prior Years**	**FY 2019**	**FY 2020**	**FY 2021 Base**	**FY 2021 OCO**	**FY 2021 Total**	**FY 2022**	**FY 2023**	**FY 2024**	**FY 2025**	**Cost To Complete**	**Total Cost**
BG2: *Modeling and Simulation for MUMT Technology*	-	0.000	3.966	3.397	-	3.397	11.054	11.277	7.846	7.846	0.000	45.386

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602784A (Military Engineering Technology) / T40 (Mob/Wpns Eff Tech).

A. Mission Description and Budget Item Justification

This Project develops Modeling and Simulation (M&S) tools and technologies to assess and improve freedom of movement for ground forces and supports vehicle developers by addressing challenges for robotic and ground vehicles. Through investigation and design, this project develops obstacle detection and classification algorithms for dynamic mobility hazards in urban and complex environments. This project develops tools to evaluate system performance reducing the need for physical testing including: real-time mobility decision support tools, vehicle-terrain interactive models for autonomous convoy operations, simulation tools for vehicle mobility in highly altered terrain, and M&S tools for predicting the performance of autonomous vehicles in a wide variety of weather and terrain conditions. These M&S technologies can be integrated across Army vehicle platforms as required.

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 Modernization Priority Next Generation Combat Vehicle (NGCV).

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

This effort is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Mobility in Complex Urban Environments	-	3.951	-	-	-
Description: This effort develops real-time mobility warning technology for manned and unmanned ground vehicles to include a real-time hardware-in-the-loop simulation environment to investigate autonomous vehicle maneuver, matures mobility obstacle detection algorithms, and refines near real-time mobility prediction software in the urban environment.					
FY 2020 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG2 / *Modeling and Simulation for MUMT Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Develop and improve a simulation environment to investigate autonomous vehicle maneuver; develop software to automatically detect mobility obstacles in near real-time and mature sensor fusion methods; and refine mobility algorithms for near real-time predictions. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned to the Simulation Tools for CoVeR effort within this Project to support the PE 0602145A (Next Generation Combat Vehicle Technology) / BF3 (Combat Vehicle Robotics (CoVeR)) Project.					
Title: Simulation Tools for CoVeR ***Description:*** This effort develops M&S capabilities to evaluate hardware and software technologies enabling battlefield autonomy in complex environments and adaptive learning algorithms for predicting mobility performance in challenging environments. ***FY 2021 Base Plans:*** Will develop M&S tools for autonomous vehicle design at the component level for successful maneuver in unstructured environments; will develop analytical tools for predicting autonomous maneuver performance in unstructured environments. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from the Mobility in Complex Urban Environments effort within this Project.	-	-	3.397	-	3.397
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.015	-	-	-
Accomplishments/Planned Programs Subtotals	-	3.966	3.397	-	3.397

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG2 / *Modeling and Simulation for MUMT Technology*

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BG6 / *Advanced Concepts for Active Defense Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BG6: *Advanced Concepts for Active Defense Technology*	-	0.000	53.469	45.983	-	45.983	43.081	47.203	47.651	49.626	0.000	287.013

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602601A Combat Vehicle and Automotive Technology
* Project C05 Armor Applied Research
PE 0602618A Ballistics Technology
* Project H80 Survivability and Lethality 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 the near, mid and far term. Work conducted in this Project will result in concepts for Adaptive and Cooperative Protection of ground combat vehicles. Additionally, research will focus on subcomponent/component models to predict performance of early concepts and the means to evaluate effectiveness on ground platforms. The Project will balance developments of active threat defeat measures with the necessary advanced passive and active components to provide solutions which will help meet the requirements of current and next generation ground tactical and combat vehicles.

This Project is coordinated with and transition to Projects in PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and builds upon weapon target interaction research in PE 0602144A (Ground Technology) and PE 0601102A (Defense Research Sciences) / Project AA7 (Mechanics and Ballistics).

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 Modernization Priority Next Generation Combat Vehicle (NGCV).

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

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Computational and Experimental Capability	-	4.565	6.532	-	6.532
Description: This effort will develop computational design tools as well as computational and experimental capabilities that support development of advanced protection systems. Such systems include passive, active and hybrid solutions for defeating (multiple) anti-armor threats and exploiting solid-dynamic, explosive-driven					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 / *Advanced Concepts for Active Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
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 2020 Plans:*** Will perform limited verification and validation assessments of computational capability; will transition impact mechanics computational models to DOE to further enhance armor design and experimental computational capability; continued improvement and transition of computational modeling and simulation capabilities to improve associated design tools; determine physical mechanisms that contribute to multi-material armor design by increasing imaging and velocity measuring diagnostic capability as well as design of novel experiments. ***FY 2021 Base Plans:*** Will increase computational modeling capability to predict performance of hybrid armor protection mechanisms during threat impact; develop machine learning methods for terminal effects interaction with protection mechanisms; develop diagnostic capability to capture three-dimensional x-ray imagery of experimental threat impacts. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: Multi-Threat Armor Technologies ***Description:*** This effort develops multi-threat hybrid armor technologies incorporating both active and passive mechanisms for ground vehicle systems that are effective against future conventional weapons and evolving improvised threats including kinetic and chemical energy as well as blast threats. ***FY 2020 Plans:*** Will computationally and experimentally explore novel passive, reactive, and active armor protection concepts in support of next generation combat vehicle protection; continue to improve understanding of hybrid armor multi-hit capabilities; continue to evaluate promising multi-threat armor designs utilizing hybrid electromagnetic armor/energetic technologies; explore top attack protection designs and potential mechanisms; develop active lightweight kinetic energy penetrator defeat mechanisms. Validate performance to Technical Readiness Level	-	9.110	7.214	-	7.214

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 / *Advanced Concepts for Active Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
(TRL) 4 for most promising designs for transition to PE 0603462A (Next Generation Combat Vehicle Advanced Technology). ***FY 2021 Base Plans:*** Will design armor mechanisms and technologies to defeat a wide range of threats to include medium and large caliber projectiles, anti-tank guided missiles, and rocket propelled grenades through the use of high performance computing, analytic modeling, and laboratory experiments; design an optimized vehicle hull concept that includes adaptive and active protection concepts for a combined threat suite through computational and experimental methods. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: Advanced Armor and Protection Technologies ***Description:*** This effort enables development of 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 ever-increasing protection. This effort funds research into the fundamental physics of new terminal effects concepts and provides a mechanistic understanding of threat platform interaction. The effort investigates the ability to analytically simulate complex threat interactions. Experiments will be conducted to validate the efficacy of the designs. ***FY 2020 Plans:*** Will develop lightweight armor for protection against Kinetic Energy (KE) and Chemical Energy (CE) threats. Will utilize advanced multi-physics computational tools developed under the computational experimental capability effort to conduct parametric analysis of threat-target interactions. The results of this analysis will aid the design of advanced armor concepts that will undergo physical experimentation (ballistic testing) to validate performance. The most promising concepts will be further developed and transitioned to PE 0603462A (Next Generation Combat Vehicle Advanced Technology) for component development and maturation. ***FY 2021 Base Plans:*** Will design and develop armor technologies to defeat top-attack munitions using modeling, simulation, and experimental techniques; conduct experiments to explore electro-magnetic protection mechanisms and	-	5.683	7.217	-	7.217

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 / *Advanced Concepts for Active Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
associated physics for armor technologies and use modeling and simulation in conjunction with the experimental results to evaluate the integration of multiple technologies to provide electro-magnetic protection mechanisms. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: Adaptive and Cooperative Protection ***Description:*** This effort pursues a holistic approach toward achieving significant weight reduction and protection from future threats by utilizing real-time information, combined with threat knowledge, to provide ever-increasing protection. This approach includes integrating individual vehicle capabilities of armor, underbody blast protection, active protection systems, and advanced soft kill methods into one layered solution to maximize survivability and minimize weight for combat and tactical vehicles. This effort will investigate modern protective technologies that implement complex kinematic mechanisms in order to bend, break and disperse threat projectiles before they can injure crew or disable vehicles. ***FY 2020 Plans:*** Will continue to mature selected adaptive armor mechanisms and conduct additional experiments against challenging threats; will continue to explore soft-kill countermeasures in conjunction with novel threat independent protection mechanisms coupled with an integrated threat warning sensor capability. ***FY 2021 Base Plans:*** Will design a countermeasure and launch mechanism to defeat anti-armor threat weapons implemented in a novel manner to increase protection coverage. Will utilize modeling, simulation, and experimental capabilities to develop adaptive armor protection mechanisms to defeat current and emerging threats. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	-	9.663	11.808	-	11.808
Title: Emerging Overmatch Technologies ***Description:*** This effort supports the development and demonstration of lethality and protection concepts that re-establish overmatch for the next generation of manned and unmanned combat platforms. It will tightly couple scientific research within a campaign of learning to form technology concepts for battlefield domination against current and future threats. This research will heavily leverage other efforts within PE 0602145A (Next Generation Combat Vehicle Advanced Technology) and PE 0603462A (Next Generation Combat Vehicle Advanced Technology).	-	1.752	2.216	-	2.216

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 / *Advanced Concepts for Active Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
FY 2020 Plans: Will evaluate coupled lethality and protection concepts; will continue to explore advanced protection and lethal mechanisms to enhance the next generation combat vehicle and small autonomous systems. ***FY 2021 Base Plans:*** Will conduct validation experiments to determine the effects of coupling of autonomy protection and lethality concepts. Will partner with The Research and Analysis Center (TRAC) to conduct Advanced Warfighting Simulation scenario iterations and evaluate combat effectiveness of these concepts. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: Survivability/Lethality/Vulnerability Analysis Tools and Methodology ***Description:*** This effort devises state-of-the-art survivability/lethality/vulnerability methodologies to dynamically model the interaction of conventional ballistic threats against future weapon systems. ***FY 2020 Plans:*** Will develop indirect and precision fire vulnerability and lethality models by investigating methodologies to provide sensitivity analyses on burst height, angle of fall, azimuth and elevation including lethal mechanisms and collateral hazards. Will examine physics-based finite element vulnerability and lethality models by exploring enhanced methods and tools for analysis of underbody threats, blast effects, fire, and combined effects. Will develop personnel vulnerability modeling by investigating models of variability in human morphology and anatomy, including the standard 95th percentile male and female warfighter. Will refine advanced visualization and interactive modeling techniques by developing scene-based models (including terrain) of multiple, complex engagements. ***FY 2021 Base Plans:*** Will complete development and validation of lethality and vulnerability analysis methods that account for multi-hit effects; models will be tailored to assess NGCV weapon systems and effects of direct fire ammunition on NGCV protection technologies; refine and demonstrate effectiveness of smart NGCV munitions in contested and degraded environments of multi-domain operations; investigate vulnerabilities of Artificial Intelligence associated with cognition capabilities provided by sensors which can be degraded when operating in contested environments and explore implications of these vulnerabilities on machine learning performance; investigate the	-	4.768	5.248	-	5.248

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 / *Advanced Concepts for Active Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
implications of vulnerabilities to robotic combat vehicles on manned-unmanned teaming performance; validate models for active protection systems and extend them to investigate adaptive protection systems. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: Warrior Injury Assessment Manikin (WIAMAN) ***Description:*** This Project develops an improved demonstrator blast test manikin, data acquisition system, and injury prediction methods and tools that incorporate new medical research and which provides an improved capability to measure and predict skeletal injuries for vehicle occupants during under-body blast events. ***FY 2020 Plans:*** Will perform experimental testing and validation of WIAMAN performance. Additional match pair testing will be conducted to confirm Advanced Technology Demonstration (ATD) performance to cadaveric specimens. Subcomponent and component certification testing will be completed to confirm data reliability. ATD performance experiments will be conducted to validate performance to requirements. The development of Finite Element Model tools will be completed and validated to allow for accurate pre-shot predictions. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Effort completes in FY20.	-	1.136	-	-	-
Title: Ground Systems Active Defense Technology Research ***Description:*** This effort contributes to the Army's ground vehicle survivability by developing technologies which electronically or physically defeat an incoming threat before it contacts the vehicle. These technologies involve sensors and effectors interacting with an incoming threat to disrupt or destroy in while it is in flight or before it is even fired at a vehicle. This effort designs and develops modern armors that directly complement and are optimized to work with active defense technologies in order to implement sophisticated mass efficient mechanisms and leverage investments in materials to act as a system for the defeat of advanced threats and active protection system residuals. This effort designs and develops active blast mitigation technologies to counter the effects of underbody attacks to ground vehicles. This effort will also design and develop the required advanced structures required to accommodate active blast mitigation technologies into vehicles. The design of the structure and active defense technology is critical to an effective blast survivability solution. ***FY 2020 Plans:***	-	14.370	5.748	-	5.748

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 / *Advanced Concepts for Active Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Will perform requirements definition and lab scale performance validation of a small flyout countermeasure. Will begin conducting research into component packaging and integration methods and concepts, including complementary base vehicle armor components to capture residual fragments from countermeasure engagements. Packaging and integration subcomponent tests will be conducted to feed design trade studies. Initial component designs for countermeasure and base vehicle armor will be developed and analyzed. Will design and develop an advanced soft-kill countermeasure technology. Will conduct testing to capture performance characteristics of the soft-kill countermeasure technology to validate the feasibility and effectiveness against advanced and emerging threats. Will build upon FY19 requirements definition and lab scale performance validation of advanced Improvised Explosive Device concepts and advanced active blast mitigation systems. Initial component designs will be developed and analyzed. ***FY 2021 Base Plans:*** Will conduct experiments to baseline current platform survivability solutions to determine effects of residual debris from an Active Protection System (APS) engagement on protection levels for ground platforms. Will investigate if residual debris impacts to explosive reactive armor introduces a vulnerability to ground vehicles. Will design armor solutions that balance requirements for protection from threat projectiles and APS residual projectiles and validate the concept to use armor and occupant protection technologies for vehicle survivability and soldier protection. Will develop test methods for evaluating occupant protection technologies to mitigate injuries resulting from APS engagement residual effects. Will leverage modeling and simulation to predict and potentially enhance performance of protection systems. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort was decreased to focus on more mature technologies and capabilities in PE 0603462A (Next Generation Combat Vehicle Advanced Technology) / BG7 (Ground Systems Active Defense).					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	2.422	-	-	-
Accomplishments/Planned Programs Subtotals	-	53.469	45.983	-	45.983

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 / *Advanced Concepts for Active Defense Technology*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BG8 / *Obscuration Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BG8: *Obscuration Technology*	-	0.000	4.070	2.620	-	2.620	2.675	2.729	2.758	2.786	0.000	17.638

Note

In Fiscal Year (FY) 2020 this Project was realigned from Program Element (PE) 0602622A Chemical, Smoke and Equipment Defeating Technology / 552 Smoke/Novel Effect Munitions

A. Mission Description and Budget Item Justification

This Project investigates and evaluates obscurant technologies that degrade threat force surveillance sensors and defeat the enemy's target acquisition devices, missile guidance, and directed energy weapons. This Project focuses on advanced infra-red and multi-spectral obscurant materials that provide effective, affordable, and efficient screening of deployed forces, while being safe and environmentally acceptable.

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 Modernization Priority Next Generation Combat Vehicle (NGCV).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Obscuration Technologies for Active Protection Systems	-	1.407	-	-	-
Description: This effort investigates dissemination technologies for various obscurants. ***FY 2020 Plans:*** Will conduct modeling and analysis of new vehicle protection concepts to determine effectiveness of obscurant dissemination. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding for this effort ends after FY20. Products are transitioned to PE 0603462 (Next Generation Combat Vehicle Advanced Technology) / BG7 (Ground Systems Active Defense Advanced Tech) for technology maturation.					
Title: Obscuration Enabling Technologies	-	2.478	2.620	-	2.620

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG8 / *Obscuration Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: This effort investigates new materials and compounds to enable safe, effective screening of personnel and equipment across the electromagnetic spectrum. This effort also provides vulnerability assessments against enemy threat systems. ***FY 2020 Plans:*** Will continue to mature and characterize advanced bi-spectral, advanced microwave, and spectrally selective obscurants. Will continue to investigate effects against various threat technologies (e.g., sensors, missile seekers) for various obscurants. ***FY 2021 Base Plans:*** Will validate packing and dissemination techniques for advanced obscuration materials including bi-spectral, advanced microwave, and spectrally selective obscurants . Will mature advanced bi-spectral materials for screening obscuration module. Will perform threat modelling for unmanned ground and aerial systems sensor systems. Will evaluate obscuration technologies against threat systems to determine probability-of-hit for vehicle platforms. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Adjustment to economic assumptions.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.185	-	-	-
Accomplishments/Planned Programs Subtotals	-	4.070	2.620	-	2.620

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG8 / *Obscuration Technology*

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BH2 / *C4ISR Modular Autonomy Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BH2: *C4ISR Modular Autonomy Technology*	-	0.000	4.874	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.874

Note

In Fiscal Year 2020 (FY20) this Project was realigned from:
Program Element (PE) 0602709A Night Vision Technology
* Project H95 Night Vision and Electro Optic Technology

In FY21 this Project will realign to:
PE 0602145A Next Generation Combat Vehicle Technology
* Project BF9 Sensors for Autonomous Operations and Surv Tech

A. Mission Description and Budget Item Justification

This Project researches and develops multifunction mission command, sensing, and communications technologies and approaches to enable the required Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) capabilities for autonomous and semi-autonomous platforms. Efforts support Manned/Unmanned Teaming and combined arms maneuver in complex environments.

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 Modernization Priority Next Generation Combat Vehicle.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: C4ISR Modular Autonomy Technology	-	4.653	-	-	-
Description: Investigates and matures embedded processing algorithms utilized in soldier systems and platforms to improve the warfighter?s decision efficiency and ability to perform Intelligence, Surveillance, and Reconnaissance (ISR), Target identification and discrimination					
FY 2020 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH2 / *C4ISR Modular Autonomy Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Will develop foundational signal and image processing algorithms; will build algorithm framework to support cognitive autonomous processing; will identify functions to assist human operators. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** The funding in this effort is realigned in FY21 to BF9 (Sensors for Autonomous Operations and Surv Tech) in this same PE for higher priority modernization needs .					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.221	-	-	-
Accomplishments/Planned Programs Subtotals	-	4.874	-	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BH5 / *Platform Electrification and Mobility Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BH5: *Platform Electrification and Mobility Tech*	-	0.000	10.024	21.275	-	21.275	19.989	16.221	13.580	18.689	0.000	99.778

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602601A Combat Vehicle and Automotive Technology / H91 Ground Vehicle Technology / H77 National Automotive Center

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 Project also continues the Advanced Vehicle Power Technology Alliance (AVPTA) between the Department of Energy and the Department of the Army with a focus on energy storage for electrification, providing an emphasis on developing advanced technologies that enable military ground vehicles to become significantly more energy efficient. The Alliance is chartered to accelerate the conceptualization and transition into deployment of inventive and creative energy-saving concepts that the Nation needs to achieve energy security. This Project researches energy storage technologies in support of lighter military vehicles which are more fuel-efficient and expeditionary with superior mobility and protection of both vehicles and occupants.

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: AVPTA - Energy Storage	-	0.762	-	-	-
Description: This effort develops and matures advanced energy storage technologies to improve power and energy performance and safety for vehicles. Higher energy stored with less space and weight increases vehicle efficiency and range. Ensures electrified ground vehicles have enough power for mobility, silent watch, and enables energy based capabilities including electromagnetic armor and directed energy weapons.					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH5 / *Platform Electrification and Mobility Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
FY 2020 Plans: Research energy storage, battery chemistry and packaging technologies to determine approach that can be developed to meet the needs of hybrid and all-electric drive combat and tactical platforms. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned to PE 0603462A (Next Generation Combat Vehicle) / BH6 (Platform Electrification and Mobility Advanced Technology).					
Title: Novel Propulsion Research ***Description:*** This effort performs research to assess and evaluate the optimal electrified propulsion system configuration for future military tactical and combat ground vehicle applications. This effort will investigate and model parallel hybrid-electric, series hybrid-electric, fuel cell and all-electric propulsion systems for the future military vehicle applications. Research is required to understand how electrified propulsion may impact future fleet mobility requirements, soldier operational scenarios, operational energy reduction, enablement of future lethality and defensive systems, sensors, and ancillary electrical loads. Novel propulsion systems such as fuel cells, high speed diesel engines, mega-watt generators, quad sprocket tracked and multi-drive wheeled mobility, as well as the logistic support and infrastructure requirements will be investigated. ***FY 2020 Plans:*** Will perform comprehensive research of novel propulsion system configurations for future military tactical and combat ground vehicle applications. Will explore current and future military requirements, potential novel propulsion system technology, component maturation, performance modeling, simulated soldier operational scenarios, Joint Operational Energy Initiative assessments, and logistical support. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned to PE 0603462A (Next Generation Combat Vehicle) / BH6 (Platform Electrification and Mobility Advanced Technology).	-	1.476	-	-	-
Title: Platform Electrification and Mobility Research ***Description:*** This effort develops technologies required to electrify both manned and unmanned Next Generation Combat Vehicle platforms. The effort develops a modular and scalable electrification architecture. The effort develops technologies to increase electric power such as a high voltage/temperature generator, high power/ temperature power electronics, electric drive motors, and energy storage. Electrification of these	-	7.330	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH5 / *Platform Electrification and Mobility Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
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. ***FY 2020 Plans:*** Will develop and model an electrification architecture that supports hybrid, fuel cell and all-electric powertrains and that is scalable for both manned and unmanned tactical and combat vehicles. Will develops high voltage/ high temperature generator, power electronics, electric motor drives, and energy storage system. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 work in this effort is realigned to Scalable Electrification and Control Architecture Research, Platform Electrification Research, and Advanced Mobility Research efforts in this Project.					
Title: Scalable Electrification & Control Architecture ***Description:*** This effort develops the power distribution and control components to implement a common, scalable, electrified vehicle power architecture to enable advanced lethality and protection capabilities, fast vehicle charging from the grid, and silent mobility on combat platforms across light to heavy weight classes. This power architecture enables the hybrid electric, fuel cell electric, and all-electric powertrains. ***FY 2021 Base Plans:*** Will develop high voltage power distribution components that enable electrified powertrains. Will develop the high voltage power converter to enable advanced lethality/protection capabilities and high voltage battery storage. Will develop import/export power converter to enable fast vehicle charging from local power sources. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Work in this effort was conducted in the Platform Electrification and Mobility Research effort in FY20.	-	-	1.996	-	1.996
Title: Platform Electrification Research ***Description:*** This effort designs and develops the electric power generation, energy storage and electrified components and sub-systems required to electrify combat vehicles across light to heavy weight classes. ***FY 2021 Base Plans:*** Will design internal components for a high voltage power system electric generator and high power inverter. Will design electric drive motors. Will design thermal management system for a modular electrification architecture. Will design electric turret drive. Will investigate novel battery chemistries that could provide up to four times	-	-	11.752	-	11.752

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH5 / *Platform Electrification and Mobility Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
more energy storage density than current batteries. Will design and develop modules for a modular high voltage energy storage system. Will design mobility/silent watch range extender. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Work in this effort was conducted in the Platform Electrification and Mobility Research effort in FY20 and was also increased in FY21 to accelerate platform electrification capabilities for NGCV.					
Title: Advanced Mobility Research ***Description:*** This effort develops a lightweight composite running gear system for medium combat vehicle applications which offers significantly reduced system weight, maintenance, noise and vibration over conventional running gear systems. Advanced composite tracks coupled with low cost, low complexity suspension systems improve operational capability via increased mobility. ***FY 2021 Base Plans:*** Will research novel running gear systems using composite materials to reduce weight. Will investigate new joining methods for rubber band track connections. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Work in this effort was conducted in the Platform Electrification and Mobility Research effort in FY20.	-	-	3.396	-	3.396
Title: Advanced Distributed Power for Autonomous Systems ***Description:*** This effort develops technologies for electrification of both manned and unmanned Next Generation Combat Vehicle platforms. Electrification of these platforms enables advanced lethality and protection systems, reduced battlefield fuel consumption, and provides new capabilities such as burst acceleration, extended silent mobility, and silent watch. 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 high power/ temperature power electronics, magnetic gears, electric drive motors, and advanced artificial intelligence/ machine learning (AI/ML) enabled autonomous control components and power management. Investigation of advanced control methods at the module and conversion component levels provides an understanding of the impact AI/ML and energy usage tracking can have on power optimization and mission effectiveness. The research enables the integration of components? status and behavior into system level management algorithms that support manned and autonomous operations while providing modular and scalable electrification architectures. This effort also investigates magnetic gear technologies that do not have physical connections	-	-	1.563	-	1.563

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH5 / *Platform Electrification and Mobility Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
connected to electrical motors and generators to reduce size and weight with increased reliability and performance providing increased torque, speed and range. Results of the research informs the Novel Propulsion Research effort in this Project. ***FY 2021 Base Plans:*** Will perform experiments on electrical conversion design concepts from PE 0602145A (Next Generation Combat Vehicle Technology), Project BH7 (Enhanced VETRONICS Technology) to understand performance and operational parameters of the components; investigate techniques to improve power conversion component performance through advanced control techniques and methodologies; investigate methods to monitor energy use and losses in real time; analyze performance of power modules utilizing AI/ML control methods to experimentally determine performance improvement enabled by use of reinforcement machine learning algorithms; analyze performance of the 200:1 gear ratio magnetic gear; and initiate improvement for reduced weight design to determine performance envelope. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort is realigned in FY21 from PE 0602145 BF8 (Artificial Intelligence & Machine Learning Tech) Project to better align the work being performed					
Title: Power Electronic Components and Materials	-	-	2.568	-	2.568
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 and packaging, and power switch module thermal management. Investigation high voltage/high frequency power semiconductor materials and devices concentrates on efficient power switching under militarily relevant temperature ranges. 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 will inform the Novel Propulsion Research effort in PE 0602145A (Next Generation Combat Vehicle Technology) / BH5 (Platform Electrification and Mobility Technology). ***FY 2021 Base Plans:*** Will determine performance of Gallium Nitride based power device process enhancements through modeling and device performance analysis; develop fabrication processes to enable wide?band-gap and ultra-wide-band-gap semiconductor device technologies; incorporate magnetic material analysis algorithms to expand					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH5 / *Platform Electrification and Mobility Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
the design envelope for the parametric optimization simulation tool used in this effort; analyze and investigate the performance of metallic phase change thermal management techniques; determine performance of power module designs for 20 kiloWatts per Liter (kW/L) and 25 kiloWatts per kilogram (kW/kg) power ratings as well as examine concepts, designs, and processes to achieve objective goal of 40kW/L and 50 kW/kg power ratings. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from PE 0603462A (Next Generation Combat Vehicle) / BH7 (Enhanced VETRONICS Technology)					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.456	-	-	-
Accomplishments/Planned Programs Subtotals	-	10.024	21.275	-	21.275

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BH7 / *Enhanced VETRONICS Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BH7: *Enhanced VETRONICS Technology*	-	0.000	3.603	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.603

Note

In Fiscal Year 2020 (FY20) this Project was realigned from:
Program Element (PE) 0602601A Combat Vehicle and Automotive Technology
* Project H91 Ground Vehicle Technology
PE 0602705A Electronics and Electronic Devices
* Project EM8 High Power and Energy Component Technology

In FY21 this Project will realign to:
PE 0602145A Next Generation Combat Vehicle Technology
* Project BH5 Platform Electrification and Mobility Tech

A. Mission Description and Budget Item Justification

This Project addresses the development of materials and device designs for compact, high-efficiency, high-temperature, and high-power Army ground tactical and combat vehicles including hybrid-electric propulsion, electric power generation and conversion, and smart micro-grid power distribution. This Project investigates aluminum gallium nitride materials for high power applications.

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 Modernization Priority Next Generation Combat Vehicle (NGCV).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Electronic Components and Materials Research	-	3.439	-	-	-
Description: This effort investigates material, device and module technologies to reduce weight, volume and energy losses for ground tactical and combat vehicles electrification while providing enhanced mission effectiveness through smart operation. Technologies provide devices and modules for high power hybrid-electric					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH7 / *Enhanced VETRONICS Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
propulsion, electric power generation and conversion, and smart power distribution. Research addresses current and future Army-unique performance and operational requirements for ground vehicle mobility. ***FY 2020 Plans:*** Will investigate and characterize high-power devices that enable high-power density and efficient electrical propulsion, and electrification of ground vehicle sub-systems; will explore integration of metallic phase change thermal management techniques to manage electrical power module and component temperatures; will develop multi-discipline parametric optimization tool for power packaging; and will study advanced materials and device structures to determine the potential of utilizing AlGaN materials for high-power application to NGCV priorities. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort is realigned to PE 0602145A (Next Generation Combat Vehicle Technology) / BH5 (Platform Electrification and Mobility Tech) to better reflect the work to be conducted.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.164	-	-	-
Accomplishments/Planned Programs Subtotals	-	3.603	-	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army											Date: February 2020	
Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*				Project (Number/Name) BH9 / *Protection for Autonomous Systems Tech*			
COST ($ in Millions)	**Prior Years**	**FY 2019**	**FY 2020**	**FY 2021 Base**	**FY 2021 OCO**	**FY 2021 Total**	**FY 2022**	**FY 2023**	**FY 2024**	**FY 2025**	**Cost To Complete**	**Total Cost**
BH9: *Protection for Autonomous Systems Tech*	-	0.000	2.548	1.499	-	1.499	1.499	1.998	2.098	2.098	0.000	11.740

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602601A (Combat Vehicle and Automotive Technology) / C05 (Armor Applied Research)

A. Mission Description and Budget Item Justification

This Project analyzes the emerging requirements for the protection and survivability of future autonomous combat platforms. Studies will be conducted at both the platform and force level to identify unique survivability needs of these platforms. It will also mature component technologies to address identified capability gaps.

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 Modernization Priority Next Generation Combat Vehicle (NGCV).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2019**	**FY 2020**	**FY 2021 Base**	**FY 2021 OCO**	**FY 2021 Total**
Title: Protection for Autonomous Systems	-	2.432	1.499	-	1.499
Description: This effort contributes to the Army's ground platform risk reduction efforts which that seek to address technical challenges of survivability and protection for autonomous systems. Specifically, this effort focuses on developing protection concepts for unique unmanned systems to ensure autonomous ground vehicles can continue their mission in contested environments.					
FY 2020 Plans: Will determine the potential vulnerabilities to an autonomous ground combat vehicle through modeling and simulation using physics-based tools. Will develop the capability to validate those vulnerabilities in a laboratory environment.					
FY 2021 Base Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH9 / *Protection for Autonomous Systems Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Will evaluate the vulnerability of autonomous ground system components such as sensors, enabling autonomous maneuver against threats to include electromagnetic effects. Evaluation will be conducted in order to understand potential threat-based mission impacts and degraded operation of unmanned system components to inform future hardening activities for military applications. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding reduced for higher priority NGCV efforts.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.116	-	-	-
Accomplishments/Planned Programs Subtotals	-	2.548	1.499	-	1.499

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BI2 / *Sensor Protection Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BI2: *Sensor Protection Technology*	-	0.000	10.584	10.340	-	10.340	10.599	10.822	10.952	10.953	0.000	64.250

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) PE 0602120A Sensors and Electronic Survivability / H16 S3I Technology
PE 0602705A Electronics and Electronic Devices / H94 Elect and Electronic Dev
PE 0602712A Countermine Systems / H35 Camouflage & Counter-Recon Tech

A. Mission Description and Budget Item Justification

This Project investigates, designs, and develops techniques for masking friendly force capabilities and intentions. The Project pursues technologies to reduce the susceptibility of sensor systems to detection and targeting by threat forces, as well as to inform the development of next generation signature reduction schemas. This Project also designs, investigates, fabricates, evaluates 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. Technologies investigated include novel optics designs combined with signal processing, spectral filtering, and threat sensing algorithms.

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 Next Generation Combat Vehicle, Soldier Lethality, and Future Vertical Lift modernization priorities.

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

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology), PE 0603118A (Soldier Lethality Advanced Technology), PE 0603465A (Future Vertical Lift Advanced Technology), and PE 0602143A (Soldier Lethality Technology)

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Sensor Protection Technology	-	6.448	6.189	-	6.189

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BI2 / *Sensor Protection Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: This effort will design and develop component technology to improve protection of sensors and sensor electronics from threats via techniques to harden optics, reduce sensor optical cross sections, novel coating approaches, filter improvements, and emerging signature reduction schemas. ***FY 2020 Plans:*** Will mature emerging optical window technologies to reduce the amount of laser energy arriving on a thermal sensor before it has a chance to reflect off of the focal plane array. Will investigate novel threat reduction technologies to protect emerging high sensitivity uncooled longwave infrared sensors. Will determine mobile camouflage system susceptibility to electro-optic/infrared cameras. ***FY 2021 Base Plans:*** Will investigate new protective sensor coatings that maximize transmission for sensor frequency bands while minimizing energy transmission of other frequencies including lasers to protect sensor components while still meeting environmental performance and durability requirements. Will develop and evaluate new designs to reduce optical cross section (OCS) and resist sensor damage for emerging large format electro-optical/infrared focal plane arrays. Will evaluate concealment performance of camouflage technologies in all environments against reflective, emissive, and radar threat sensors. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is reduced to support Army modernization priorities.					
Title: Laser Protection Technologies ***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 man-made 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. ***FY 2020 Plans:*** Will investigate tunable mid-wave infrared filter designs and improve tunable long-wave infrared filters based on previous experiments; will improve multi-chromophore solid-state optical limiter to increase operational	-	3.655	4.151	-	4.151

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BI2 / *Sensor Protection Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
bandwidth; will investigate pulsed wave laser limiter concepts in the mid-wave infrared; and will improve high-power continuous wave laser protection concepts. ***FY 2021 Base Plans:*** Will analyze results of study previously conducted on threats to sensor systems and develop optical system protection concepts to mitigate the impact of the study findings; validate ultrashort laser sensor focal plane array damage protection materials; conduct high-power laser experiments to test protection concepts; investigate the capabilities of tunable infrared filters coupled with shape memory alloy shutters for protection of uncooled infrared sensors. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.481	-	-	-
Accomplishments/Planned Programs Subtotals	-	10.584	10.340	-	10.340

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BI4 / *Materials Application and Integration Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BI4: *Materials Application and Integration Tech*	-	0.000	8.313	7.689	-	7.689	7.819	7.972	8.057	8.058	0.000	47.908

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602105A Materials Technology / H84 (Materials
PE 0602601A Combat Vehicle and Automotive Technology / H77 National Automotive Center

A. Mission Description and Budget Item Justification

This Project designs, develops, fabricates and evaluates a variety of materials (e.g. metals, ceramics, polymers and composites) to enable more survivable, lighter weight vehicle armor, chemical and biological protection, armaments and electronics for the next generation combat vehicle. Research focuses on unique and /or novel materials properties, developing physics-based models, materials characterization techniques, non-destructive testing methods and advanced fabrication/processing methodologies to transition candidate solutions for maturity, scale-up, and integration into systems.

This Project also continues the Advanced Vehicle Power Technology Alliance between the Department of Energy and the Department of the Army with a focus on materials, providing an emphasis on developing advanced technologies that enable military ground vehicles to become significantly more energy efficient. The Alliance is chartered to accelerate the conceptualization and transition into deployment of inventive and creative energy-saving concepts that the Nation needs to achieve energy security. This Project matures and integrates lightweight materials and joining technologies in support of lighter military vehicles which are more fuel-efficient and expeditionary with superior mobility and protection of both vehicles and occupants.

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 Modernization Priority Next Generation Combat Vehicle.

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

Work in this Project leverages research from PE 0601102A (Defense Research Sciences) / Project AA7 (Mechanics and Ballistics) and 0602144A (Ground Technology) / Project BL1 (Materials and Manufacturing Research Technology). This work is also coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Lightweight Armor Materials and Processes for Vehicle Protection	-	3.782	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BI4 / *Materials Application and Integration Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: This effort conducts applied research to design, develop and evaluate lightweight armor materials and structures, investigate novel processing methodologies for cost effective manufacturing, use existing and emerging modeling and simulation tools to enable formulation of lightweight, frontal, and structural armor materials for current and future platform applications. This effort also explores ground vehicle structural mechanics and dynamics technologies to improve damage tolerance, durability, fatigue-resistance, and dynamic response (i.e., shock, vibration, harshness, and damping). ***FY 2020 Plans:*** Will investigate new metal alloys, including corrosion resistant magnesium alloys and lighter weight high hardness steels; will assess the causes of delayed cracking in high hardness steel armor by performing stress corrosion cracking characterization on a statistically significant number of armor plates; will develop novel composite design capabilities to enable improved, lightweight ballistic resistance using first principles methods and techniques. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort is combined with the Novel Armor Materials and Processes for Vehicle Protection effort in this Project to better reflect combat vehicle protection materials work.					
Title: Novel Armor Materials and Processes for Vehicle Protection	-	2.387	7.689	-	7.689
Description: Develop novel metal alloys and associated processes through the scale-up and exploitation of revolutionary new metal alloys, which have demonstrated capabilities to overcome traditional engineering trade-offs (e.g., strength and ductility) with exceptional high temperature stability. ***FY 2020 Plans:*** Will develop scalable processing methods for strengthened nanocrystalline iron materials and generate initial ballistic data; will investigate the processing of aluminum alloys with novel chemistries for the generation of hydrogen. ***FY 2021 Base Plans:*** Will investigate performance of nanocrystalline and novel high-hardness metal alloys, validating their use for ballistic protection applications; investigate corrosion-resistant magnesium alloys and validate for ballistic protection and structural applications. ***FY 2020 to FY 2021 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BI4 / *Materials Application and Integration Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
The Lightweight Armor Materials and Processes for Vehicle Protection effort is realigned into this effort to better reflect vehicle materials protection work.					
Title: Advanced Vehicle Power Technology Alliance Materials ***Description:*** This effort develops and matures lightweight materials and joining technologies to enable lighter, more fuel-efficient tactical and combat vehicles with superior mobility and protection of both vehicles and occupants. Lighter materials and advances in joining technologies such as multi-material and dissimilar material joining will lead to lightweight military vehicle structures. ***FY 2020 Plans:*** Will continue to develop lightweight materials such as iron, manganese, aluminum (FeMnAl) alloy; magnesium and high strength aluminum alloys; will validate material and component performance through experiments on manufacturability, blast/ballistic performance, machinability, weldability, corrosion and stiffness; will investigate and develop solid state joining methods such as friction stir dovetailing and scribing for joining dissimilar materials; will develop, characterize and validate innovative weld wire materials for joining high strength aluminum alloys and advanced high strength steels; will Investigate emerging breakthrough techniques in dissimilar material joining. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort is realigned in FY21 to PE 0603462A (Next Generation Combat Vehicle Advanced Technology) / BI5 (Materials Application and Integration Adv Tech).	-	1.767	-	-	-
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.377	-	-	-
Accomplishments/Planned Programs Subtotals	-	8.313	7.689	-	7.689

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BI4 / *Materials Application and Integration Tech*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BI9 / *Vehicle System Security Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BI9: *Vehicle System Security Technology*	-	0.000	2.951	2.777	-	2.777	2.827	2.253	2.125	3.572	0.000	16.505

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602601 Combat Vehicle and Automotive Technology:
* Project H77 National Automotive Center

A. Mission Description and Budget Item Justification

This Project develops ground vehicle cyber protection and resilience technologies to increase the cybersecurity of ground vehicles and ensure their continued operation in near-peer cyber contested environments. This Project will develop cybersecurity technologies at the vehicle platform level to defeat cybersecurity threats and maintain assured vehicle functionality and freedom of maneuver in the cyber warfighting domain. This effort is critical to address the continuous expanding vulnerability of military platforms to cyber threats due to their increasing reliance on computers, networks, data, digitization, and communications technology.

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 Modernization Priority Next Generation Combat Vehicle (NGCV).

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

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and 0602213A (C3I Applied Cyber).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Vehicle System Security Technology	-	2.817	2.777	-	2.777
Description: This effort develops cybersecurity technologies to defeat cybersecurity threats and maintain assured vehicle functionality and freedom of maneuver in the cyber warfighting domain. This effort develops technologies required to maintain operating tempo and overmatch capability during offensive digital attacks to ground vehicle systems. Additionally, the technologies developed will maintain critical vehicle functionality in peer and near-peer cyber-contested environments through robust cyber-defensive protections. The effort will also develop cyber-defensive technologies to mitigate risk of future and emerging enemy cyberattack vectors by designing highly assured systems with cybersecurity designed from the beginning.					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BI9 / *Vehicle System Security Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
FY 2020 Plans: Will develop quantifiable security and resiliency metrics to inform digital protection requirements for future ground vehicle capabilities; will develop an advanced data bus technology with embedded cyber-resilient defensive agents to protect against offensive and malicious attacks and ensure continued freedom of maneuver in the cyber warfighting domain; will develop resilient technologies for real-time threat detection and operation in near-peer cyber-contested environments. ***FY 2021 Base Plans:*** Will develop resilient runtime functionality in vehicle electronic components in a security centered databus and Vehicle Integration of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)/Electronic Warfare Interoperability (VICTORY) architecture-compliant security protocols. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.134	-	-	-
Accomplishments/Planned Programs Subtotals	-	2.951	2.777	-	2.777

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BJ2 / *Tactical and Navigation Lasers Sensors Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BJ2: *Tactical and Navigation Lasers Sensors Technology*	-	0.000	4.990	5.453	-	5.453	5.562	5.673	5.737	5.794	0.000	33.209

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602709A Night Vision Technology / H95 Night Vision and Electro Optic Technology

A. Mission Description and Budget Item Justification

This Project designs and develops novel laser sensor technologies which provide improved maneuver, lethality, and survivability capabilities via manned and autonomous navigation, adversary sensor threat detection, and target detection and designation in all environments. It will deliver novel laser technologies which will provide low Size, Weight, and Power (SWaP) laser sources for optical augmentation detection systems; and compact Laser Detection And Ranging (LADAR) sources for situational awareness and air and ground vehicle operations and navigation in all environments. This Project is a critical enabler for autonomous operations in environments where other imaging technologies are not sufficient.

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 Modernization Priority Next Generation Combat Vehicle (NGCV), Soldier Lethality, and Future Vertical Lift (FVL).

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

This effort is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology), 0603118A (Soldier Lethality Advanced Technology), 0603465A (Future Vertical Lift Advanced Technology), and 0602143A (Soldier Lethality Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Tactical and Navigation Lasers Sensors Technology	-	4.763	5.453	-	5.453
Description: This effort designs and develops novel low SWaP, compact, high peak power pulsed laser sources for optical augmentation detection systems; and compact LADAR sources for situational awareness and manned and unmanned air and ground vehicle operations and navigation in all environments.					
FY 2020 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BJ2 / *Tactical and Navigation Lasers Sensors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Will develop mid-wave infrared component technology and conduct field trial to evaluate range performance and optical detection capabilities. Will investigate laser detection and ranging applications to support autonomous vehicle operations. ***FY 2021 Base Plans:*** Will investigate emerging longwave infrared (LWIR) laser sources and integrate with a novel solid state laser in order to achieve a LWIR solution with sufficient power to meet battlefield needs. Will design and build brassboard demonstrator for evaluation in a laboratory environment. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.227	-	-	-
Accomplishments/Planned Programs Subtotals	-	4.990	5.453	-	5.453

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BJ3 / *Hydrogen Based Combat System Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BJ3: *Hydrogen Based Combat System Technology*	-	0.000	7.127	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.127

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602601A Combat Vehicle and Automotive Technology:
* Project H77 National Automotive Center

In FY21 this Project is realigned to:
PE 0602145A Next Generation Combat Vehicle Technology:
* Project BH5 Platform Electrification and Mobility Tech

A. Mission Description and Budget Item Justification

This Project focuses on developing the controls required to integrate multiple fuel cell stacks in order to generate sufficient electrical power for combat systems both for mobility and to enable future lethality, protection, communications and sensor capabilities. This Project also identifies and develops the solutions for generating and moving hydrogen in a battlefield environment, enabling vehicles to take advantage of the efficiencies of fuel cell 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 Modernization Priority Next Generation Combat Vehicle.

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

This effort is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Hydrogen Based Combat System Technology	-	6.803	-	-	-
Description: This effort develops the required fuel cell controls and hydrogen generation technologies required to leverage commercial development in hydrogen based fuel cells to create energy efficient combat and tactical systems.					
FY 2020 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BJ3 / *Hydrogen Based Combat System Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Will develop the controls strategy for combining multiple commercial fuel cell stacks into one combat vehicle power module; will develop an aluminum based hydrogen generation system that can provide hydrogen to vehicles effectively and efficiently. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort is realigned in FY21 to PE 0602145A (Next Generation Combat Vehicle Technology) / BH5 (Platform Electrification and Mobility Tech) to support Army Modernization Priorities.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.324	-	-	-
Accomplishments/Planned Programs Subtotals	-	7.127	-	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BJ7 / *Detection of Explosive Hazards Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BJ7: *Detection of Explosive Hazards Technology*	-	0.000	11.882	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.882

Note

In Fiscal Year 2020 (FY20) this Project was realigned from:
Program Element (PE) 0602712A Countermine Systems
* Project H24 Countermine Tech

In FY21 this Project will realign to:
PE 0602145A Next Generation Combat Vehicle Technology
* Project BF9 Sensors for Autonomous Operations and Surv Tech

A. Mission Description and Budget Item Justification

This Project designs and develops adaptive, modular sensing technologies for manned and unmanned vehicles with highly specialized emerging artificial intelligence/ machine learning tools for the autonomous detection of mines, minefields and improvised explosive devices (IEDs) in high clutter environments as well as technology to defeat near peer mines, minefields and IEDs in all environments. This effort is a critical enabler of future complex breach 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 Modernization Priority Next Generation Combat Vehicle, and Soldier Lethality.

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

Work in this Project is coordinated with PEs 0633462A (Next Generation Combat Vehicle Advanced Technology), 0603118A (Soldier Lethality Advanced Technology), and 0602143A (Soldier Lethality Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Detection of Explosive Hazards Technology	-	11.342	-	-	-
Description: This effort focuses on designing and developing novel component technology for detection and defeat of mines, minefields, IEDs and other explosive hazard threats for manned and unmanned vehicles.					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BJ7 / *Detection of Explosive Hazards Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Artificial intelligence and machine learning tools will be exploited to provide autonomous capabilities and enable increased survivability through greatly increased mine detection standoff ranges. ***FY 2020 Plans:*** Will design modular, adaptive, reduced size, weight and power explosive hazard (EH) detection payloads for incorporation on small unmanned aerial and ground vehicles; will determine sensor component performance against expected threats through collection and analysis of data from different standoff sensor combinations to include close-in sensors; will validate different sensor modalities to determine ideal component mix for EH detection in urban and arctic environments; will mature EH detection algorithms through their application against novel threat data sets; will validate sensor fusion using results of data collections will investigate techniques to exploit vulnerabilities of near peer EH threats. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort is realigned in FY21 to 0602145A (Next Generation Combat Vehicle Technology) / BF9 (Sensors for Autonomous Operations and Survivability Technology) for higher priority modernization areas.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.540	-	-	-
Accomplishments/Planned Programs Subtotals	-	11.882	-	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BJ9 / *Autonomous Mobility Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BJ9: *Autonomous Mobility Tech*	-	0.000	3.060	2.498	-	2.498	3.996	0.000	0.000	0.000	0.000	9.554

Note

Project BJ9 Autonomous Mobility Tech is a new start in Fiscal Year (FY) 2020.

A. Mission Description and Budget Item Justification

This Project designs and developsArtificial Intelligence and Machine Learning (AI/ML) technologies to increase autonomy and mobility to perform teamed operations with manned and unmanned air and ground vehicles in a military relevant environment through data collection on relevant platforms. Data collection investigates the usage of both simulation and live data. Simulation will provide a baseline to collect, clean, and analyze data that meets the need for developing algorithms to enable both intelligent formation control and Unmanned Aerial Systems (UAS) map input for unmanned ground vehicle Mobility. This Project will allow proper collection techniques, tools, and data to maximize embedded autonomy using ML and other AI methods before utilizing live data collection. The Project will use AI/ML techniques to develop intelligent formation control to be used on maintained roads and in complex terrain without the need for Global Positioning System. Data will be collected from mounted platforms utilizing special internal and external sensors to develop algorithms for exact positioning, undistributed formation control, and increased speeds of unmanned platforms. Also, the Project will use AI/ML techniques to develop intelligent autonomous ground platform planning through the use of UAS mapped areas. Data collected from the UAS will be converted to maneuverable information for manned ground platform with the identification of enemy positions, go/no-go areas, terrain classification, and optimal suggested paths.

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 Modernization Priority Next Generation Combat Vehicle (NGCV).

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

This work is coordinated with Program Element (PE) 0603462A (Next Generation Combat Vehicles Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Big Data Storage Techniques	-	2.891	-	-	-
Description: This effort develops techniques and technologies for storage of machine learning data sets to be used collaboratively for Army research.					
FY 2020 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BJ9 / *Autonomous Mobility Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Will develop automated data labeling/cleaning techniques across large amounts of data. Will examine and integrate storage requirements of different types of datasets into a unified system. Will integrate hardware and software components for the storage sub-system. Will integrate each step in storage process into a single pipeline for ease of access and use. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding decrease due to this effort completing in FY20 and realigning funding in FY21 to the Formation Control ? Novel Technique Investigation effort in this Project.					
Title: Unmanned Aerial Vehicle (UAV) Mapping ***Description:*** Develop a collaboration of UAV map input for ground vehicle mobility via artificial intelligence and machine learning. ***FY 2020 Plans:*** Will develop UAV and ground vehicle architectures for integration of artificial intelligence. Will integrate existing UAV and ground vehicle architectures into single architecture for collaboration and data passing. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding decrease due to this effort completing in FY20 and realigning funding in FY21 to the Formation Control ? Novel Technique Investigation effort in this Project.	-	0.030	-	-	-
Title: Formation Control ? Novel Technique Investigation ***Description:*** This effort focuses on performing the applied research needed to investigate cutting edge ML techniques to be used for advanced collaborative movement. Areas of investigation here look to advance the utility of ML mobility beyond the current, widely utilized algorithms to allow for more natural coordination of autonomous vehicles and Soldiers. ***FY 2021 Base Plans:*** Will perform thorough survey of cutting edge ML techniques, investigate the algorithms that apply to formation control, and conduct experiments to determine applicability to NGCV. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This funding increase is to conduct important groundwork for formation control and is realigned from the Big Data Storage Techniques and Unmanned Aerial Vehicle Mapping efforts in this Project.	-	-	2.498	-	2.498
Title: FY 2020 SBIR/STTR Transfer	-	0.139	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BJ9 / *Autonomous Mobility Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Description: Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638					
Accomplishments/Planned Programs Subtotals	-	3.060	2.498	-	2.498

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BK2 / *Virtual Prototyping Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BK2: *Virtual Prototyping Technology*	-	0.000	5.426	8.609	-	8.609	8.482	8.608	8.292	8.316	0.000	47.733

Note

Project BK2 Virtual Prototyping Technology is a new start in Fiscal Year (FY) 2020.

A. Mission Description and Budget Item Justification

This Project matures an integrated Virtual Prototyping capability that investigates Next Generation Combat Vehicle (NGCV) technology integration into a range of novel ground vehicle design concepts that will be analyzed and evaluated through virtual experimentation to provide engineering data and operational feedback to inform NGCV analysis and requirements. Designs and analyzes novel NGCV system level ground vehicle concepts by integrating advanced mobility, survivability, lethality, sensing and electrical/electronic technologies to address emerging and future advanced threats. This Project provides system level ground vehicle design concepts and performance analysis, assesses cost and performance trades, and provides real-time soldier feedback on technology performance for the Army's NGCVs. Technologies to be evaluated include high efficiency advanced powertrains, power generation, active protection systems, active blast, advanced lethality and robotic control and autonomy technologies. The NGCV virtual experiments provide an efficient means to give warfighters an up-front, virtual hands-on operational evaluation of next generation ground vehicle concepts and emerging technologies. The Virtual Prototyping results provide critical inputs to the Army's NGCV program by providing independent technical and operational performance results, as well as assessing trades for the Army's next generation of ground 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 Modernization Priority NGCV.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Virtual Prototyping	-	5.180	8.609	-	8.609
Description: This effort addresses technical and integration challenges in the areas of mobility, survivability, lethality, vehicle architecture, and systems integration for the Army's next generation of ground combat vehicles. Specifically, this effort focuses on developing integrated design concepts, performance analysis, identifying					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BK2 / *Virtual Prototyping Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
and assessing trade space, and conducting virtual operational experiments for the NGCV. The combination of technical performance and operational feedback provides insights ***FY 2020 Plans:*** WIll generate multiple novel NGCV manned and unmanned system level ground vehicle concepts, assess performance, and conduct soldier involved virtual experiments to provide operational feedback from warfighters on NGCV system designs and technology performance. ***FY 2021 Base Plans:*** Will design and develop new NGCV manned and unmanned ground vehicle concepts. Will integrate new advanced technology components such as lethality and protection systems in a virtual environment. Will conduct analyses, trade studies, and Soldier-in-the-loop virtual experiments to provide Warfighter feedback on design concepts and inform NGCV performance and suggest design paths to improve performance. Will partner with industry to generate additional NGCV ground vehicle design concepts to expand the investigation of enabling technologies and performance for NGCV. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Increased in FY2021 to expand collaboration with industry on the design and development of NGCV system level concepts.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.246	-	-	-
Accomplishments/Planned Programs Subtotals	-	5.426	8.609	-	8.609

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BK2 / *Virtual Prototyping Technology*

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BK3 / *Next Gen Intelligent Fire Control (NG-IFC) Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BK3: *Next Gen Intelligent Fire Control (NG-IFC) Tech*	-	0.000	1.050	4.196	-	4.196	0.999	0.999	0.000	0.000	0.000	7.244

Note

This Project, BK3 (Next Gen Intelligent Fire Control (NG-IFC) Tech), is a new start in Fiscal Year (FY) 2020.

A. Mission Description and Budget Item Justification

This Project will develop armament specific hardware, algorithms and architectures to support Next Generation Combat Vehicle (NGCV) with the necessary fire control on future manned and unmanned platforms.

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 Modernization Priority NGCV.

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

Work in this Project is related to and fully integrated with the efforts funded in PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Next Generation Intelligent Fire Control Technology	-	1.002	4.196	-	4.196
Description: This effort investigates image sets for computer vision algorithms, target acquisition validation schemes and experimentation of large caliber armament systems. ***FY 2020 Plans:*** Will conduct experiments with pre-shot hardware for future integration into unmanned ground vehicle system and develop common fire controller components. ***FY 2021 Base Plans:*** Will validate fire control system components and algorithms for implementing machine learning training; develop new algorithms and models to generate and validate prioritized target lists using documented battlefield metrics; and conduct experiments to collect fire control scenario data to support algorithm/model training and development. ***FY 2020 to FY 2021 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BK3 / *Next Gen Intelligent Fire Control (NG-IFC) Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
In FY21 funding in this effort is increased to support data collection for algorithm training for machine learning.					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.048	-	-	-
Accomplishments/Planned Programs Subtotals	-	1.050	4.196	-	4.196

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BK5 / *Adv Direct In-Direct Armament Sys (ADIDAS) Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BK5: *Adv Direct In-Direct Armament Sys (ADIDAS) Tech*	-	0.000	1.190	3.959	-	3.959	12.542	15.084	15.921	17.017	0.000	65.713

Note

Project BK5 Adv Direct In-Direct Armament Sys (ADIDAS) Tech is a new start in Fiscal Year (FY) 2020.

A. Mission Description and Budget Item Justification

This Project matures and conducts experiments on component technologies for large caliber direct fire light-weight armament systems that will exceed the current capability of 120mm direct fire and be optimized for future operational environment with cross-domain engagement capability. This Project also researches large caliber direct fire munitions to project overwhelming lethality while ensuring maneuver forces remains mobile and sustainable during close-combat engagements at extended ranges.

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 Modernization Priority Next Generation Combat Vehicle.

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

Work in this Project is related to and fully integrated with the efforts funded in PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and PE 0602141A (Lethality Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Advanced Direct In-Direct Armament System Technology	-	1.136	-	-	-
Description: This effort designs and develops technologies for large caliber direct fire light-weight armament systems that will exceed the current capability of 120mm direct fire cannons and be optimized for future operational environment, including dense urban, with cross-domain engagement capability. Specifically, this effort matures technologies for rapid fire on-the-move at all elevations (direct & indirect), compact ammunition design with advanced ignition, advanced recoil mitigation to reduce impulse and automated ammunition handling and reloading.					
FY 2020 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BK5 / *Adv Direct In-Direct Armament Sys (ADIDAS) Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Will investigate armament system configurations for high elevations and advanced recoil mitigation to reduce impulse. Will develop component technologies for ammunition handling and the primary weapon that support the configurations needed for high elevation and reduced impulse. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** This effort has been realigned to the Advanced Lethality ? Kinetic Energy (AL-KE) effort in this Project to better describe the work to be performed.					
Title: Advanced Lethality ? Kinetic Energy (AL-KE) ***Description:*** This effort designs and develops component technologies for large caliber direct fire light-weight armament systems that will exceed the current 120mm direct fire cannon performance for future operational environments, including dense urban, with multi -domain engagement capability. The component technologies that support rapid fire on-the-move (direct & indirect) engagements include: compact ammunition design with advanced ignition, reduced gun impulse on platform through advanced recoil mitigation techniques, and automated ammunition handling and reloading. ***FY 2021 Base Plans:*** Will investigate range-extending technologies for direct fire kinetic energy ammunition with increased propulsion efficiency; will design and develop direct fire kinetic energy cartridge technologies to defeat future threats to ground vehicle systems. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort has been realigned from Advanced Direct In-Direct Armament System Technology in this Project.	-	-	1.485	-	1.485
Title: NGCV Penetrator Technology for Decisive Lethality ***Description:*** This effort develops energy-efficient lethal mechanism technologies for next-generation warheads and projectiles for large-caliber ammunition launched from direct fire weapon systems that maximize the lethality against an array of targets and provide tactical advantage at extended ranges for next generation threats. The results of this research will provide the basis for the lethality required for the next generation of combat vehicles and enable the development of the next generation of ammunition to ensure lethal overmatch throughout the operational environment. ***FY 2021 Base Plans:***	-	-	2.474	-	2.474

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BK5 / *Adv Direct In-Direct Armament Sys (ADIDAS) Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Will develop kinetic energy penetrator concepts for next generation armament systems to enable decisive lethality capabilities for the next generation of combat vehicles including tanks and unmanned platforms. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** In FY21 this effort is realigned from PE 0602141A (Lethality Technology).					
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.054	-	-	-
Accomplishments/Planned Programs Subtotals	-	1.190	3.959	-	3.959

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / *Next Generation Combat Vehicle Technology*	Project (Number/Name) BP5 / *Ground Vehicle Technology (CA)*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BP5: *Ground Vehicle Technology (CA)*	-	0.000	44.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	44.500

Note

Congressional Interest Item funding provided for Ground Vehicle Technology.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Ground Vehicle Technology.

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 2019	FY 2020
Congressional Add: Prototyping Energy Smart Autonomous Ground Systems	-	10.000
FY 2020 Plans: Prototyping Energy Smart Autonomous Ground Systems		
Congressional Add: Highly Electrified Vehicles	-	5.000
FY 2020 Plans: Highly Electrified Vehicles		
Congressional Add: Additive Metals Manufacturing	-	3.000
FY 2020 Plans: Additive Metals Manufacturing		
Congressional Add: RPG and IED Protection	-	3.000
FY 2020 Plans: RPG and IED Protection		
Congressional Add: Modeling and Simulation	-	3.000
FY 2020 Plans: Modeling and Simulation		
Congressional Add: Structural Thermoplastics	-	3.000
FY 2020 Plans: Structural Thermoplastics		
Congressional Add: Advanced Materials Development for Survivability	-	10.000
FY 2020 Plans: Advanced Materials Development for Survivability		
Congressional Add: Autonomous Vehicle Mobility	-	7.500

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BP5 / *Ground Vehicle Technology (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020
FY 2020 Plans: Autonomous Vehicle Mobility		
Congressional Adds Subtotals	-	44.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A