

**UNCLASSIFIED**

**Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army** **Date:** February 2016

<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>
--	---

COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	71.811	98.439	67.959	-	67.959	65.912	61.755	61.083	62.560	-	-
C05: <i>Armor Applied Research</i>	-	30.796	29.251	24.380	-	24.380	22.751	17.503	13.397	13.783	-	-
H77: <i>National Automotive Center</i>	-	15.371	15.738	15.936	-	15.936	15.359	16.322	19.369	19.761	-	-
H91: <i>Ground Vehicle Technology</i>	-	25.644	23.850	27.643	-	27.643	27.802	27.930	28.317	29.016	-	-
T26: <i>Ground Vehicle Technologies (CA)</i>	-	0.000	9.600	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
T31: <i>NAT'L AUTO CENTER APP RES INIT (CA)</i>	-	0.000	20.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

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

This Program Element (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 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, instrumentation and survivability packaging concepts to achieve superior survivability/protection for Soldiers and military ground vehicles. Additional efforts include design and develop enhanced technologies for active protection countermeasures against advanced and emerging threats, and will be designed in such a way that the technologies will be easily integrated into the established Modular Active Protection System (MAPS). Project H77 funds the National Automotive Center (NAC), 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 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.

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), 0603734 (Military Engineering Advanced Technology), and 0708045A (Manufacturing 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.

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

**UNCLASSIFIED**

**Exhibit R-2, RDT&E Budget Item Justification:** PB 2017 Army **Date:** February 2016

<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>
--	---

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

<b>B. Program Change Summary (\$ in Millions)</b>	<b>FY 2015</b>	<b>FY 2016</b>	<b>FY 2017 Base</b>	<b>FY 2017 OCO</b>	<b>FY 2017 Total</b>
Previous President's Budget	72.861	68.839	69.739	-	69.739
Current President's Budget	71.811	98.439	67.959	-	67.959
Total Adjustments	-1.050	29.600	-1.780	-	-1.780
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	29.600			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.500	-			
• SBIR/STTR Transfer	-1.550	-			
• Adjustments to Budget Years	-	-	-1.780	-	-1.780

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

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

Congressional Add: *Program Increase*

Congressional Add Subtotals for Project: T26

**Project:** T31: *NAT'L AUTO CENTER APP RES INIT (CA)*

Congressional Add: *Alternative Energy Research*

Congressional Add Subtotals for Project: T31

Congressional Add Totals for all Projects

	<b>FY 2015</b>	<b>FY 2016</b>
	-	9.600
Congressional Add Subtotals for Project: T26	-	9.600
	-	20.000
Congressional Add Subtotals for Project: T31	-	20.000
Congressional Add Totals for all Projects	-	29.600

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army										<b>Date:</b> February 2016		
<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 2015</b>	<b>FY 2016</b>	<b>FY 2017 Base</b>	<b>FY 2017 OCO</b>	<b>FY 2017 Total</b>	<b>FY 2018</b>	<b>FY 2019</b>	<b>FY 2020</b>	<b>FY 2021</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
C05: <i>Armor Applied Research</i>	-	30.796	29.251	24.380	-	24.380	22.751	17.503	13.397	13.783	-	-

**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 Program Element (PE) 0603005A, Project 221.

This project supports Army science and technology efforts in the Ground Maneuver portfolio.

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

Work in this project is performed by the Tank Automotive Research, Development, and Engineering Center (TARDEC) Warren, MI and is fully coordinated with work at the Army Research Laboratory (ARL), Aberdeen Proving Ground, MD and at Communications-Electronics Research, Development and Engineering Center (CERDEC), Aberdeen Proving Ground, MD and Fort Belvoir, VA.

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

	<b>FY 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<b>Title:</b> Advanced Armor Development:	15.252	12.744	9.893
<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 and kinetic energy (CE and KE) emerging threats for combat and tactical vehicles. These systems include base armor (small arms / medium caliber opaque B-kits and transparent), applique armor (passive / reactive / active multi-threat C-kits), multifunctional armor, and adaptive and cooperative armors. This effort coordinates with PEs 0602618A and 0603005A.			
<b>FY 2015 Accomplishments:</b> Continued characterization of next generation advanced lightweight combat and tactical vehicle armors; performed environmental and ballistic testing, along with modeling and simulation integration analysis for combat and tactical objective threat-based laminate and encapsulated kinetic energy armor systems (B-Kits); performed risk mitigation and integration analysis for combat			

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<p>vehicle threat-based passive, reactive and electromagnetic chemical energy armor systems (C-Kits); explored adaptive armor applicability and related platform integration techniques to reduce armor weights while increasing protection levels.</p> <p><b>FY 2016 Plans:</b> Develop new armor materials and mechanisms to achieve an overall ground vehicle armor subsystem weight reduction of 10-15%. Mature advanced passive and explosive reactive armor component technologies using new and novel material selections and design approaches for defeat of kinetic energy threats, chemical energy threats, and improvised explosive devices. Conduct advanced passive kinetic energy armor and explosive reactive armor integration experiments for component integration, and system seams and attachments. Begin validation of advanced passive B-Kits, and advanced reactive armor systems for C-Kits by conducting ballistic experiments. Mature lightweight materials for structural application and structural designs to provide the protection capability required when integrated with B-Kit and C-Kit armor.</p> <p><b>FY 2017 Plans:</b> Will complete advanced passive B-Kit and C-Kit integration experiments for component integration, and system seams and attachments; will use the integration experiment results to identify and design the desired seam and attachment approach for follow-on integration and demonstration of those technologies; will complete validation of the ballistic performance of the B-kit and C-kit technologies through ballistic coupon experiments; will conduct modeling and simulation of the next generation armor systems that evaluate integration feasibility and resulting performance of those technologies.</p>				
<p><b>Title:</b> Blast Mitigation:</p> <p><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. This effort creates the laboratory capability needed to enable expeditious research and development of blast-mitigating technologies. Blast and crash mitigation technologies are further investigated and matured in such areas as active and passive exterior/hull/cab/kits, interior energy absorbing capabilities for seats, floors, restraints, sensors for active blast mitigating technologies and performance evaluation, M&amp;S, experimentation and instrumentation. This effort coordinates with PEs 0602618A and 0603005A.</p> <p><b>FY 2015 Accomplishments:</b> Researched and conducted experiments to evaluate the use of advanced passive and active approaches to mitigate the effects of underbody blast threats in areas such as seats, restraints, energy absorbing materials and active blast countermeasures; conducted tests to evaluate the integration of exterior and interior blast mitigation solutions onto the Occupant-Centric Protection (OCP) demonstrators, vehicle systems, test assets and/or sub-systems; verified and validated occupant-centric design guidelines/standards, M&amp;S tools, test procedures, laboratory processes, experimentation capabilities; researched means to allow mechanical</p>		9.284	6.541	3.335

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<p>countermine tactics or products to be more effective; supported testing of new instrumentation capabilities being developed by other programs such as the Warrior Injury Assessment Manikin (WIAMan) Generation 1 blast dummy.</p> <p><b>FY 2016 Plans:</b> Develop blast mitigation technologies to include seats, restraints, flooring and structures at the component and sub-system level to verify sub-system interactions. Evaluate passive and active technology solutions using Finite Element Modeling and Simulation tools along with sub-system laboratory tools to develop a variety of concepts. Verify component and sub-system design guidelines and evaluation techniques. Mature the WIAMan in the laboratory environment through durability, repeatability and sensitivity tests of the WIAMan device components and system. Begin development of WIAMan test device certification procedures through calibration testing.</p> <p><b>FY 2017 Plans:</b> Will complete the design of subsystem concepts for the integration of seats, restraints, flooring and structures; will verify subsystem concepts and the associated technology interactions of the seats, restraints, flooring and structures through performance modeling and simulation; will develop certification test procedures to enable verification of the next generation WIAMan technology demonstrator based on laboratory and calibration testing.</p>				
<p><b>Title:</b> Synergistic Vehicle Protection Technologies:</p> <p><b>Description:</b> This effort investigates and integrates advanced synergistic survivability technologies and simulation tools to provide enhanced protection for ground vehicles while minimizing overall system burdens. Synergistic survivability technologies such as, armor and active protection, offer the potential of non-linear survivability improvements. The modular approach facilitates trade-offs between protection, payload, performance, cost drivers and performance of vulnerability assessments throughout the life cycle of a system. Provides quantifiable metrics for development of requirements and evaluation of concept feasibility in the development of survivable combat systems.</p> <p><b>FY 2015 Accomplishments:</b> Provided enhanced capabilities for protected mobility and survivability optimization to support combat modeling, and assessment of technologies that provide enhanced protection with minimum increase in system burdens; provided enhanced assessment methodologies for quantifying and mitigating post-engagement damage and crew casualties from effects such as blast and fire; and provided enhanced assessment methodologies for mobility and survivability on protected mobility.</p> <p><b>FY 2016 Plans:</b></p>		3.253	1.000	2.202

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<p>Leverage the enhanced protected mobility optimization and assessment tools and methodologies developed previously to design future vehicle concepts, optimize protection and mobility technologies to minimize system burdens, and identify future technology metrics and requirements.</p> <p><b>FY 2017 Plans:</b> Will utilize survivability and mobility assessment tools and methodologies to continue to develop future vehicle concepts targeting a range of vehicle weight classes; will investigate vehicle concepts that are modular in nature to accommodate multiple mission requirements; will explore vehicle concepts that utilize lightweight non-structural components while maintaining survivability and mobility performance.</p>				
<p><b>Title:</b> Improved Situational Awareness for Ground Platforms</p> <p><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. This effort coordinates with PEs 0603005A, 0602709A, and 0603710A.</p> <p><b>FY 2015 Accomplishments:</b> Conducted initial investigation of video and data architectures that enable the efficient integration of DVE SA technologies; conducted feasibility analysis, trade studies and interface definitions of DVE SA technologies from aviation and commercial applications onto ground combat and tactical vehicles utilizing advanced vehicle digital architectures.</p> <p><b>FY 2016 Plans:</b> Integrate aviation-based DVE sensors onto an Indirect Vision Driving vehicle through the Integrated Digital Video System (IDVS); develop algorithms that determine how to take World Model information from various sources and overlay that information in real time on the Indirect Vision Driving screens to aid the vehicle operator in visually occluded environments. Conduct human-in-the-loop experiments of the Indirect Vision Driving system augmented with DVE sensors.</p> <p><b>FY 2017 Plans:</b> Will design and develop scalable sensing and immersive intelligence for local SA for DVE for ground vehicle systems; will develop digital architecture and sensor processing with in-vehicle displays for the indirect vision driver. Will investigate hostile fire localization and collision avoidance through the radar and electro-optic sensor, which will improve situational awareness, improve indirect driving maneuverability, and threat detection for improved vehicle and occupant survivability.</p>		3.007	7.040	7.242
<p><b>Title:</b> Vision Protection</p>		-	1.926	1.708

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<p><b>Description:</b> This effort investigates and develops protection materials, concepts, and devices to protect vehicle occupants' eyes, vehicle cameras and electro-optical fire control systems against emerging laser threats. This effort also evaluates methods to apply the advanced protection materials, concepts, and devices onto vehicle cameras and electro-optical systems to prevent lasers from destroying sighting systems, disabling cameras that provide situational awareness, and damaging or disorienting Warfighter vision. Coordinated work is also being performed in PEs 0602120A, 0602705A, 0602712A and 0603005A.</p> <p><b>FY 2016 Plans:</b> Conduct damage threshold and damage mechanism studies on current day cameras and optical systems from short-pulsed laser threats. Improve capability to conduct experiments and validation of protection concepts against emerging laser threats.</p> <p><b>FY 2017 Plans:</b> Will evaluate high energy laser threats to determine their threat parameters for testing sensors against the threats; will develop concepts to protect current systems against the ultra-short pulse laser threat that leverages initial capability testing completed on power-limiting materials.</p>				
<b>Accomplishments/Planned Programs Subtotals</b>		30.796	29.251	24.380
<b>C. Other Program Funding Summary (\$ in Millions)</b>				
N/A				
<b>Remarks</b>				
<b>D. Acquisition Strategy</b>				
N/A				
<b>E. Performance Metrics</b>				
N/A				

**UNCLASSIFIED**

**Exhibit R-2A, RDT&E Project Justification:** PB 2017 Army **Date:** February 2016

<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>
--	---	---

COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
<i>H77: National Automotive Center</i>	-	15.371	15.738	15.936	-	15.936	15.359	16.322	19.369	19.761	-	-

**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 Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Modernization Strategy.

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

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

	FY 2015	FY 2016	FY 2017
<b>Title:</b> Power, Energy and Mobility:	4.234	4.236	4.309
<p><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. This work is done in conjunction with Program Elements (PEs) 0603005A and 0603125A.</p> <p><b>FY 2015 Accomplishments:</b> Collaborated with the Department of Transportation, to leverage activities in the active safety and autonomy areas to exploit efficient fuel vehicle operation over military platforms and duty cycles. Performed next generation of joint activities under the AVPTA vehicle efficiency alliance with the Department of Energy (DOE). Developed modeling and simulation of advanced vehicle technologies with DOE AVPTA activities. Investigated energy efficient lubrication potential to produce a significant savings in overall fuel efficiency for our fleets. This work was coordinated with PE 0603125A.</p> <p><b>FY 2016 Plans:</b></p>			

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<p>Continue joint activities with Department of Energy and Department of Transportation to exploit fuel efficient vehicle operation for military platforms and duty cycles. Continue to support the transition of technology to/from industry and government. Develop and mature fuel cell systems for initial integration experiments of fuel cells onto vehicles. Investigate fuel reduction and water generation technologies to determine logistical impacts, leveraging commercial and academic investments.</p> <p><b>FY 2017 Plans:</b> Will continue to support the transition of technology to/from industry and government. Will continue to investigate fuel reduction and water generation technologies to determine logistical impacts, leveraging commercial and academic investments. Will mature fuel quality monitoring technologies for dual use in commercial, combat, and tactical systems. Will design and develop water treatment and reuse technologies to reduce logistics burdens of resupplying water to the battlefield. Will continue to collaborate with automotive industry and Department of Energy in fuel cell technology maturation.</p>				
<p><b>Title:</b> Dual Use Technologies:</p> <p><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, and advanced vehicle networking and 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. This work is done in conjunction with PE 0603005A.</p> <p><b>FY 2015 Accomplishments:</b> Continued to partner with the Department of Transportation to leverage both traditional crash worthiness as well as active safety and autonomous driving. Other areas of collaborative research included component safety, human interface and distracted driving technologies. Proceeded to leverage the commercial automotive and trucking research and development centers at the original equipment manufacturer (OEM) and tier suppliers to bring reliable, affordable technology solutions to our military ground vehicle fleet.</p> <p><b>FY 2016 Plans:</b> Continue to leverage commercial automotive and trucking research and development centers to transition reliable, affordable technology solutions to our military ground vehicle fleet. Continue to leverage industry's state of the art vehicle electrification and open vehicle architecture standards and facilitate transition into military ground vehicles. Continue to research and develop autonomous vehicle standards with industry and other government organizations. Mature intelligent ground vehicle systems and develop mission payloads for dual use applications to increase efficiencies. Investigate solutions to transition commercial fuel cell technologies to military ground systems.</p> <p><b>FY 2017 Plans:</b></p>		11.137	11.502	11.627

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016
<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 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
Will continue to leverage commercial automotive and trucking research and development centers to transition reliable, affordable technology solutions to our military ground vehicle fleet. Will continue dual use collaborative investigations of military & commercial open vehicle architecture standards, electrification standards, vehicle security engineering best practices, and communication systems integration challenges through collaborative mechanisms such as High-efficiency Truck Users Forum (HTUF). Will design and develop dual use autonomy-enabled vehicle component technologies and material handling equipment for use in reducing convoy manpower and optimizing logistical operations.			
<b>Accomplishments/Planned Programs Subtotals</b>	15.371	15.738	15.936

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

N/A

**UNCLASSIFIED**

**Exhibit R-2A, RDT&E Project Justification:** PB 2017 Army **Date:** February 2016

<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>
--	---	--

COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H91: <i>Ground Vehicle Technology</i>	-	25.644	23.850	27.643	-	27.643	27.802	27.930	28.317	29.016	-	-

**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, 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 Assistant Secretary of Defense for Research and Engineering science and technology priority focus areas and the Army Combat Vehicle Modernization Strategy.

Work in this project is performed by the Tank Automotive Research, Development, and Engineering Center (TARDEC), Warren, Michigan. Efforts in this project are closely coordinated with the Army Research Laboratory (ARL), the Defense Advanced Research Projects Agency (DARPA), the Army Engineer Research and Development Center, Edgewood Chemical Biological Center (ECBC), and the Army Medical Command (MEDCOM).

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

	FY 2015	FY 2016	FY 2017
<b>Title:</b> Pulse Power:	3.369	3.423	3.568
<b>Description:</b> This effort focuses on growing compact, high frequency/high energy/high power density components and devices for several advanced electric-based survivability and lethality weapon systems. Technologies include direct current (DC) to DC chargers, high energy batteries, pulse chargers, high density capacitors, and solid state switches. This effort is coordinated with Program Elements (PEs) 0603005A and 0602705A.			
<b>FY 2015 Accomplishments:</b> Fabricated electrified armor and pulse power components for validation at the subsystem level against MIL-STD-810G test procedures, thermal, rain and salt testing, shock/vibration and performance testing. Conducted road testing and soldier-in-the-loop testing with electrified armors for safety and performance validation.			
<b>FY 2016 Plans:</b> Complete the design and integration of energy storage and high-voltage power electronic components into a system that enables high mass-efficiency electromagnetic threat defeat mechanisms. Begin pulse power system laboratory testing to validate the			

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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>		
<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<p>power system performance needed for electromagnetic armor threat defeat. Complete design of an electromagnetic armor module.</p> <p><b>FY 2017 Plans:</b> Will complete laboratory testing of pulse power system performance to enable electromagnetic armor threat defeat. Will complete pulse power system environmental and durability laboratory testing to validate the ability of the system to operate in relevant environments. Will mature electromagnetic armor modules in preparation for testing of the integrated pulse power and electromagnetic armor system.</p>				
<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. This effort is coordinated with PE 0603005A.</p> <p><b>FY 2015 Accomplishments:</b> Investigated waste heat recovery applications for military vehicles to increase system efficiencies. Investigated grill designs for greater cooling capability. Designed and fabricated a high power density, low heat rejection, fuel efficient engine technology that is scalable and modular for combat and tactical vehicles to address increasing vehicle weights, commonality and thermal burden issues that are not available in commercial-off-the-shelf engines specific to military applications.</p> <p><b>FY 2016 Plans:</b> Design and develop an advanced heat exchanger and efficient fan subsystem to increase cooling capabilities and fuel efficiency. Design waste heat recovery system for military vehicle applications to provide additional onboard electrical power. Mature engine component concept designs through thermal, structural and reliability modeling and simulation.</p> <p><b>FY 2017 Plans:</b> Will investigate advanced heat exchanger and efficient fan components to determine cooling performance and component efficiencies. Will conduct analysis and cooling system design optimization on an advanced combat vehicle propulsion system design that incorporates the advanced cooling components with a waste heat recovery system that maximizes propulsion cooling performance and minimizes parasitic power draw from the vehicle.</p>		4.283	5.122	5.895
<p><b>Title:</b> Power Management Technologies:</p>		2.823	2.583	2.625

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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>		
<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<p><b>Description:</b> This effort investigates power management technologies, software, and implementation approaches. Technologies include Alternating Current (AC) to DC inverters, DC-DC converters, solid state circuit protection, power distribution, 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. This effort coordinates with PE 0603005A.</p> <p><b>FY 2015 Accomplishments:</b> Tested Silicon Carbide-based power electronics for power conversion, distribution, and control to implement the next generation, open, non-proprietary electrical power architecture for military ground vehicles. Continued development of the power management algorithms and software for the next generation power architecture. Demonstrated power management and advanced electrical power architecture fuel savings gains of at least 10% on a 72-hour combat mission. Began integration of the components for the next generation power architecture into a Systems Integration Lab (SIL) to demonstrate SiC and automated power management.</p> <p><b>FY 2016 Plans:</b> Complete development of the next generation power architecture and corresponding system design using SiC power electronics and low cost computers. Integrate high and low voltage power components into a SIL and conduct validation of the power architecture and power electronics in the SIL, demonstrating SiC and automated power management.</p> <p><b>FY 2017 Plans:</b> Will conduct analysis and system integration laboratory testing power architectures for the next generation military vehicles in order to provide efficient distribution and control of power across the platform. Will begin power architecture control software development in order to establish power quality, prioritization and optimization algorithms that maximize available power on the vehicle. Will begin environmental, electromagnetic interference (EMI) and reliability performance testing of vehicle power architecture system components.</p>				
<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. This effort is coordinated with PE 0603005A.</p> <p><b>FY 2015 Accomplishments:</b></p>		1.328	1.218	1.288

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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>		
<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<p>Investigated approaches to further electrify and control parasitic vehicle automotive loads and increase efficiency; modeled and simulated tracked vehicle performance with OBVP technologies integrated; investigated approaches to implement mild hybrid (system that integrates electric machines to assist internal combustion engines for propulsion) capabilities on OBVP equipped vehicles. Investigated intelligent engine start/stop strategy, architecture and controls to dramatically reduce engine idling.</p> <p><b>FY 2016 Plans:</b> Design and develop a high power generator, high temperature inverter and electronic controls strategy to electrify and control parasitic vehicle automotive loads to increase onboard vehicle power availability and fuel efficiency with no negative impact to vehicle mobility.</p> <p><b>FY 2017 Plans:</b> Will continue development of components for a high power generator, high temperature inverter and electronic controls strategy to electrify and control parasitic vehicle automotive loads to increase onboard vehicle power availability and fuel efficiency with no negative impact to vehicle mobility. Components will be assembled into a brass board configuration to begin system design and control algorithm development for a vehicle power system control strategy.</p>				
<p><b>Title:</b> Advanced Non-Primary Power Systems:</p> <p><b>Description:</b> This effort researches, investigates, conducts experiments and validates Auxiliary Power Units (APUs) technologies such as modular/scalable engine based APUs, fuel cell reformer systems to convert JP-8 to hydrogen, sulfur tolerant JP-8 fuel cell APUs and novel engine based APUs for military ground vehicle and unmanned ground systems. This effort also determines inputs for APU interface control documents, as well as investigates solutions for reducing APU acoustic signature for silent operation during mounted surveillance missions. This effort investigates the use of small engines and JP-8 fuel cell systems for use as prime power solutions for unmanned ground systems.</p> <p><b>FY 2015 Accomplishments:</b> Investigated technologies that would enable a 20kW fuel cell APU; began initial experiments on increasing fuel cell components resistance to sulfur; began initial experiments of high power rotary engine APU designs; began to investigate noise mitigation solutions for high power rotary engine APUs.</p> <p><b>FY 2016 Plans:</b> Design and develop high power rotary engine technologies to increase the power density up to two times current power densities of other heavy fueled internal combustion engines. Investigate and design active noise control, muffler and insulation technologies to reduce the acoustic signature of engine-based APU to decrease detection during mounted surveillance missions.</p> <p><b>FY 2017 Plans:</b></p>		3.052	1.909	1.298

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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>		
<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
Will complete system analysis of an advanced APU to include cooling, dust mitigation and control approaches for a rotary engine-based engine-generator. Will continue the development of an approach to advanced noise control strategies that include technologies such as active noise cancellation, isolation and muffling to reduce acoustic signature of engine-based APUs to decrease auditory detection during mounted surveillance missions.				
<p><b>Title:</b> Elastomer Improvement Program:</p> <p><b>Description:</b> This effort researches, formulates and tests new elastomer (rubber) compounds for vehicle track systems to increase track system durability, reduce track system failures and reduce Operations &amp; Sustainment (O&amp;S) costs related to premature track system failures.</p> <p><b>FY 2015 Accomplishments:</b> Performed analysis of previously tested short fiber materials; optimized fiber orientation and validated through laboratory testing; analyzed the potential of combining short fiber material with novel other fillers to further reduce black carbon in the elastomer material; performed laboratory testing of optimized compounds.</p> <p><b>FY 2016 Plans:</b> Fabricate elastomer samples with optimized compounds for durability evaluation. Validate durability evaluation data with predictive fatigue models. Perform design iterations of track system elastomer components based on field test results and fatigue modeling and simulation.</p> <p><b>FY 2017 Plans:</b> Based on results from previous field testing, will update current compounds or designs for elastomeric components in both road wheels and track systems to improve durability performance. Will update modeling and simulation of elastomer durability models with validated results. Will fabricate the updated component designs for road wheels and track systems, and evaluate the latest designs through laboratory testing.</p>		0.662	0.662	0.662
<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. This effort is coordinated with efforts in PEs 0602120A, 0602784A, 0603005A, and 0603734A.</p> <p><b>FY 2015 Accomplishments:</b> Extended the capabilities of active safety systems for military vehicles to reduce soldier injury due to vehicle accidents and rollovers; advanced capabilities for manned/unmanned teaming; enhanced command and control software to enable single-</p>		7.592	6.614	9.832

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016		
<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>		
<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
<p>operator control of multiple unmanned systems; refined algorithms, sensor fusion, dismounted behaviors, and soldier-robot interaction capabilities to enable mission planning and execution in dynamic environments; further developed interoperability profiles and mission package integration; developed capabilities for longer-duration/higher-tempo operations.</p> <p><b>FY 2016 Plans:</b> Develop autonomous behaviors for mounted and dismounted ground vehicle systems that are adaptable to different missions and environments. Develop advanced cognitive control through feedback coupling of Soldier-Unmanned Ground Vehicle system capabilities and behavior at neural, neurocognitive, and sociocognitive levels. Mature reliable and consistent autonomous capabilities for mounted and dismounted ground vehicle systems to increase autonomous vehicle control and reduce required level of human interaction.</p> <p><b>FY 2017 Plans:</b> Will investigate effective control of unmanned systems operating with soldier trust in autonomous systems, and manned/unmanned teaming. Will design and develop common interfaces, drive-by-wire, and advanced vehicle behavior technologies with immediate installation and base operation requirements that will allow investigation between controlled to uncontrolled hostile environments. Will design and develop the Warfighter-Machine Interface with scalability and driver/crew aids. Will investigate tactical resupply perception models, location fidelity of supply, and software algorithms to meet dynamic stockage objectives to improve throughput.</p>				
<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 MIL-STD-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> <p><b>FY 2015 Accomplishments:</b> Integrated novel battery materials (anode, cathode, electrolyte, and separators) into battery cells designed to fit into existing military battery form-factors (ex: 6T); improved existing advanced 6T battery pack prototypes and designs by incorporating new cell technologies and refining their battery management systems, control algorithms, and physical construction for shock &amp; vibration and Electro-Magnetic Interference (EMI); improved 6T battery designs for manufacturability, commonality and cost reduction; validated improved 6T designs against latest battery &amp; vehicle safety and performance requirements.</p> <p><b>FY 2016 Plans:</b></p>		2.535	2.319	2.475

**UNCLASSIFIED**

<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2017 Army		<b>Date:</b> February 2016
<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>

<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2015</b>	<b>FY 2016</b>	<b>FY 2017</b>
Design and develop advanced cell level materials to fit into standardized military battery form factors such as 6T. Design improved advanced standardized battery prototypes by incorporating advanced cell materials. Develop and mature electrochemical cell designs to improve energy density, starting, lighting, propulsion system ignition, silent watch and reliability of military specific battery.			
<b><i>FY 2017 Plans:</i></b> Will conduct durability and performance testing at the battery cell level for advanced Li-ion chemistries to improve energy density, starting, lighting, propulsion system ignition, silent watch and reliability of military specific batteries. Will begin design work to package the battery cells into modules and full battery packs in the military form factor, (6T) to include battery voltage monitoring, state of charge and battery safety control systems.			
<b>Accomplishments/Planned Programs Subtotals</b>	25.644	23.850	27.643

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

N/A

**UNCLASSIFIED**

**Exhibit R-2A, RDT&E Project Justification:** PB 2017 Army **Date:** February 2016

<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>
--	---	---

COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
<i>T26: Ground Vehicle Technologies (CA)</i>	-	0.000	9.600	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

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

Congressional Interest Item funding for Ground Vehicle Technology applied research.

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

	FY 2015	FY 2016
<b><i>Congressional Add:</i></b> Program Increase	-	9.600
<b><i>FY 2016 Plans:</i></b> This is a Congressional Interest Item.		
<b>Congressional Adds Subtotals</b>	-	9.600

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

N/A

**UNCLASSIFIED**

**Exhibit R-2A, RDT&E Project Justification:** PB 2017 Army **Date:** February 2016

<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> T31 / <i>NAT'L AUTO CENTER APP RES INIT (CA)</i>
--	---	--

COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T31: <i>NAT'L AUTO CENTER APP RES INIT (CA)</i>	-	0.000	20.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

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

Congressional Interest Item funding for National Automotive Center applied research.

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

	FY 2015	FY 2016
<b><i>Congressional Add:</i></b> Alternative Energy Research	-	20.000
<b><i>FY 2016 Plans:</i></b> This is a Congressional Interest item		
<b>Congressional Adds Subtotals</b>	-	20.000

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

N/A

**Remarks**

**D. Acquisition Strategy**

N/A

**E. Performance Metrics**

N/A

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**