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

Appropriation/Budget Activity 2040: <i>Research, Development, Test & Evaluation, Army / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602105A / <i>Materials Technology</i>
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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	-	45.563	68.314	31.533	-	31.533	31.849	32.666	33.286	34.367	-	-
H7B: <i>Advanced Materials Initiatives (CA)</i>	-	18.000	40.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
H7G: <i>Nanomaterials Applied Research</i>	-	3.235	3.674	3.454	-	3.454	3.107	3.345	3.212	3.522	-	-
H84: <i>Materials</i>	-	24.328	24.640	28.079	-	28.079	28.742	29.321	30.074	30.845	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) evaluates materials for lighter weight and more survivable armor and for more lethal armaments. Project H7G researches and explores nanostructure materials properties and exploits the strength and durability of these materials to enable lighter weight, increased performance in Soldier weapons and protection applications. Project H84, researches a variety of materials and designs, fabricates and evaluates performance of components for lighter weight Soldier and vehicle armors, armaments, and electronics.

Work in this PE builds on the materials research transitioned from PE 0601102A (Defense Research Sciences), project H42 (Materials and Mechanics) and PE 0601104A (University and Industry Research Centers), project J12 (Institute for Soldier Nanotechnologies). This work complements and is fully coordinated with PE 0602601A (Combat Vehicle and Automotive Technology), PE 0602618A (Ballistics Technology), PE 0602786A (Warfighter Technology), PE 0603001A (Warfighter Advanced Technology), PE 0603004A (Weapons and Munitions Advanced Technology), PE 0603005A (Combat Vehicle Advanced Technology), and PE 0708045A (Manufacturing Technology).

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 is performed by the Army Research Laboratory (ARL), Adelphi, MD and Aberdeen Proving Ground, MD, and the Massachusetts Institute of Technology.

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B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	46.000	28.314	30.295	-	30.295
Current President's Budget	45.563	68.314	31.533	-	31.533
Total Adjustments	-0.437	40.000	1.238	-	1.238
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	40.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.437	-			
• Adjustments to Budget Years	-	-	1.238	-	1.238

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

Project: H7B: *Advanced Materials Initiatives (CA)*

Congressional Add: *Program Increase*

Congressional Add: *High Performance Polymers Research*

	FY 2015	FY 2016
	18.000	35.000
	-	5.000
Congressional Add Subtotals for Project: H7B	18.000	40.000
Congressional Add Totals for all Projects	18.000	40.000

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

Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602105A / <i>Materials Technology</i>				Project (Number/Name) H7B / <i>Advanced Materials Initiatives (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
H7B: <i>Advanced Materials Initiatives (CA)</i>	-	18.000	40.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

Note

Not applicable for this item.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Advanced Materials Initiatives.

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

	FY 2015	FY 2016
Congressional Add: Program Increase	18.000	35.000
FY 2015 Accomplishments: Conducted research in the areas of Materials-by-Design; Energy Coupled to Matter; Strategic Materials; and Innovative Manufacturing Science.		
FY 2016 Plans: This is a Congressional Interest Item.		
Congressional Add: High Performance Polymers Research	-	5.000
FY 2016 Plans: This is a Congressional Interest Item		
Congressional Adds Subtotals	18.000	40.000

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

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

Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602105A / <i>Materials Technology</i>				Project (Number/Name) H7G / <i>Nanomaterials Applied Research</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
H7G: <i>Nanomaterials Applied Research</i>	-	3.235	3.674	3.454	-	3.454	3.107	3.345	3.212	3.522	-	-

A. Mission Description and Budget Item Justification

This effort conducts nanoscience research relevant to the Soldier focused on new materials, properties and phenomena in five research areas: (1) lightweight, multifunctional nanostructured materials and hybrid assemblies, (2) soldier medicine, (3) multiple blast and ballistic threats, (4) hazardous substances sensing, recognition, and protection, and (5) nanosystem integration for protected communications, diagnostic sensing, and operational flexibility in complex environments. This project funds collaborative applied research and integration of government, academic, and industry scientific research on nanomaterials derived from Program Element (PE) 0601104A/project J12 (Institute for Soldier Nanotechnologies (ISN)) to advance innovative capabilities.

This project sustains Army science and technology efforts supporting the Soldier/Squad portfolio.

Work in this project builds on the materials research transitioned from PE 0601104A. This work complements and is fully coordinated with PE 0602618A (Ballistics Technology), PE 0602786A (Warfighter Technology), and PE 0603001A (Warfighter Advanced Technology).

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 Army Research Laboratory (ARL), Adelphi, MD and Aberdeen Proving Ground, MD, AND the Massachusetts Institute of Technology, and the ISN industrial partners.

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

	FY 2015	FY 2016	FY 2017
Title: Nanomaterials Applied Research	3.235	3.674	3.454
Description: Devise and validate improved physics-based, materials property models and concepts for multifunctional, lightweight, and responsive materials. Exploit breakthroughs in nanomaterials and multifunctional fiber processing technologies, such as scale-up of processes and fabrication into woven materials, to enable revolutionary future Soldier capabilities.			
FY 2015 Accomplishments: Developed new materials capable of selective energy absorption based on novel coating technologies using nano- and microparticles; synthesized unique molecules for use as additives in transparent eye protection materials that simultaneously solved processing issues and enhanced material performance; and demonstrated stability and performance of a daylight visible taggant system based on a quantum dot-enabled paint for covert tracking and combat identification applications.			
FY 2016 Plans:			

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Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602105A / <i>Materials Technology</i>	Project (Number/Name) H7G / <i>Nanomaterials Applied Research</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Develop nano-structured protective materials and associated processing capabilities to enable novel light-weight materials solutions with enhanced impact performance; and develop novel nano-materials that enable sensing and communication platforms through the use and optimization of size-dependent properties (e.g., quantum confinement) for detection and non-traditional communications. <i>FY 2017 Plans:</i> Will develop nano-enabled sensors that provide low cost detection of hazardous substances in a complex environment; and use novel quantum dot technology to develop materials for reconfigurable antenna applications.			
Accomplishments/Planned Programs Subtotals	3.235	3.674	3.454

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

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

Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602105A / <i>Materials Technology</i>				Project (Number/Name) H84 / <i>Materials</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
H84: <i>Materials</i>	-	24.328	24.640	28.079	-	28.079	28.742	29.321	30.074	30.845	-	-

A. Mission Description and Budget Item Justification

This project designs, fabricates, and evaluates a variety of materials (e.g. metals, ceramics, polymers, and composites) that have potential to enable more survivable, lighter weight Soldier and vehicle armor, chemical and biological protection, armaments, and electronics. Research conducted focuses on unique and/or novel material properties, developing physics-based models, materials characterization techniques, non-destructive testing methods and advanced fabrication/processing methodologies.

This project sustains Army science and technology efforts supporting the Ground Maneuver, Lethality, and Soldier/Squad portfolios.

Work in this project makes extensive use of high performance computing and experimental validation and builds on research transitioned from Program Element (PE) 0601102A (Defense Research Sciences), project H42 (Materials and Mechanics), and project H43 (Ballistics). The work complements and is fully coordinated with efforts in PE 0602105A (Materials Technology), PE 0602601A (Combat Vehicle and Automotive Technology), PE 0602618A (Survivability and Lethality Technologies), PE 0602786A (Warfighter Technology), PE 0603001A (Warfighter Advanced Technology), PE 0603004A (Weapons and Munitions Advanced Technology), PE 0603005A (Combat Vehicle Advanced Technology), and PE 0708045A (Manufacturing Technology).

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.

The work is conducted by the Army Research Laboratory (ARL) at Aberdeen Proving Ground, MD.

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

	FY 2015	FY 2016	FY 2017
<p>Title: Structural Armor Materials</p> <p>Description: Conduct applied research to design 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. Explore ground vehicle structural mechanics and dynamics technologies to improve damage tolerance, durability, fatigue-resistance, and dynamic response (shock, vibration, harshness, and damping).</p> <p>FY 2015 Accomplishments: Developed improved delamination resistance and damage tolerance of thick composites using innovative, cost-effective manufacturing concepts; demonstrated ballistic performance of monolithic baseline magnesium (Mg) alloy and layered ceramic/Mg alloy/ultra-high-molecular-weight polyethylene (UHMWPE) sandwich structure variants with weight reduction goal of 5-12% over current designs; developed validated physics-based models for fatigue of Mg alloy structures for lightweight vehicles that</p>	5.380	5.289	5.338

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>eliminate traditional empirical modeling approaches; and validated novel algorithms to identify links between the microstructure of armor ceramics and ballistic performance, enabling both screening of as-processed tiles as well as development of next generation armor ceramics.</p> <p>FY 2016 Plans: Advance the manufacturing science of magnesium alloys using specific combinations of processing techniques to impart unique structure and achieve large, high performance plates for armor applications; mature development of damage tolerance concepts for thick composites through refinement of novel experimental and simulation strategies that enable material property and performance optimization through control of processing parameters; investigate multiscale structure-property relationships and construct predictive characterization schemes with an aim to influence manufacturability of preferred properties.</p> <p>FY 2017 Plans: Will develop enhanced transparent protective materials by determining the role of material composition on ballistic performance of glass, and by establishing new processing science for producing transparent composites; and develop new strategies for modification of surfaces and interfaces in composite and nanocomposite systems to produce enhanced structural and ballistic materials.</p>				
<p>Title: Soldier-Borne Armor Materials</p> <p>Description: Utilizing understanding of defeat mechanisms from PE 0602618A/project H80, conduct applied research of emerging lightweight armor materials and structures to enable affordable design of multifunctional ballistic protective systems for the future Soldier. Provide quantitative scientific basis for modeling and simulation that result in materials that utilize new lethal mechanisms/protection schemes for the individual Warfighter.</p> <p>FY 2015 Accomplishments: Developed a filament-level three-dimensional (3D) textile model for use in the development of soft body armor; developed and characterized new materials for extremity armor; and developed validated numerical modeling capability to analyze new materials for the range of personnel protection options that utilize the inherent multifunctional nature of composite materials to enhance survivability.</p> <p>FY 2016 Plans: Develop lab-scale processing approaches for boron-based ceramics using dopants and glassy films to achieve dramatic toughness improvements; investigate energy absorption improvements in helmet padding materials; and develop a validated multi-physics model predicting microstructure and residual stress in UHMWPE composites as a function of process history to enable improvements in material properties through process optimization.</p> <p>FY 2017 Plans:</p>		5.283	5.348	6.898

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Will develop methods to produce, characterize, and model layered 2-dimensional polymer and/or graphene composites to explore new protection concepts and will compare to traditional textile based protection; develop improved unidirectional laminates based on UHMWPE using new computational models; and validate multiscale models of protective fabrics that utilize single-fiber and sub-fiber level details to predict mechanical deformation and failure.</p> <p>Title: Lethality Materials Technology</p> <p>Description: This effort involves applied research to develop innovative materials solutions aimed at achieving leap-ahead increases in lethality and weapons effectiveness through dramatic improvements in weight and volume efficiency, lethal effects, and sustainability of military systems that can only be achieved through advances in materials technology.</p> <p>FY 2015 Accomplishments: Developed metal matrix composites to meet thermal requirements of gun barrels at reduced weight; utilized a combination of consolidation and diffusion processes to create nanostructured copper materials for coatings/liners that enable reduction in shape charge jet size while maintaining jet effect; and explored interfacial/bonding effects on the coupled and high loading rate failure modes in thermoplastic composites.</p> <p>FY 2016 Plans: Advance understanding of metal-based gun barrel materials by establishing wear properties and exploring active cooling technologies; determine properties and liner performance of nanostructured copper-based materials; and investigate alternative lower-cost compositions that will provide improved shape charge jet formation and performance of the liner.</p> <p>FY 2017 Plans: Will develop new Iron (Fe) based alloys using dispersion of oxides to create ultra-high strength, high toughness, and thermally stable materials for a range of lethality applications; utilize synthesis, characterization, and modeling to develop high energy density polymeric materials for use as energetic binders.</p>		4.395	4.483	4.492
<p>Title: Multifunctional Armor Materials</p> <p>Description: This effort researches novel multifunctional armor materials and associated processing science aimed at enabling critical Army applications in survivability and sustainment. Research efforts include multifunctional protective films and coatings, joining of dissimilar materials, and additive manufacturing of multifunctional materials. Soldier personnel protection materials transition to PE 0602786A/project H98. Vehicle armor materials transition to PE 0602618A/project H80 and PE 0602601A/project C05.</p> <p>FY 2015 Accomplishments: Validated new embedded power and enhanced survivability capabilities in multifunctional composite materials using enhanced modeling and processing techniques; developed new additive manufacturing capabilities using 3D printing, cold spray, and/or related techniques to explore methods for low-volume production and expand design space (e.g., bio-inspired protection</p>		7.360	7.554	9.356

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>concepts); established electric field effects on select ceramics and metals to enable Electric Field Assisted Sintering (EFAS) of new multifunctional materials; and identified inelastic deformation mechanisms as a function of strain rate in silicon carbide armor ceramics through development of novel experimental techniques.</p> <p>FY 2016 Plans: Mature the additive manufacturing and processing of multi-component materials and develop a new simulation tool that links process science to the desired materials structure and properties; investigate the use of electromagnetic (EM) fields to control and optimize microstructure in metals and ceramics used in armor applications; assess the formation of ceramic materials through the use of low temperature solidification processing using locally sourced materials; and investigate and characterize peptides (that act as glue in natural/biological materials in warm moist environments) with a goal of demonstrating triple the lifetime and strength in high humidity conditions.</p> <p>FY 2017 Plans: Will enhance computational capabilities to link additive manufacturing process science to the desired materials structure and properties while further expanding additive manufacturing capabilities; expand investigations in electromagnetic (EM) fields applications during processing of metals and ceramics to enable new abilities to control and optimize microstructures and develop new low temperature, low pressure processing methods; develop process modeling tools and related experimental capabilities to capture effects of EM fields during ceramic sintering and the resulting structure-property relationships.</p>				
<p>Title: Nanomaterials</p> <p>Description: Mature and scale-up nanomaterials processes, fabrication, characterization and performance measures to enable revolutionary concepts for future force lethality and survivability beyond those addressed for individual Soldier protection in PE 062105A/project H7G.</p> <p>FY 2015 Accomplishments: Developed thermally stable nanocrystalline cellulosic particles and networks for incorporation into impact resistant transparent polymers used for personnel protection; established bulk mechanical properties of thermally stabilized nanocrystalline alloys to expand design space for structural and armor applications; and synthesized novel third generation chromophores and incorporated into thick polymer materials used in anti-laser sensor protection devices.</p> <p>FY 2016 Plans: Develop nanocellulose-based fibers with surface modifications for improved toughness and demonstrate improved impact strength in nanocellulose composites; investigate scaled-up fabrication of thermally stable iron-based nanomaterials with enhanced strength and ductility; and determine performance capabilities of nanostructure copper-based shaped charge liners.</p> <p>FY 2017 Plans:</p>		1.910	1.966	1.995

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Will synthesize novel small molecules and utilize nanostructured additives and other nanomaterials to develop new hybrid and multifunctional polymer coatings, composites, and films with enhanced dielectric and electromagnetic properties to enable new active / adaptive armor and weapons concepts.			
Accomplishments/Planned Programs Subtotals	24.328	24.640	28.079

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A