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**Exhibit R-2, RDT&E Budget Item Justification:** PB 2021 Army **Date:** February 2020

<b>Appropriation/Budget Activity</b> 2040: <i>Research, Development, Test &amp; Evaluation, Army / BA 2: Applied Research</i>	<b>R-1 Program Element (Number/Name)</b> PE 0602601A / <i>Combat Vehicle and Automotive Technology</i>
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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	-	102.899	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	102.899
C05: <i>Armor Applied Research</i>	-	20.912	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	20.912
H77: <i>National Automotive Center</i>	-	11.721	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.721
H91: <i>Ground Vehicle Technology</i>	-	36.266	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	36.266
T26: <i>Ground Vehicle Technologies (CA)</i>	-	34.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	34.000

**Note**

In Fiscal Year (FY) 2020, this Program Element (PE) is realigned with continuity of effort to:  
 \* PE 0602145A (Next Generation Combat Vehicle Technology).

**A. Mission Description and Budget Item Justification**

This PE researches, designs, and evaluates combat and tactical vehicle automotive technologies that enable the Army to have a lighter, more survivable, more mobile and more deployable force. Project C05 (Armor Applied Research) investigates, researches, and evaluates advanced ground vehicle design and occupant protection technologies in such areas as armor concepts, ballistic defeat mechanisms, blast mitigation, survivability modeling and simulation (M&S), hit avoidance, kill avoidance, safety, sensors, counter measures, instrumentation, and survivability packaging concepts to achieve superior survivability/protection for Soldiers and military ground vehicles. Survivability technologies will be designed for integration into/with the Modular Active Protection System (MAPS). Project H77 (National Automotive Center), which was chartered by the Secretary of the Army to conduct shared government and industry, or "dual use", technology programs to leverage commercial investments in automotive technology research and development for Army ground combat and tactical vehicle applications. Project H91 (Ground Vehicle Technology) designs, matures, and evaluates a variety of innovative and enabling technologies in the areas of electrical power, thermal management, propulsion, mobility, power for advanced survivability, vehicle diagnostics, fuels, lubricants, water purification, intelligent systems, autonomy enabled systems, and other component technologies to enhance the mobility, power and energy, and reduce the logistic chain of combat and tactical vehicles. This PE executes the Army's Combat Vehicle Prototyping (CVP) program to mature, integrate, and demonstrate ground vehicle leap ahead technologies in support of future combat vehicles.

In FY18/FY19 work in this PE is related to, and fully coordinated with, PEs 0602105A (Materials Technology), 0602618A (Ballistics Technology, Robotics Technology), 0602705A (Electronics and Electronic Devices), 0602716A (Human Factors Engineering Technology), 0603005A (Combat Vehicle and Automotive Advanced Technology), 0603125A (Combating Terrorism Technology Development), 0603734A (Military Engineering Advanced Technology), and 0708045A (Manufacturing Technology). Beginning in FY20, work in this PE is related to, and fully coordinated with PE 0602145A (Next Generation Combat Vehicle Technology) and PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

Work in this PE is coordinated with the United States Marine Corps, the Naval Surface Warfare Center, and other ground vehicle developers within the Defense Advanced Research Projects Agency (DARPA) and the Departments of Energy, Commerce, and Transportation.

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<b>Appropriation/Budget Activity</b> 2040: <i>Research, Development, Test &amp; Evaluation, Army / BA 2: Applied Research</i>	<b>R-1 Program Element (Number/Name)</b> PE 0602601A / <i>Combat Vehicle and Automotive Technology</i>
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The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

The Ground Portfolio technology investments are creating a layered vehicle protection suite including Active Protection (Hard-Kill and Soft-Kill) capabilities supported by robust advanced armor (Enhanced Survivability).

<b>B. Program Change Summary (\$ in Millions)</b>	<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021 Base</b>	<b>FY 2021 OCO</b>	<b>FY 2021 Total</b>
Previous President's Budget	104.404	0.000	0.000	-	0.000
Current President's Budget	102.899	0.000	0.000	-	0.000
Total Adjustments	-1.505	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.505	-			

**Congressional Add Details (\$ in Millions, and Includes General Reductions)**

**Project:** T26: *Ground Vehicle Technologies (CA)*

- Congressional Add: *Program Increase - Duel-use Technology Programs*
- Congressional Add: *Program Increase - Advanced Materials Development for Survivability*
- Congressional Add: *Program Increase - High Electrified Vehicles and Infrastructure Connectivity*
- Congressional Add: *Program Increase - Structural Thermoplastics for Vehicles*
- Congressional Add: *FY 2018 NDAA SEC 825 MDAP Cost Overrun*

Congressional Add Subtotals for Project: T26

Congressional Add Totals for all Projects

	<b>FY 2019</b>	<b>FY 2020</b>
	9.000	-
	14.982	-
	4.000	-
	6.000	-
	0.018	-
Congressional Add Subtotals for Project: T26	34.000	-
Congressional Add Totals for all Projects	34.000	-

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<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2021 Army										<b>Date:</b> February 2020			
<b>Appropriation/Budget Activity</b> 2040 / 2					<b>R-1 Program Element (Number/Name)</b> PE 0602601A / <i>Combat Vehicle and Automotive Technology</i>					<b>Project (Number/Name)</b> C05 / <i>Armor Applied Research</i>			
<b>COST (\$ in Millions)</b>	<b>Prior Years</b>	<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021 Base</b>	<b>FY 2021 OCO</b>	<b>FY 2021 Total</b>	<b>FY 2022</b>	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025</b>	<b>Cost To Complete</b>	<b>Total Cost</b>	
<i>C05: Armor Applied Research</i>	-	20.912	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	20.912	

**Note**

In Fiscal Year (FY) 2020, the Project will be realigned to:  
Program Element (PE) 0602145A Next Generation Combat Vehicle Technology:

- \* Project BG6 Advanced Concepts for Active Defense Technology
- \* Project BH9 Protection for Autonomous Systems Tech

**A. Mission Description and Budget Item Justification**

This Project investigates, researches, and evaluates advanced ground vehicle design and occupant protection technologies in such areas as armor concepts, ballistic defeat mechanisms, blast mitigation, survivability modeling and simulation (M&S), improved situational awareness, hit avoidance, kill avoidance, safety, sensors for blast, crash and rollovers, instrumentation and survivability packaging concepts to achieve superior survivability/protection for Soldiers and ground combat and tactical vehicles. Survivability/protection technologies are being investigated to meet anticipated ground combat and tactical vehicle survivability objectives. Additionally, this project focuses on analysis, modeling, and characterization of potential survivability solutions that could protect against existing and emerging threats. This analysis is used to aid in the identification of technologies to enter maturation and development in PE 0603005A (Combat Vehicle and Automotive Advanced Technology) / Project 221 (Combat Vehicle Survivability).

This Project supports Army Science and Technology efforts in the Ground Maneuver portfolio.

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)**

	<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021</b>
<b>Title:</b> Advanced Armor Development:	9.826	-	-
<b>Description:</b> The objective of this effort is to design, integrate and validate performance of advanced armor systems to defeat single and multiple chemical energy (CE) and kinetic energy (KE) emerging threats for combat and tactical vehicles. These systems include base armor (small arms / medium caliber, opaque and transparent B-kits), applique armor (passive / reactive / active multi-threat C-kits), multifunctional armor, and adaptive and cooperative armors.			
<b>Title:</b> Blast Mitigation:	2.430	-	-
<b>Description:</b> This effort designs, fabricates and evaluates advanced survivability and protection capabilities, tools and technologies to improve protection against vehicle mines, improvised explosive devices (IEDs) and other underbody threats and crash events. This effort also designs and evaluates technologies purposed for protecting the occupant such as seats and restraints. Blast and crash mitigation technologies are further investigated and matured in such areas as active and passive			

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<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2021 Army		<b>Date:</b> February 2020		
<b>Appropriation/Budget Activity</b> 2040 / 2	<b>R-1 Program Element (Number/Name)</b> PE 0602601A / <i>Combat Vehicle and Automotive Technology</i>	<b>Project (Number/Name)</b> C05 / <i>Armor Applied Research</i>		
<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021</b>
exterior/hull/cab/kits, interior energy absorbing capabilities for seats, floors, restraints, sensors for active blast mitigating technologies and performance evaluation, M&S, experimentation and instrumentation.				
<b>Title:</b> Improved Situational Awareness for Ground Platforms <b>Description:</b> This effort investigates situational awareness (SA) technologies and architectures to improve occupant and vehicle survivability in all conditions and environments to include degraded visual environments (DVE) for ground vehicles. This effort also investigates and analyzes electronic architectures to enable the efficient integration of DVE systems such as intra-vehicle data and video networks, SA input/output devices, and associated software architectures and interfaces.		4.499	-	-
<b>Title:</b> Protection for Autonomous Systems <b>Description:</b> This effort investigates and develops materials, concepts, and devices to protect autonomous systems against emerging threats. This effort also evaluates methods to apply the advanced protection materials, concepts, and devices onto autonomous systems to prevent disabling or destroying sensors, electronics, and mechanical components, or physical exploitation of subsystems.		2.384	-	-
<b>Title:</b> Active Defense Technologies <b>Description:</b> This effort investigates, analyzes, and designs active hard-kill (physical countermeasure) and soft-kill (non-kinetic countermeasure such as electronic jamming or spoofing) protection Active Protection System (APS) components for future integration onto tactical and combat vehicle platforms. This effort also investigates, designs, and development active, modular components and controls for APS vehicle protection and associated architectures and interfaces.		1.762	-	-
<b>Title:</b> FY 2018 NDAA SEC 825 MDAP Cost Overrun <b>Description:</b> FY 2018 NDAA SEC 825 MDAP Cost Overrun		0.011	-	-
<b>Accomplishments/Planned Programs Subtotals</b>		20.912	-	-
<b>C. Other Program Funding Summary (\$ in Millions)</b> N/A				
<b>Remarks</b>				
<b>D. Acquisition Strategy</b> N/A				

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<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2021 Army										<b>Date:</b> February 2020		
<b>Appropriation/Budget Activity</b> 2040 / 2					<b>R-1 Program Element (Number/Name)</b> PE 0602601A / <i>Combat Vehicle and Automotive Technology</i>				<b>Project (Number/Name)</b> H77 / <i>National Automotive Center</i>			
<b>COST (\$ in Millions)</b>	<b>Prior Years</b>	<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021 Base</b>	<b>FY 2021 OCO</b>	<b>FY 2021 Total</b>	<b>FY 2022</b>	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
H77: <i>National Automotive Center</i>	-	11.721	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.721

**Note**

In Fiscal Year (FY) 2020, funding for this Project is realigned to Program Element (PE) 0602145A Next Generation Combat Vehicle Technology:

- \* Project BJ3 (Hydrogen Based Combat System Technology)
- \* Project BI9 (Vehicle System Security Technology)
- \* Project BH5 (Platform Electrification and Mobility Tech)
- \* Project BI4 (Materials Application and Integration Tech)

**A. Mission Description and Budget Item Justification**

This Project funds the National Automotive Center (NAC), which was chartered by the Secretary of the Army to conduct shared government and industry (dual use) technology programs to leverage commercial investments in automotive technology research and development for Army ground combat and tactical vehicle applications. Primary thrusts for this activity include advanced power and energy technologies for tactical and non-tactical ground vehicles, electric infrastructure and alternative energy for installations and bases, vehicle networking and connectivity to maximize overlap between commercial and military requirements. Active outreach to industry, academia and other government agencies develops new thrust areas for this Project to maximize shared commercial and government investment.

This Project supports Army Science and Technology efforts in the Ground Maneuver portfolio.

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

The Ground Portfolio technology investments are maturing powertrain technologies to provide a fuel efficient engine/power plant capability that is common across the fleet to reduce fuel, training, maintenance and parts requirements.

**B. Accomplishments/Planned Programs (\$ in Millions)**

	<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021</b>
<b>Title:</b> Power, Energy and Mobility:	4.224	-	-
<b>Description:</b> This effort investigates dual use power, energy, and mobility technologies leveraging commercial and academic investment to military application. This effort focuses on technologies such as lightweight composite materials, electrification of engine accessories, alternative fuels, hybrid vehicle architectures, and compact electrical power generation in order to maximize common investment to meet Army ground vehicle requirements.			
<b>Title:</b> Dual Use Technologies:	7.472	-	-

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<b>Appropriation/Budget Activity</b> 2040 / 2	<b>R-1 Program Element (Number/Name)</b> PE 0602601A / <i>Combat Vehicle and Automotive Technology</i>	<b>Project (Number/Name)</b> H77 / <i>National Automotive Center</i>

<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021</b>
<b>Description:</b> This effort investigates, researches and evaluates ground vehicle technologies with both military and commercial applications such as renewable energy technologies, electrical power management between vehicles and the grid, alternative fuels, new human machine interfaces, and advanced vehicle networking, automation, and secure communication (telematics). This effort maximizes commercial technology investment for military applications in line with the National Automotive Center's Charter. Collaborations with industry, universities and other government agencies on standards writing for joint applications will facilitate this activity.			
<b>Title:</b> FY 2018 NDAA SEC 825 MDAP Cost Overrun <b>Description:</b> FY 2018 NDAA SEC 825 MDAP Cost Overrun	0.025	-	-
<b>Accomplishments/Planned Programs Subtotals</b>	11.721	-	-

**C. Other Program Funding Summary (\$ in Millions)**  
N/A

**Remarks**

**D. Acquisition Strategy**  
N/A

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**Exhibit R-2A, RDT&E Project Justification:** PB 2021 Army **Date:** February 2020

<b>Appropriation/Budget Activity</b> 2040 / 2	<b>R-1 Program Element (Number/Name)</b> PE 0602601A / <i>Combat Vehicle and Automotive Technology</i>	<b>Project (Number/Name)</b> H91 / <i>Ground Vehicle Technology</i>
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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
H91: <i>Ground Vehicle Technology</i>	-	36.266	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	36.266

**Note**

In Fiscal Year (FY) 2020, this Project realigns to Program Element (PE) 0602145A Next Generation Combat Vehicle Technology:

- \* Project BH5 Platform Electrification & Mobility Tech
- \* Project BF1 Autonomous Ground Resupply Tech
- \* Project BF3 Combat Vehicle Robotics Tech
- \* Project BF6 Crew Augmentation and Optimization Tech

**A. Mission Description and Budget Item Justification**

This Project designs, develops, and evaluates a variety of innovative enabling technologies in the areas of vehicle concepts, virtual prototyping, electronic controls, electrical power, thermal management, propulsion, mobility, survivability, vehicle diagnostics, fuels, lubricants, water purification, intelligent systems, autonomy enabled systems, and other component technologies for application to combat and tactical vehicles.

This Project supports Army Science and Technology efforts in the Ground Maneuver portfolio.

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	FY 2021
<p><b>Title:</b> Propulsion and Thermal Systems:</p> <p><b>Description:</b> This effort researches, designs and evaluates high power density engines and transmission systems needed to offset increasing combat vehicle weights (armor), improved fuel economy (fuel cost &amp; range), and reduced cooling system burden (size, heat rejection). This effort also researches and matures thermal management technologies and systems including heat energy recovery, propulsion and cabin thermal management sub systems to utilize waste heat energy and meet objective power and mobility requirements on all ground vehicles. Lastly, this effort maximizes efficiencies within propulsion and thermal systems to reduce burden on the vehicle while providing the same or greater performance capability.</p>	5.909	-	-
<p><b>Title:</b> Power Management Technologies:</p> <p><b>Description:</b> This effort investigates power management technologies, software, and implementation approaches. Technologies include Alternating Current (AC) to Direct Current (DC) inverters, DC converters, solid state circuit protection, power distribution,</p>	2.586	-	-

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021</b>
and automated control of complete power systems. Special emphasis has been placed on developing high temperature capable power electronics, leading to the use of Silicon Carbide (SiC) in the above technologies.				
<p><b>Title:</b> Power Electronics, Hybrid Electric and Onboard Vehicle Power (OBVP) Components:</p> <p><b>Description:</b> This effort researches, develops and evaluates technologies to increase onboard vehicle electric power to enable vehicle systems such as advanced survivability systems, situational awareness systems, advanced computing, and the Army network. This effort researches, designs and evaluates high temperature and efficient power generation components to provide increased electrical power and reduced thermal loads using high operating temperature switching devices and advanced electrical generation components such as integrated starter generators and integrated starter alternators. This effort also researches, designs and evaluates advanced control techniques for power generation components to make these systems more efficient, increase electrical power output and reduce thermal loads.</p>		0.233	-	-
<p><b>Title:</b> Intelligent Systems Technology Research:</p> <p><b>Description:</b> This effort investigates improved operations of manned platforms through the application of sensing and autonomy technologies developed for unmanned systems such as maneuver and tactical behavior algorithms, driver assist techniques, autonomy kits, advanced navigation and planning, vehicle self-protection, local situational awareness, advanced perception, vehicle and pedestrian safety, active safety, and robotic command and control.</p>		9.919	-	-
<p><b>Title:</b> Energy Storage:</p> <p><b>Description:</b> This effort investigates novel advanced ground vehicle energy storage devices such as advanced chemistry batteries and ultra-capacitors for starting, lighting, and ignition and silent watch requirements for powering vehicle electronics and communications systems with main engine off. Develop and test energy storage devices to meet harsh military requirements that far exceed commercial requirements such as extreme temperature operation (46 to +71C), ballistic shock and vibration, and electromagnetic interference (in accordance with Military Standard 810G). Designs and develops advanced batteries to reduce battery volume and weight while improving battery energy and power densities within the same footprint and standardized form factor of current batteries (6T) to enhance logistics.</p>		2.451	-	-
<p><b>Title:</b> Crew Station</p> <p><b>Description:</b> 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 provision of cohesive domain personalization to permit soldiers to achieve leap ahead performance beyond today's constrained ground vehicle environment.</p>		4.690	-	-
<b>Title:</b> Unmanned Ground Systems Research		10.478	-	-

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021</b>
<b>Description:</b> This effort researches, designs, and develops technologies that enable scalable integration of multi domain teamed robotic and autonomous system capabilities supporting Army combat formations. Investigate behaviors and algorithms to mature functions that detect and classify risks and threats, reduce burden on the Soldier operator, and validate initial safety procedures for armed Unmanned Ground Vehicles (UGVs) in contested, austere and congested environments. Investigates increased situational awareness needed for a high degree of survivability and lethality for complex maneuvers. Mature government owned autonomy architecture to enable iterative software capability upgrades for systems. Conduct experiments in static environment with multiple live and simulated manned unmanned vehicles with evolving threats. Investigate behaviors and hardware needed to rapidly learn, adapt & reason faster than the adversary.			
<b>Accomplishments/Planned Programs Subtotals</b>	36.266	-	-

**C. Other Program Funding Summary (\$ in Millions)**

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

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**Exhibit R-2A, RDT&E Project Justification:** PB 2021 Army **Date:** February 2020

<b>Appropriation/Budget Activity</b> 2040 / 2	<b>R-1 Program Element (Number/Name)</b> PE 0602601A / <i>Combat Vehicle and Automotive Technology</i>	<b>Project (Number/Name)</b> T26 / <i>Ground Vehicle Technologies (CA)</i>
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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
<i>T26: Ground Vehicle Technologies (CA)</i>	-	34.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	34.000

**Note**

Congressional increase.

**A. Mission Description and Budget Item Justification**

Congressional Interest Item funding for Ground Vehicle Technology applied research.

**B. Accomplishments/Planned Programs (\$ in Millions)**

	FY 2019	FY 2020
<b>Congressional Add:</b> Program Increase - Duel-use Technology Programs	9.000	-
<b>FY 2019 Accomplishments:</b> Program Increase - Duel-use Technology Programs		
<b>Congressional Add:</b> Program Increase - Advanced Materials Development for Survivability	14.982	-
<b>FY 2019 Accomplishments:</b> Program Increase - Advanced Materials Development for Survivability		
<b>Congressional Add:</b> Program Increase - High Electrified Vehicles and Infrastructure Connectivity	4.000	-
<b>FY 2019 Accomplishments:</b> Program Increase - High Electrified Vehicles and Infrastructure Connectivity		
<b>Congressional Add:</b> Prohgram Increase - Structural Thermoplastics for Vehicles	6.000	-
<b>FY 2019 Accomplishments:</b> Prohgram Increase - Structural Thermoplastics for Vehicles		
<b>Congressional Add:</b> FY 2018 NDAA SEC 825 MDAP Cost Overrun	0.018	-
<b>FY 2019 Accomplishments:</b> FY 2018 NDAA SEC 825 MDAP Cost Overrun		
<b>Congressional Adds Subtotals</b>	34.000	-

**C. Other Program Funding Summary (\$ in Millions)**

N/A

**Remarks**

**D. Acquisition Strategy**

N/A