Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*							
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	271.933	253.116	263.590	-	263.590	277.166	290.818	295.100	304.156	-	-
305: *ATR Research*	-	1.993	2.057	2.102	-	2.102	2.142	2.186	2.231	2.276	-	-
31B: *Infrared Optics Rsch*	-	2.797	4.213	3.742	-	3.742	3.748	3.752	3.753	3.812	-	-
52C: *Mapping & Remote Sens*	-	1.996	2.057	2.101	-	2.101	2.141	2.185	2.228	2.273	-	-
53A: *Battlefield Env & Sig*	-	3.667	3.808	3.892	-	3.892	3.971	4.055	4.135	4.218	-	-
74A: *Human Engineering*	-	12.830	13.342	14.057	-	14.057	15.532	15.852	16.136	16.445	-	-
74F: *Pers Perf & Training*	-	5.260	5.540	5.485	-	5.485	5.586	5.699	5.812	5.930	-	-
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	0.000	4.201	4.780	-	4.780	4.866	2.646	2.570	3.053	-	-
F20: *Adv Propulsion Rsch*	-	4.097	4.220	3.460	-	3.460	3.545	3.637	3.726	3.818	-	-
F22: *Rsch In Veh Mobility*	-	0.679	0.718	0.735	-	0.735	0.749	0.765	0.778	0.795	-	-
H42: *Materials & Mechanics*	-	8.329	8.731	9.748	-	9.748	12.211	12.262	12.556	12.868	-	-
H43: *Research In Ballistics*	-	8.211	8.531	11.319	-	11.319	11.723	12.032	12.304	12.659	-	-
H44: *Adv Sensors Research*	-	8.455	9.436	8.899	-	8.899	9.915	10.590	10.861	11.099	-	-
H45: *Air Mobility*	-	2.236	2.364	2.410	-	2.410	2.458	2.506	2.556	2.608	-	-
H47: *Applied Physics Rsch*	-	5.574	4.285	5.689	-	5.689	5.848	5.434	5.559	5.676	-	-
H48: *Battlespace Info & Comm Rsc*	-	24.710	28.276	31.394	-	31.394	32.292	36.816	37.397	38.249	-	-
H52: *Equip For The Soldier*	-	1.113	1.133	1.156	-	1.156	1.178	1.204	1.228	1.252	-	-
H57: *Single Investigator Basic Research*	-	84.464	94.519	96.081	-	96.081	101.690	105.185	106.679	110.878	-	-
H66: *Adv Structures Rsch*	-	2.008	2.061	3.108	-	3.108	3.153	3.197	3.240	3.285	-	-
H67: *Environmental Research*	-	0.877	0.928	1.036	-	1.036	1.056	1.076	1.099	1.121	-	-
S13: *Sci BS/Med Rsh Inf Dis*	-	10.951	11.318	11.039	-	11.039	11.272	11.509	11.501	12.253	-	-
S14: *Sci BS/Cbt Cas Care Rs*	-	8.923	5.699	5.296	-	5.296	5.610	6.559	7.042	7.077	-	-

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017		
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*								
S15: *Sci BS/Army Op Med Rsh*	-	6.492	6.688	7.116	-	7.116	6.443	9.654	9.093	8.710	-	-
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	40.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
T22: *Soil & Rock Mech*	-	4.334	4.520	4.606	-	4.606	4.695	4.788	4.883	4.982	-	-
T23: *Basic Res Mil Const*	-	1.679	1.747	1.781	-	1.781	1.815	1.850	1.887	1.929	-	-
T24: *Signature Physics And Terrain State Basic Research*	-	1.619	1.649	1.685	-	1.685	1.720	1.755	1.792	1.828	-	-
T25: *Environmental Science Basic Research*	-	6.744	7.081	6.708	-	6.708	6.845	6.990	7.139	7.797	-	-
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	6.947	8.764	8.847	-	8.847	9.546	11.112	11.281	11.516	-	-
T64: *Sci BS/System Biology And Network Science*	-	2.814	2.974	3.025	-	3.025	3.079	3.139	3.203	3.268	-	-
VR9: *Surface Science Research*	-	2.134	2.256	2.293	-	2.293	2.337	2.383	2.431	2.481	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine is in Project S14. The Clinical and Rehabilitative Medicine basic research effort moves to Project ET6 starting in FY17.

A. Mission Description and Budget Item Justification

This Program Element (PE) builds fundamental scientific knowledge contributing to the sustainment of United States (U.S.) Army scientific and technological superiority in land warfighting capability and to solving military problems related to long-term national security needs, investigates new concepts and technologies for the Army's future force, and provides the means to exploit scientific breakthroughs and avoid technological surprises. This PE fosters innovation in Army niche areas (e.g., lightweight armor, energetic materials, and night vision capability) and areas where there is no commercial investment due to limited markets (e.g., vaccines for tropical diseases). It also focuses university single investigator research on areas of high interest to the Army (e.g., high-density compact power and novel sensor phenomenologies). The in-house portion of the program capitalizes on the Army's scientific talent and specialized facilities to transition knowledge and technology into appropriate developmental activities. The extramural program leverages the research efforts of other government agencies, academia, and industry.

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army	Date: May 2017
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*

Work in this PE is performed by: the U.S. Army Research Laboratory (ARL), Adelphi, MD; the U.S. Research, Development and Engineering Command (RDECOM), Aberdeen, MD; the U.S. Army Medical Research and Materiel Command (MRMC), Ft. Detrick, MD; the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS; and the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), Arlington, VA.

B. Program Change Summary ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	279.118	253.116	256.042	-	256.042
Current President's Budget	271.933	253.116	263.590	-	263.590
Total Adjustments	-7.185	0.000	7.548	-	7.548
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-7.185	-			
• Adjustments to Budget Years	0.000	0.000	7.040	-	7.040
• Civ Pay Adjustments	0.000	0.000	0.508	-	0.508

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Program Increase*	40.000	-
Congressional Add Subtotals for Project: T14	40.000	-
Congressional Add Totals for all Projects	40.000	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army									Date: May 2017			
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 305 / *ATR Research*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
305: *ATR Research*	-	1.993	2.057	2.102	-	2.102	2.142	2.186	2.231	2.276	-	-

A. Mission Description and Budget Item Justification

This Project fosters research for automatic target recognition (ATR) concepts to enhance the effectiveness of Army systems while simultaneously reducing the workload on the Soldier. This Project focuses on the fundamental underpinnings of aided and unaided target detection and identification techniques for land warfare scenarios. This research enables Army systems that can act independently of the human operator to detect and track targets including clandestine tracking of non-cooperative targets. Such capabilities are needed for smart munitions, unattended ground sensors, and as replacements for existing systems. Critical technology issues include low depression angle, relatively short range, and highly competing background clutter. The resulting research will provide a fundamental capability to predict, explain, and characterize target and background signature content, and reduce the workload on the analyst. This research is aimed at determining the complexity and variability of target and clutter signatures and ultimately utilizing that knowledge to conceptualize and design advanced ATR paradigms to enhance robustness and effectiveness of land warfare systems. ATR research strategies include emerging sensor modalities such as spectral and multi-sensor imaging. Research in this Project builds knowledge for several technology efforts including multi-domain smart sensors, third generation Forward Looking Infrared (FLIR), and advanced multi-function laser radar (LADAR).

Work in this Project complements and is fully coordinated with the United States (U.S.) Army Armaments Research, Development, and Engineering Center (ARDEC); the U.S. Army Communications-Electronics Research, Development, and Engineering Center (CERDEC); and the U.S. Army Edgewood Chemical Biological Center (ECBC).

Work is this Project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602270A (Electronic Warfare Technology)/Project 906 (Tactical Electronic Warfare Applied Research).

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

Work in this project is performed by the U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018**
Title: ATR Algorithms	1.993	2.057	2.102
Description: Investigate new algorithms to improve aided/unaided target detection and identification.			
FY 2016 Accomplishments: Expanded investigation of human and vehicle activity detection methods to include joint exploitation of text and video data; extended biometric research techniques to enable automated face recognition using low resolution imagery and multimodal data sets; investigated methods for synthesizing scene understanding from multi-viewpoint imagery including three-dimensional (3D)			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 305 / *ATR Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
models for face recognition; investigated image processing methods for detecting unmanned aircraft systems (UAS) in electro-optical/infrared (EO/IR) data for use in counter-unmanned aircraft systems (CUAS); and investigated algorithms for use in target detection and recognition. ***FY 2017 Plans:*** Will investigate methods for automatic object recognition from multi-perspective/multi-platform image data and assess their expected performance improvement over existing single perspective methods; investigate methods for improved vehicle tracking using 3D scene reconstructions; research methods for multi-pose detection of humans in images which are expected to extend robustness of previous methods that have been demonstrated to work only on upright human postures; investigate methods for semantic classification of human actions in video; and investigate joint representations of polarimetric and visible face data for increased accuracy of face recognition using thermal data. ***FY 2018 Plans:*** Will investigate approaches for image and video analytics and scene understanding at the tactical edge using resource constrained computation platforms for Soldiers and unmanned vehicle/robotic systems; will investigate joint text and video approaches for semantic summarization of unconstrained videos; will create methods for augmented 3-D scene segmentation and unsupervised labeling of objects viewed at different perspectives in geo-located areas of interest; and will create algorithms for producing and fusing photogrammetry-based point clouds and hyperspectral data collected from multiple flying platforms.			
Accomplishments/Planned Programs Subtotals	1.993	2.057	2.102

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army										Date: May 2017		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 31B / *Infrared Optics Rsch*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
31B: *Infrared Optics Rsch*	-	2.797	4.213	3.742	-	3.742	3.748	3.752	3.753	3.812	-	-

A. Mission Description and Budget Item Justification

This Project supports Army research in materials and devices for active and passive infrared (IR) imaging systems; radio frequency (RF) photonics for radar, communications, and electronic warfare applications; and laser technology for missile threat countermeasure protection. This research aims to generate new technologies for unprecedented battlefield situational awareness and to continue the dominance of Army units during night operations. To achieve these objectives, IR focal plane arrays (FPAs) and lasers with significantly improved performance, lower cost, and increased operating temperatures are required. This research has direct application to Army ground vehicles, aviation platforms, weapon systems, and the individual Soldier. Research is focused on material growth, detector and laser design, and processing for large-area, multicolor IR FPAs, ultraviolet (UV) avalanche photodiodes (APDs), and mid-wavelength IR and UV lasers. The principal efforts are directed towards novel materials for detectors and lasers, and investigating energy band-gap structures in semiconductor materials to enhance the performance of lasers, IR FPAs and UV APDs. In the area of RF Photonics, near-IR modeling and nanofabrication techniques are applied to the design and fabrication of IR photonic-crystal waveguide structures having customized IR properties. This research also is intended to lay the foundation for the development of integrated optoelectronic circuits using active and passive devices and components such as lasers, waveguides, and detectors in conjunction with fiber optic interconnects for the generation, distribution, processing, and control of microwaves. The fundamental physics of signal processing and noise generation as well as the conversion between the time and frequency domains and the optical and electrical domains in these optoelectronic circuits/systems will also be studied. The technical goals are to: 1) manage and control defects in the raw, unprocessed materials, maintaining quality control in the fabrication of the devices and arrays, 2) limit introduction of impurities in the material, shielding device surfaces so that they are resistant to degradation over time and 3) thermal management, particularly as it applies to lasers. This work is coordinated with the United States (U.S.) Army Communications Electronics Research, Development, and Engineering Center (CERDEC). In the area of Advanced Materials, the research is to investigate the fundamental physics of energy, charge, and spin transport along and across active heterogeneous interfaces such as topological insulators, van der Waals heterostructures, solid/liquid interfaces, and bio/a-bio interfaces, and in new materials to achieve new electronic/optoelectronic device functionalities.

Work in this Project supports key Army needs and provides the technical underpinning to Program Element (PE) 0602709A (Night Vision Technology)/Project H95 (Night Vision and Electro-Optic Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Optoelectronic and Integrated Photonic Materials and Device Research	2.797	4.213	1.005

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 31B / *Infrared Optics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Conduct research into materials and structures used for IR devices, UV emitters and detectors, and integrated photonic devices to increase situational awareness in open and complex terrains; improve target detection, identification, and discrimination; and create new device functionality while reducing size, weight, and power requirements. ***FY 2016 Accomplishments:*** Studied engineered IR sensing semiconductor materials processed with micron-scale resonant surface features for improved single color, dual color, and higher operating temperature devices that add functionality in degraded visual environments and reduced system cost; studied diode performance of semiconductor materials composed of indium arsenide antimonide (InAsSb) for improved long wavelength IR performance; researched and advanced optoelectronic oscillator technology for fiber-based acoustic sensor applications and better-than-global positioning system (GPS) clock precision; studied photonics integration for biological and chemical sensing applications; and performed studies and developed and provided fundamental technologies to build UV sources (e.g., light emitting diodes and lasers) with increased output power. ***FY 2017 Plans:*** Will explore new concepts in heterojunction and superlattice design, growth, and fabrication for improved long-wave infrared detection; conduct studies of indium gallium nitride materials for use in achieving large area, high brightness, high power emitters in the near ultraviolet; pursue free-space optical time and frequency transfer using phase noise induced by air turbulence and other environmental effects; investigate techniques for improving the signal-to-noise ratio for standoff detection of chemical/ explosive hazards; and explore the modeling, growth, and fundamental physical properties of novel alloy heterostructures for topological insulators, low power/multifunctional electronics, and high performance thermoelectrics, as well as for highly efficient solar energy harvesting and fuel generation. ***FY 2018 Plans:*** Will perform fundamental studies of carrier transport and vertical light emission in near-UV heterostructures in III-Nitrides to address the challenges associated with device efficiency; will demonstrate reduction in surface and side-wall charge accumulation in IR devices through novel passivation using atomic layer deposition; will design and develop semiconductor-based integrated photonic devices using new metamaterial or device architectures to obtain new and multiple functionalities such as processing microwave signals in the optical domain.			
Title: Advanced Materials	-	-	2.737
Description: Investigation of the fundamental physics of energy, charge, and spin materials with an emphasis on understanding the transport along and across novel designed surfaces and active heterogeneous interfaces to achieve new electronic/ optoelectronic device functionalities. Additionally, study beta-photovoltaic and beta-voltaic energy capture.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 31B / *Infrared Optics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will explore surface properties of InAsSb to study the topological state phenomenon on the surfaces of this material; will study the external field dependence of topological insulator phase transition of Indium Nitride (InN) structures as a function of gate bias and study the bulk bandgap tunability and its effect on bulk conductivity; will study the role of hot electron effects which affect the current and catalytic over-potential in a photoelectrode necessary for water splitting; will study the relevant electrical properties of Gallium Nitride Antimonide (GaNSb) for water splitting power generation applications; will study diamond surface conduction channels to enable ultra-high frequency and high power-density RF devices; will explore complex crystal properties in hybrid one-dimensional (1D) molecular chains and two-dimensional (2D) van der Waals-stacked layered solids to serve as building blocks for high performance and low power electronics; and will investigate beta-photovoltaic and beta-voltaic hybrid energy conversion efficiencies.			
Accomplishments/Planned Programs Subtotals	2.797	4.213	3.742

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) 52C / *Mapping & Remote Sens*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
52C: *Mapping & Remote Sens*	-	1.996	2.057	2.101	-	2.101	2.141	2.185	2.228	2.273	-	-

A. Mission Description and Budget Item Justification

This Project increases knowledge of terrain and human geography with a focus on improving the generation, management, analysis/reasoning, and modeling of geospatial data, and the exploitation of multi-source data. This fundamental knowledge forms the scientific "springboard" for the future development of applications, techniques, and tools to improve the tactical commander's knowledge of the operating environment. Results of this research are used to: extract and characterize natural and man-made features from reconnaissance imagery in near-real time; understand socio-cultural influences; exploit terrain analysis and reasoning techniques; and explore the potential of space, airborne, and terrestrial geospatial sensor technologies to provide real-time geospatial intelligence to all Army Warfighting functions. This research uses terrain and socio-cultural data to improve situational awareness and enhance information dominance, leading to increased survivability, lethality, and mobility.

Work in this Project provides theoretical underpinnings for Program Element (PE) 0602784A (Military Engineering Technology), Project 855 (Topographical, Image Intel & Space).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Sensor Phenomenology and Spatial-Temporal Pattern Discovery	1.996	2.057	2.101
Description: Conduct fundamental research to inform the development of applications, techniques, and tools to improve the tactical commander's knowledge of the operating environment.			
FY 2016 Accomplishments: Investigated algorithms to index and query massive amounts of data with spatial and temporal context; theorized and explored framework of pattern learning tasks to rapidly analyze geospatial and temporal data; investigated quantifiable relationships between plant physiology and soil crust biology; explored relationship between biogeochemistry of permafrost in arctic soils and remote sensing signatures; and explored uncertainty in seismic signatures due to both the source and propagation mediums (i.e., soil and rock).			
FY 2017 Plans: Will investigate remotely measurable signatures of polysaccharide content of biological soil crusts for assessment of soil stability and potential of dust lofting; investigate the observable biogeochemical and remote sensing signals from permafrost wetlands to understand the impact of these unique terrain attributes on military training (e.g., sensor performance, operational mobility), and			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 52C / *Mapping & Remote Sens*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
infrastructure stability; and investigate novel statistical approaches to characterize uncertainty for seismic wave propagation due to military activity of interest in regions where detailed local ground characterization is not possible. ***FY 2018 Plans:*** Will characterize seismic sources caused by human activity; will link biogeochemical measurements and remote sensing signals from permafrost bog systems that are in transition and from stable bogs; and will explore the radiometric complexities between illumination and look angles of natural soils.			
Accomplishments/Planned Programs Subtotals	1.996	2.057	2.101

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) 53A / *Battlefield Env & Sig*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
53A: *Battlefield Env & Sig*	-	3.667	3.808	3.892	-	3.892	3.971	4.055	4.135	4.218	-	-

A. Mission Description and Budget Item Justification

This Project focuses on research to seek an in-depth understanding of the complex atmospheric boundary layer associated with high-resolution meteorology; the transport, dispersion, optical properties and characterization of chemical and biological aerosols; and the propagation of full-spectrum electro-magnetic and acoustic energy. The future Army will operate in very complex environments (e.g., urban, mountainous, forested and jungle terrain) requiring new approaches to understand, characterize, and depict environmental phenomena and their effects on military systems, personnel and operations. The lack of a complete understanding of the meteorological aspects of the complex microscale boundary layer in which the Army operates continues to impact our ability to provide predictable, actionable, accurate and timely tactical environmental intelligence to battlefield commanders and small Soldier units. This Project focuses on producing the foundational environmental science research to characterize the atmospheric boundary layer and deliver novel capabilities and techniques including urban turbulence characterization for its effects on micro platforms and sensor payloads, high resolution urban wind flow modeling for more efficient and accurate prediction of the transport and dispersion of obscurants and chemicals, battlefield aerosol characterization and the interaction between aerosols and meteorological processes for Soldier health initiatives, characterization and detection of bio-warfare agent aerosols, environmental effects on acoustic and electromagnetic signal propagation in urban and other complex domains for improved target location and imaging, exploration of previously unexploited regions of the acoustic and electro-magnetic spectrum, and formulation of objective analysis tools that can assimilate on-scene all-source weather observations, atmospheric composition, and fuse this information with forecasts to provide immediate Nowcast products and actionable information. These capabilities will have a direct impact on ensuring Soldier survivability, weapon system lethality, effective surveillance and reconnaissance, and the mobility required for future warfighter mission planning and execution operations.

Work in this Project supports key Army needs and provides the theoretical underpinnings for Program Element (PE) 0602784A (Military Engineering Technology)/Project H71 (Meteorological Research for Battle Command).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD and White Sands Missile Range, NM.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Predictive Modeling of the Boundary Layer	3.667	3.808	3.892
Description: Increase survivability and improve situational awareness for a variety of sensors, optics, and flying objects (e.g., projectiles, unmanned aircraft systems, etc.) through research to enhance accuracy of predictive modeling of the atmospheric boundary layer and improve the ability to function effectively in adverse conditions.			
FY 2016 Accomplishments: Investigated boundary layer aerosol fate chemistry (i.e., how an aerosol moves and transforms in the atmosphere/environment) in support of chemical/biological detection methods, transport and dispersion; investigated boundary layer aerosol effect on			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 53A / *Battlefield Env & Sig*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
surface energy budget; used the field observed data to improve both the Weather Running Estimates–Nowcast (WRE-N) and the microscale numerical model accuracy for complex terrain, especially for thermal-driven flows due to differential heating; initiated research of large turbulent eddies in the atmospheric boundary layer using the microscale model so that turbulent transport of momentum, energy and moisture between the boundary layer and the free atmosphere could be be better predicted and parameterized in microscale and mesoscale models; developed a data assimilation approach for WRE-N and extended the finest mesh to hundreds-of-meters grid spacing; began efforts to integrate WRE-N and Atmospheric Boundary Layer Environment (ABLE), and developed improved surface energy budget and multi-scale turbulence models that enhanced the accuracy of predictive diurnal and vertical profile models of optical and mechanical turbulence in the boundary layer. ***FY 2017 Plans:*** Will research active and passive sensing methodologies for microscale boundary layer modeling to predict and correct turbulent image distortion; combine ultra-high-resolution microscale modeling methodologies into ABLE (to provide a full-physics microscale predictive system); conduct experiments using WRE-N/ABLE mesoscale-microscale modeling system with varying forecast resolutions (ranging from hundreds down to tens of meters); develop model enhancements for urban and complex terrain flows, and new data assimilation capabilities (to improve accuracy in battlefield domains); research novel computational methods for fielding on small, tactical computer platforms and Soldier-hosted mobile handheld devices; research the transport and diffusion of atmospheric aerosols, to include background haze, that potentially confounds chemical and biological sensors/detectors/warning systems; research chemical and biological fate when exposed to various naturally-occurring ambient atmospheric aerosols, using both single-particle and bulk sample spectroscopic techniques; and research acoustic and electro-optical propagation for use in characterizing the atmospheric state of the atmospheric boundary layer using both in situ and remote sensing techniques. ***FY 2018 Plans:*** Will identify new methods of enhancing electro-optical communication signal transmission through atmospheric “channels” that are created by ultra-short laser pulses; will create an approach to conduct multi-modal wind sensing by merging Doppler wind Light Detection and Ranging (LiDAR) and radar data together to create highly accurate and detailed, remotely-sensed wind observations; will investigate a new capability to optically trap atmospheric aerosol particles, allowing very precise measurement and characterization of their composition; will research numerical techniques for estimating atmospheric effects on the propagation of acoustic signals; will investigate and incorporate a comprehensive atmospheric radiation algorithm into a microscale numerical weather prediction model, enhancing the accuracy of the forecasts by accounting for both dense urban and forest canopy domains; will expand datasets and investigate correlations between meteorological conditions/observations and significant threat activities; and will explore microscale model initialization and physics refinements based on boundary layer urban and complex terrain discoveries from the Meteorological Sensor Array and other high-resolution atmospheric sensing experiments.			
Accomplishments/Planned Programs Subtotals	3.667	3.808	3.892

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 53A / *Battlefield Env & Sig*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 74A / *Human Engineering*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
74A: *Human Engineering*	-	12.830	13.342	14.057	-	14.057	15.532	15.852	16.136	16.445	-	-

A. Mission Description and Budget Item Justification

This Project focuses on research that improves Soldier-system performance in future force environments by looking at key phenomena underlying Soldier performance such as auditory spatial orientation (e.g., perception of azimuth, elevation and distance of sounds) within uncertain, degraded acoustic conditions; extending and protecting auditory and cognitive performance; human performance in automated, mixed-initiative (human control-machine control) environments; communications in hearing-degraded conditions; visual scanning and target detection; Soldier emotion and fatigue states; integration across multiple sensory modalities; perceptual-motor behavior; collaborative (team) and independent multi-task, multi-modal, multi-echelon Soldier-system performance - all cast against the influx of emerging transformation-driven technological solutions and opportunities. Technical barriers include lack of methods for describing, measuring, modeling, analyzing and managing the interplay of these phenomena due to the dynamic nature of human behavior and to the situational complexity and ambiguity that characterize operations in the future force. Technical solutions are being pursued in the areas of data generation and algorithm development in these emerging environments in order to update and improve our understanding of performance boundaries and requirements and enable neuroengineering. These solutions include multi-disciplinary partnerships, metrics, simulation capabilities, and modeling tools for characterizing Soldier-system performance, and provide a shared conceptual and operational framework for militarily relevant research on cognitive and perceptual processes. In the area of translational neuroscience, which is the transition of basic neuroscience research to relevant applications, research is carried out to examine leading edge methodologies and technologies to improve the measurement and classification of neural states and behavior in operationally-relevant environments, to examine the potential application of neuroscience theories to autonomous systems to improve Soldier-system interactions, to model the relationship between brain structure and cognitive performance for understanding individual differences and injury, and to assess how neural pathways implicated in functional processing can be enhanced through dynamic system interface technologies for improving in-theatre performance and training. In the area of cybernetics, which is a scientific discipline that bridges the fields of control theory and communication theory for the study and modeling of behavior in complex systems, research is carried out to examine the complex human-system-environment relationships that define, constrain, and influence the interactions between Soldier and system. Research efforts are pursued to advance theory, models, and methodological approaches that capture the dynamic and multidimensional nature of human behavior, including the temporal dependencies inherent to human behavior, through an integrated program of research efforts focused on: novel cybernetic models of human multisensory integration and human-system communication; neuro-inspired, bio-inspired, and engineering approaches to computational algorithms for multisensory integration and multi-sensor fusion to enable enhanced and augmented Soldier perception in human-system interactions; new methodological approaches for the design of multisensory displays and human-system communications; and multisensory test bed platforms for examining experimental hypotheses driven by model predictions and proof-of-principle applications of identified algorithms and methods.

Work in this Project supports key Army needs and provides the technical underpinnings to several Program Elements (PEs) to include PE 0601104A (University and Industry Research Centers)/Project H09 (Robotics Collaborative Technology Alliance) and PE 0602716A (Human Factors Engineering Technology)/H70 (Human Factors Engineering System Development).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

Work in this project is performed by the United States (U.S.) Army Research Laboratory (ARL), Human Research and Engineering Directorate, Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Research to Characterize and Enhance Soldier Performance ***Description:*** Characterize and enhance human auditory performance of the dismounted warrior in complex environments while protecting the hearing of the Soldier. ***FY 2016 Accomplishments:*** Conducted Soldier-oriented research to understand the auditory conditions that determine recognition and identification of relevant auditory events; and expanded basic psychophysical research paradigms by incorporating elements that reflect the complexity of the military context, such as sound class categories and semantic assessments of relevance.	1.586	-	-
Title: Soldier Performance ***Description:*** Conduct fundamental research on human performance in military-relevant environments to include operations, command, and training. Use approaches such as computational cognitive modeling and social network analyses to investigate the factors affecting the information flow, situational understanding and prediction, and technology-mediated collaboration under conditions of stress and uncertainty. Determine the environmental and context factors affecting performance, learning, and retention in immersive and simulated environments; establish realism/fidelity boundary conditions for perceptual, cognitive, and physical parameters for experimentation and for training. ***FY 2016 Accomplishments:*** Investigated integrative aspects of key psycho-social factors of cyber security to understand behaviors of attackers, defenders, and users in operational settings; created a scientific experimental infrastructure of game-modeling and empirical studies to examine risk to operation completeness and to study strategic decision-making for responding to human-machine attacker units; and enhanced basic understanding of big data implications on distributed team communications and decision making by refining task network models to study the feasibility of the doctrinal tenets surrounding network-enabled warfare (e.g., more data leads to enhanced situational awareness).	1.586	-	-
Title: Translational Neuroscience ***Description:*** Integrating neuroscience with traditional approaches to understanding Soldier behavior to enable systems designs that maximize Soldier performance. ***FY 2016 Accomplishments:*** Developed algorithms to detect changes in brain state during long-term performance of a task for a non-invasive brain-computer interface; collected novel neurophysiological datasets based on real-world measurements of stress and fatigue; collected	3.485	3.639	3.715

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
innovative structural imaging data from a large cohort (N>100) of participants to quantify sensitivity of measurement and variability between individuals; and investigated signatures of brain networks that capture changes in task performance. ***FY 2017 Plans:*** Will develop adaptive algorithms to enable semi-supervised learning of brain states in support of human-in-the-loop systems; analyze the reliable relationships between objective physiological measurements and subjective assessments of fatigue; assess the sensitivity in the structural topology or shape of connections between brain regions in a large cohort (N<100) to characterize human variability. ***FY 2018 Plans:*** Will identify novel functional models of visual search using combined measures of gaze position and neural activity in real-word tasks to quantify the effect of cognitive state on task performance; will investigate data-driven classification methods to predict emergent behavior in complex tasks with time-evolving brain states; and will utilize innovations in community detection analyses to link allegiance and flexibility of functional brain networks to variability in task performance.			
Title: Human System Integration – Cybernetics ***Description:*** Apply a cybernetic approach (i.e., a theoretical study and comparison of communication and control processes in biological and artificial systems) to human systems integration to achieve tighter control of devices and communications among humans and between machines and humans. Use social, computational, and information approaches to extend the scope of interaction beyond individual systems to the full network context. ***FY 2016 Accomplishments:*** Examined computational models consistent with cybernetic principles, including feedback models of adaptive mechanisms in human multisensory integration for sensor and motor systems control; implemented and studied novel neuro- and bio-inspired architectures for cybernetic models that can be applied to the critical challenge of multisensory integration across sensory features that cannot be measured on the same metric dimensions; designed a multi-model platform to support human multisensory research efforts in augmented reality and perception; examined critical parameters of multisensory displays to enhance and support human perceptual performance in human-system interactions; explored novel methodologies for identifying and integrating variables in cybernetic models to improve human-system communications; and explored methods for the design of novel, dynamic, and adaptive human-system interactions through methods for mutual human-system communications that leverage information and social science approaches. ***FY 2017 Plans:*** Will advance conceptual, theoretical, and computational closed-loop models (such as neuro-inspired and bio-inspired models) of adaptive behavior and multisensory integration; develop and assess statistical and computational methods to account for variability in and improve prediction of human performance by leveraging temporal dependencies inherent to human neural, physiological, and/or behavioral data; advance display and multi-aspect measurement capabilities for highly-mobile, immersive,	4.984	5.157	5.205

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
multimodal platforms to support human performance research efforts in augmented perception in real-world contexts; develop and extend novel methodologies for metrics to capture the complex interrelationships in dynamic unisensory and multisensory parameters that drive human adaptive behavior; implement and assess novel, cybernetic approaches to human-system communication and interaction that induce or support adaptive and/or mutually adaptive behavior to improve human performance. ***FY 2018 Plans:*** Will extend the complexity of conceptual and theoretical closed-loop models of complex, functional, and adaptive behaviors focused on large-scale computational and neuronal models, including exploration of high-performance computing implementations; will advance statistical models to improve human performance characterization and prediction, leveraging temporal dependencies inherent to closed-loop systems in human perception and human-system interactions; will explore closed-loop (e.g., neuro- and bio-feedback, augmented reality) human-computer interactions for adaptive interfaces that account for individual differences in brain and behavioral dynamics; and will apply machine learning and big data approaches to capture higher dimensional features in complex data for implementation in novel cybernetic approaches to human-system communications and interactions.			
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***Description:*** This effort will investigate technologies that provide the foundation for future Army systems to adapt to individual Soldier's states, behaviors, and intentions in real-time. Enable high fidelity, continuous prediction that can account for continuous changes in Soldier's physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. ***FY 2017 Plans:*** Will advance theories for dynamically integrating asynchronously recorded data from multiple sources with different temporal resolution and time-varying levels of information quality; understand relationships between behavioral, physiological, environmental, and task-based factors and human variability in task performance in real-world environments; and characterize quality of information recorded from behavioral, physiological, environmental, and task-based sensors continuously used in real-world environments. ***FY 2018 Plans:*** Will develop algorithms to predict changes in task performance in controlled environments on the basis of behavioral, physiological, environmental, and task-based factors; will develop algorithms for interpreting state variability in pseudo-controlled environments; will collect novel longitudinal, low-resolution, multi-faceted dataset from a large cohort (N > 50) of individuals for several months to characterize state variability in real-world environments	-	3.306	3.873
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance and behavior. Determine the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to affect	1.189	1.240	1.264

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
performance similar to that in an operational environment. Characterize the appropriate use of different classes of simulated environments to ensure valid results. Develop guidelines for using mobility platforms in simulators to induce physical and cognitive stress representative of the operational environment. Implementation of these guidelines will enhance training effectiveness. ***FY 2016 Accomplishments:*** Explored effects of mobility platform and training environment on route selection during training scenarios; manipulated level of information in the environment to determine how information influences route selection, traversal time, and other Soldier performance parameters; used results from these studies to augment current models and develop new models of Soldier performance and behavior using empirical data to predict Soldier behavior based on training environment. ***FY 2017 Plans:*** Will explore state-of-the-art techniques in immersion, presence, and fidelity with regard to simulation-based training effectiveness to identify appropriate theories of how these factors might be used to predict training outcomes; and develop conceptual-based models that can predict training outcomes. ***FY 2018 Plans:*** Will explore the impact of state and trait measures in empirically-driven conceptual models that describe and predict the relationships between training environment design elements, individual user differences, and training outcomes.			
Accomplishments/Planned Programs Subtotals	12.830	13.342	14.057

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) 74F / *Pers Perf & Training*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
74F: *Pers Perf & Training*	-	5.260	5.540	5.485	-	5.485	5.586	5.699	5.812	5.930	-	-

A. Mission Description and Budget Item Justification

This Project provides the funding to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development, as well as provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. The research within these domains will enable advances in psychometrics to support the development of the next generation of psychological assessments for selection, classification, and assignment. The research also will target how to improve the assessment of difficult-to-measure skills and enable theoretical advances to inform and support the accelerated development of complex cognitive and social skills. This research lays the foundation for future applications that address the behavioral and organizational dynamics that impact Army flexibility, effectiveness, and resilience.

Work in this Project complements and is fully coordinated with Program Element (PE) 0602785A (Project 790) and PE 0603007A (Project 792).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Human Capital Strategy.

Work in this Project is performed by the Army Research Institute for the Behavioral and Social Sciences (ARI), Ft. Belvoir, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Personnel Measures (previously Human Behavior)	1.727	1.900	1.915
Description: Funding is provided for basic research to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development. ***FY 2016 Accomplishments:*** Investigated the integration of psychological and neurometric approaches for improving individual difference assessment and personnel testing methods ***FY 2017 Plans:*** Will initiate research to develop assessment methods for difficult to measure skills & attributes related to complex organizational behaviors. ***FY 2018 Plans:*** Will conduct research to advance theoretical knowledge of leadership development during deployment and in garrison.			
Title: Climate, Readiness, and Resilience (previously Human in Complex Organizations)	3.533	3.640	3.570

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74F / *Pers Perf & Training*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Funding is provided for basic research that will provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. ***FY 2016 Accomplishments:*** Investigated integrated approaches to understanding and assessing systematic contextual moderators of behavior in organizations with primary emphasis on improving prediction of mistreatment and inclusion ***FY 2017 Plans:*** Will initiate research to develop models to better understand organizational processes needed to achieve maximal organizational flexibility, effectiveness, and resilience. ***FY 2018 Plans:*** Will initiate research to advance theoretical understanding of how best to apply the learning of complex tactical/technical and interpersonal skills (in both formal & informal learning environments) to on-the-job performance to maximize unit readiness.			
Accomplishments/Planned Programs Subtotals	5.260	5.540	5.485

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	0.000	4.201	4.780	-	4.780	4.866	2.646	2.570	3.053	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine was in Project S14. The Clinical and Rehabilitative Medicine basic research effort moves to Project ET6 starting in FY17. This is not a new start.

A. Mission Description and Budget Item Justification

This Project supports basic research on experimental models that are developed to support in-depth trauma research studies. This Project includes studies to understand the healing of burned or traumatically injured tissues including eye, bone, nerve, skin, muscle, organs and composite tissues. Such efforts will minimize lost duty time and provide military medical capabilities for post-evacuation restorative and rehabilitative care.

Research conducted in this Project focuses on Clinical and Rehabilitative Medicine.

Work in this Project complements and is fully coordinated with Program Element (PE) 0602787A (Medical 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 United States (U.S.) Army Institute of Surgical Research (USAISR), Joint Base San Antonio, TX; and the Armed Forces Institute of Regenerative Medicine (AFIRM), which has multiple Institutes.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Clinical and Rehabilitative Medicine	-	4.201	4.780
Description: This effort conducts basic studies of mechanisms of tissue growth and traumatic injury to gain an understanding that will assist or facilitate the healing or transplantation process. The focus is placed on severe blast trauma to the limbs, head, face (including eye), and genitalia (organs of reproduction), and abdomen.			
FY 2017 Plans: Will characterize and define the post-injury cellular mechanisms resulting in functional deficits of the eyes; will formulate concepts and identify promising novel therapies and strategies to treat traumatically injured eyes; will assess and characterize the future threats and battlefield logistics impacting eye injuries and treatments; and will continue to define innovative strategies to			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
regenerate and reconstruct hard (e.g. bone) and soft (e.g. skin, muscle, nerve, vascular) tissues to enable promising approaches to advance into the applied research phase through directed experimentation in the laboratory to address injuries of the extremities, face (including eyes), genital, and abdominal body regions. Will identify novel immunomodulation (modification of the immune response / immune system functioning) technologies as well as vascular technologies that reduce the requirement for vein harvest and nerve regeneration technologies that address nerve gap injuries. ***FY 2018 Plans:*** Will investigate stem-cell released factors to identify promising and innovative therapies to regenerate damaged eye tissue. Will characterize cellular mechanisms leading to vision dysfunction. Will define and characterize cellular mechanisms that encourage growth of microvasculature (part of the circulatory system made up of the smallest vessels) for multiple tissue types such as hand transplants. Will develop innovative biologics (pharmaceutical drug made from biological sources) to encourage improved regeneration of craniofacial tissues. Will define biological markers for prognosis (predicting the likely outcome) of wound healing and scarring. Will analyze immunomodulatory (modification of the immune response/immune system functioning) technologies that reduce the need for long term immune suppression following transplantation.			
Accomplishments/Planned Programs Subtotals	-	4.201	4.780

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) F20 / *Adv Propulsion Rsch*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
F20: *Adv Propulsion Rsch*	-	4.097	4.220	3.460	-	3.460	3.545	3.637	3.726	3.818	-	-

A. Mission Description and Budget Item Justification

This Project fosters research to increase the performance of small air-breathing engines and power-trains to support improved system mobility, reliability, and survivability for air and/or ground vehicles; and ultimately serves to reduce the logistics cost burden for the future force. Problems addressed include the need for greater fuel efficiency and reduced weight in these propulsion systems. Technical barriers to advanced propulsion systems are the inadequacy of existing materials to safely withstand higher temperature demands, the lack of capability to accurately simulate the flow physics and the mechanical behavior of these systems, including the engine and drive train. The Army is the lead Service in these technology areas and performs basic research in propulsion, as applicable to rotorcraft as well as tracked and wheeled vehicles. Technical solutions are being pursued through analysis, code generation, and evaluations to improve engine and drive train components and investigate advanced materials. Component level investigations include compressors, combustors, turbines, energy sources and conversion, injectors, pistons, cylinder liners, piston rings, gears, seals, bearings, shafts, and controls.

Work in this Project provides the technical underpinnings for Program Element (PE) 0602211A (Aviation Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL) at Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Thermal Materials	2.367	4.220	-
Description: Investigate new materials needed to withstand the higher temperature regimen of advanced high performance engines, and evaluate improved tools and methods that will accurately simulate the flow physics and the mechanical behavior of future engines and drive trains, which will contribute to the design of more fuel efficient and reliable propulsion systems.			
FY 2016 Accomplishments: Formulated and validated physics-based model of 1) calcium–magnesium–alumino-silicate (CMAS) degradation on thermal barrier coating in a gas turbine environment, and 2) the thermal softening and oxidation degradation on advanced gear steel surfaces. This work provided the foundation for developing physics-based full-length scale concept-to-design of high-speed thermomechanical turbomachinery and mechanical energy transfer for future rotorcraft.			
FY 2017 Plans: Will formulate and validate physics-based model of 1) CMAS degradation on thermal barrier coating in a gas turbine environment, and 2) the thermal softening and oxidation degradation on advanced gear steel surfaces. This work will provide the foundation for			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F20 / *Adv Propulsion Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
developing physics-based full-length scale concept-to-design of high-speed thermomechanical turbomachinery and mechanical energy transfer for future rotorcraft.			
Title: Reliable Small Engines for Unmanned Systems ***Description:*** Develop improved tools and methods to enhance the reliability and fuel efficiency of small engines for air and ground vehicles and to enable the use of heavy fuels. ***FY 2016 Accomplishments:*** Evaluated liquid and vapor partitioning in transient spray phenomenon to discover injection-kinetic dependency of spray and combustion events, analyzed droplet size distributions in transient spray, and assess ignition, combustion intensity and radical dependency on transient spray; characterized spray and combustion processes of Jet Propellant 8 (JP-8), Jet A, and alternative jet fuels for fuel property correlation with spray and combustion parameters; and researched modeling and simulation methodologies (both semi-empirical and physics-based) that predicted spray and combustion characteristics under complex fluid dynamics conditions.	1.730	-	-
Title: Vehicle Propulsion & Power Research ***Description:*** Basic research investigating engine and drivetrain technologies for Army manned-and-unmanned vehicles. Research investigates concepts and theories to provide enhanced tools, methods, and innovative concepts to enable improvements in propulsion power density, energy efficiency, reliability, and lifecycle cost for increased performance and capabilities in future Army systems. ***FY 2018 Plans:*** Will investigate engine and drivetrain technologies to enable improved performance and reduced maintenance costs for Army vehicles including: 1) Fuel ignition behavior at Army-relevant altitude and low-temperature conditions for fundamental understanding of multi-regime, multi-mode high-pressure turbulent combustion; 2) Tailored gradient ceramic coating concepts for high-temperature, low thermal conductivity, sand resistance, and low particulate adherence for Army turboshaft engine hot section component performance and debris tolerance; and 3) Advanced lubricant additives and corresponding chemistry interactions to protect highly-loaded mechanical interfaces, such as gear and bearing surfaces, to meet Army needs for extended operation during loss-of-lubrication events.	-	-	3.460
Accomplishments/Planned Programs Subtotals	4.097	4.220	3.460

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F20 / *Adv Propulsion Rsch*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) F22 / *Rsch In Veh Mobility*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
F22: *Rsch In Veh Mobility*	-	0.679	0.718	0.735	-	0.735	0.749	0.765	0.778	0.795	-	-

A. Mission Description and Budget Item Justification

This Project conducts research in support of advanced military vehicle technology with emphasis on advanced propulsion, sophisticated vehicle dynamics and simulation, vehicle-terrain interaction, vehicle control, and advanced track and suspension concepts. Advanced propulsion research will dramatically improve power density, performance and thermal efficiency for advanced engines, transient heat transfer, high temperature materials and thermodynamics. This Project also supports state-of-the-art simulation technologies to achieve a more fundamental understanding of advanced mobility concepts. The subject research is directed at unique, state-of-the-art phenomena in specific areas such as: non-linear ground vehicle control algorithms, using off-road terrain characteristics; and unique mobility approaches, using advanced analytical and experimental procedures.

Work in this Project provides the theoretical underpinnings for Program Element (PE) 0602601A (Combat Vehicle and Automotive Technology).

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency	0.679	0.718	0.735
Description: Research in support of advanced military mobility technologies with emphasis on Terramechanics (vehicle-terrain interaction), and complex vehicle dynamics and simulation. Research is directed at development of advanced mathematical and computational methodologies using state-of-the-art analytical and empirical procedures.			
FY 2016 Accomplishments: Researched development of North Atlantic Treaty Organization (NATO) Reference Mobility Model mobility metrics using new physics-based analytical tools for more accurately and rapidly predicting vehicle terrain interaction effects (off-road mobility); continued to explore new methodologies/relationships for improving autonomous mobility including latency; and researched math modeling human driver actions/responses critical to predicting vehicle dynamics and interactions with the environment.			
FY 2017 Plans: Will continue to develop the framework for the next-generation NATO Reference Mobility Model methodology, a tool-agnostic solution which can be tailored by the various NATO nations based on their software tools of choice; adapt National Aeronautics Space Administration (NASA) Jet Propulsion Laboratory's Rover Analysis Modeling and Simulation methodology to autonomous and tele-operated ground vehicles; develop detailed models for different off-road terrains (sand, loam, clay) using Discrete Elements Method, finite elements analysis and mesh-free method approaches; develop multi-scale computational algorithms that			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F22 / *Rsch In Veh Mobility*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
can model both large ground vehicle systems and fine soil particles in an integrated mobility simulation; and investigate high-speed mobility of tele-operated vehicles in transcontinental scenarios. ***FY 2018 Plans:*** Will mature the development of the framework for the next-generation NATO Reference Mobility Model methodology with the end objective of establishing it as a NATO Standardization Agreement (STANAG document) for use by all NATO nations in development of tools that predict more accurate, operational evaluations for mobility and traversability. The research activity will focus on 6 key thrust areas: Geographic Information System (GIS) Terrain and Mobility Map, Simple Terramechanics, Mobility Standards, Complex Terramechanics, Intelligent Vehicle, Uncertainty treatment, and Verification and Validation.			
Accomplishments/Planned Programs Subtotals	0.679	0.718	0.735

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H42 / *Materials & Mechanics*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H42: *Materials & Mechanics*	-	8.329	8.731	9.748	-	9.748	12.211	12.262	12.556	12.868	-	-

A. Mission Description and Budget Item Justification

This Project conducts basic research in materials science, which includes research into key phenomena enabling the creation and production of revolutionary materials that will provide higher performance, lighter weight, lower cost, improved reliability, and environmental compatibility for Army unique applications. The current methodology of using materials to gain added functionality for Army systems is to use a layered approach, whereby each layer provides added capability (e.g., ballistic, chemical/biological, signature, etc.), but ultimately makes the system too heavy and too expensive. Technical solutions are being pursued through understanding the fundamental aspects of chemistry and microstructure that influence the performance and failure mechanisms of ceramics, advanced polymer composites, and advanced metals, with the goal of creating hierarchically organized materials systems that possess multifunctional attributes at greatly reduced weight and cost. These advanced materials will enable revolutionary lethality and survivability technologies for the future.

Work in this Project supports key Army needs and provides the technical underpinnings for several Program Elements (PE) to include PE 0602105A (Materials Technology)/ Project H84 (Materials) and PE 0602786A (Warfighter Technology)/H98 (Clothing & Equipment Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Microscopic/Nanostructural Materials	2.267	2.375	3.072
Description: Devise new materials and design capabilities based upon fundamental concepts derived at the microscopic and nanostructural levels for the future force.			
FY 2016 Accomplishments: Developed computational capabilities and methods to explore grain boundary structure-property relationships for predicting the strength and failure response of metals and ceramics; and continued thermodynamic stability research of micro/nanomaterials including synthesis of new nanocrystalline iron-based alloys that employ novel particulate oxide strengthening mechanisms.			
FY 2017 Plans: Will advance development of computational methods to discover and exploit interfacial structure-property relationships at grain boundaries in metals and ceramics to improve strength and fracture resistance; and develop a series of model fibers to investigate structure-property relationships as a function of processing.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H42 / *Materials & Mechanics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will complete the development of an advanced computational model that will predict optimal processing parameters and chemistries for alloys and ceramics with improved strength and fracture toughness; and will fully characterize a series of model fibers to determine the structure-property relationship as a function of processing.			
Title: High Deformation Rate Materials ***Description:*** Develop the fundamental understanding necessary to design, process, and characterize materials specifically intended for high loading-rate applications, as in armor and armaments. ***FY 2016 Accomplishments:*** Enhanced multiscale, multidisciplinary materials research to include 1) the investigation of methods that couple electromagnetic and continuum mechanics (i.e., modeling behaviors of materials as a continuous mass rather than discrete particles) theories and algorithms that help model the transition of micro-cracks at small length scales to macro-cracks at larger scales and 2) experimental and modeling capabilities to capture the high-rate response and failure of polymer materials under extreme loading conditions. ***FY 2017 Plans:*** Will advance multiscale, multidisciplinary materials research by developing 1) computational methods to link electromagnetics and continuum mechanics theories and bridge length scales to model crack growth, and 2) experimental and modeling capabilities to capture the high rate and pressure-dependent response of polymer materials. ***FY 2018 Plans:*** Will develop and validate a fully coupled model that predicts the evolution of a failure event based on the dependence of initial microstructure and viscoelastic behavior of an alloy undergoing high-rate and extreme loading.	3.008	3.153	3.211
Title: Materials Research and Processing at Small Scale ***Description:*** Elucidate and exploit unique structure, processing, and property relationships that occur in materials at small length scales and develop methods to tailor the physical, chemical and mechanical response of these materials to enable unprecedented performance improvements in materials properties. ***FY 2016 Accomplishments:*** Explored fundamental effects of alloying elements on atomic level structure and resulting properties and dynamic (i.e., high-rate) response to enable new lightweight alloys; developed novel modeling capabilities to capture physics at small scales in protective fibers and composite materials; and began new foundational research on next-generation protective fibers with controlled nano/ microscale structures. ***FY 2017 Plans:***	3.054	1.089	1.110

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H42 / *Materials & Mechanics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will perform research into high energy processing techniques to consolidate metal powders to form thermodynamically stable, nano-grained alloy materials, that exhibit high strength, ductility, and toughness. ***FY 2018 Plans:*** Will produce bulk material from optimized metal powders using hot-isostatic-press and fully characterize its microstructure and mechanical properties.			
Title: Materiel Research and Processing Using High Energy Fields ***Description:*** Explore interactions between materials and intense energy fields (magnetic, electric, pressure, etc.) to discover new pathways and mechanisms for controlling and altering material structure, enabling the development of new materials with unique property combinations and abilities to respond adaptively to battlefield conditions. ***FY 2017 Plans:*** Will develop new models and experimental capabilities to understand effects of electromagnetic (EM) fields on multiscale structure of armor ceramics during processing, including using EM fields to control engineer grain boundaries for enhanced energy dissipation and fracture resistance under high-rate loading. ***FY 2018 Plans:*** Will characterize new ceramic armor material produced using experimental parameters identified by preliminary models and iteratively refine models based on validation results.	-	2.114	2.355
Accomplishments/Planned Programs Subtotals	8.329	8.731	9.748

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H43 / *Research In Ballistics*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H43: *Research In Ballistics*	-	8.211	8.531	11.319	-	11.319	11.723	12.032	12.304	12.659	-	-

A. Mission Description and Budget Item Justification

This Project seeks to improve the understanding of the chemistry and physics controlling the propulsion, launch, and flight of gun-launched projectiles and missiles, and to understand the interaction of these weapons with armored targets. This research results in basic new knowledge, which allows the formulation of more energetic propellants, more accurate and non-lethal (NL)/lethal projectiles and missiles, and advanced armors for increased survivability of Army combat systems. This effort supports the Office of the Secretary of Defense Advanced Energetics Initiative to mature the fundamental technologies required to transition the next generation of energetic materials into field use.

Work in this Project supports key Army needs and provides the theoretical underpinnings for Program Element (PE) 0602618A (Ballistics Technology)/Project H80 (Survivability and Lethality Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Aberdeen Proving Ground, Adelphi, MD; and Research Triangle Park, NC.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Advanced Energetics Initiative	3.081	3.203	3.565
Description: Expand and confirm physics based models and validation techniques to enable design of novel insensitive propellants/explosives with tailored energy release for revolutionary future force survivability and weapons effectiveness.			
FY 2016 Accomplishments: Explored novel high-nitrogen carbon, hydrogen, nitrogen and oxygen (CHNO) synthesis methodologies to create unique energetic molecular structures while maintaining stability of reactive properties; expanded investigation and explored novel extended solid energetic materials, in particular poly-carbon monoxide (CO), and alternatives to high-pressure synthesis methods; developed predictive models and associated experimental methods to enable precise control of energy release in shear-mediated acceleration of solid-solid chemical reactions.			
FY 2017 Plans: Will develop novel small scale experimental strategies to release and measure the energy and power stored in structural bond energy release materials (e.g., nanodiamonds), extended solids (e.g., poly-CO), and other types of disruptive energetic materials; and develop computational models to guide understanding of potential materials, methods and mechanisms to enable release of energy to be converted to work, both in terms of propulsion of a flight body and lethal effects on a target.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H43 / *Research In Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will explore experimental techniques to maximize energy release of chemical formulations for either propulsive or energetic applications; will explore methods for larger-scale production: will create new computational models which can be used to predict solid-state reaction rates for energetic materials at extreme conditions for upscaling to higher-order models; and will develop and validate detailed reaction chemistry representations of plasticizer blends for propulsive applications.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles ***Description:*** Improve the fundamental understanding of the mechanisms controlling the launch and flight of gun-launched projectiles and missiles, and understand the interaction of these weapons with armored targets. ***FY 2016 Accomplishments:*** Investigated dynamics and controls of extreme aerodynamic maneuvers and assessed transient effects and potential for maneuver without the use of sensors; and explored and created capabilities for prescribing favorable forces and moments on flight bodies across multiple Mach regimes. ***FY 2017 Plans:*** Will develop unique modeling and experimental capabilities to predict and characterize the flight physics associated with complex rapid maneuvering of a flight body as well as the nonlinear control algorithms required for navigation in constrained environments (e.g., global positioning system denied). ***FY 2018 Plans:*** Will derive mathematical frameworks and proofs of convergence for estimation of flight vehicle swarm states in absence of global positioning system; and will conduct numerical experiments to demonstrate increased maneuverability of air vehicles using thrust-vector control or enhanced aerodynamic control.	1.689	2.020	2.892
Title: Armor Research ***Description:*** Develop fundamental knowledge of mechanisms that can be exploited to ensure the next generation of lightweight and efficient armor technologies. ***FY 2016 Accomplishments:*** Developed analytic and numerical methods and associated experiments for rigorous coupling of electromagnetic and solid dynamic models; explored the validity of phase-field methods to track coupled deformation mechanisms in polycrystalline solids under rapid deformation; and assessed accuracy and ability of multi-scale computations that account for material-scale mechanisms during penetration events. ***FY 2017 Plans:***	3.441	2.558	3.711

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H43 / *Research In Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will develop computational methods to capture multiple deformation and failure mechanisms occurring simultaneously that occur under ballistic and blast loading conditions; and develop novel experiments to probe and quantify high-rate deformation mechanisms at small length scales to improve multi-scale computations. ***FY 2018 Plans:*** Will further advance computational methods that predict and explain simultaneous deformation and failure occurring under various ballistic and blast loading conditions; and will perform recently developed experiments to validate multi-scale computations that quantify the cause of high-rate deformation.			
Title: Humans in Extreme Ballistic Environments Research ***Description:*** Provide physics-based discovery of novel protection mechanisms through increased understanding of wave propagation through tissue, and the resulting deformation and damage of tissue during ballistic and blast events. ***FY 2017 Plans:*** Will develop novel experimental techniques to explore cell-level response of neuronal tissue as a function of various potential high-rate loading variables. ***FY 2018 Plans:*** Will experimentally evaluate blast effects on tissues; will model simulation techniques to produce three-dimensional (3D) shock environments; and will experimentally evaluate 3D shock model and use results to refine model.	-	0.750	1.151
Accomplishments/Planned Programs Subtotals	8.211	8.531	11.319

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army										Date: May 2017		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H44 / *Adv Sensors Research*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
H44: *Adv Sensors Research*	-	8.455	9.436	8.899	-	8.899	9.915	10.590	10.861	11.099	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to produce future generations of sensors with capabilities beyond those currently being employed. Technical barriers include the fundamental speed and bandwidth limitations of current materials and devices, the efficiency of current algorithms, current computing architectures, organic material lifetimes, the understanding of the fundamental concepts of quantum cryptography, and the spatial resolution of current radio frequency (RF) sensors. The technical approach is to exploit large-scale electromagnetic (EM) models to predict and explain target and clutter scattering behavior, and research new digital and image processing modules and algorithms, beam propagation and material models of nonlinear optical effects, remote sensing and intelligent system distributive interactive simulations, and battlefield acoustic signal processing algorithms for improved, hazardous material detection and sensor data feature and information fusion under, unique sensor development, and survivable sensor systems. This Project also funds research in the development of biologically inspired materials for use as sensors as well as for power generation and storage; and physics-based multi-scale models for electronic, optical, mechanical, and chemical materials. Payoffs include high-data-rate military communications, improved radar signal processing techniques that will allow existing systems to improve spatial resolution, improved ultra-wideband radar technology for detection of explosives including mine detection, through-the-wall sensing and improved robotics perception, improved sensor approaches and signal processing techniques for enhanced acoustic/seismic sensing systems in noisy environments, distributed sensor data fusion in ad hoc networks, improved cryptography techniques, improved understanding of the physics and atomic properties of materials, and improved capabilities in hazardous material and event sensing.

Work in this Project supports key Army needs and provides the theoretical underpinnings to Program Element (PE) 0602786A (Warfighter Technology)/Project H98 (Clothing & Equipment Technology).

Work in this project complements and is fully coordinated with research at the Army Armaments Research, Development, and Engineering Center (ARDEC); the Army Communications Electronics Research, Development, and Engineering Center (CERDEC), the Army Natick Soldier Research, Development, and Engineering Center (NSRDEC) and the Army Edgewood Chemical Biological Center (ECBC).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Improving Sensor Research (previously Improving Sensor and Photonics Research (Nano))	2.783	2.393	1.547
Description: Create more survivable and secure sensors and displays, and investigate new magnetic- and electric-field sensor technologies for personnel, activity, and improvised explosive device (IED) detection. Develop novel algorithms and electromagnetic models to investigate radio frequency (RF) propagation and exploitation in complex clutter environments for improved RF and radar sensing.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Researched design of electrically-small antennas using adaptive metamaterials and adaptive surfaces; developed foliage penetrating (FOPEN) tree clutter model; developed low-frequency acoustic transducers to enhance signatures for improved tracking and classification algorithms that also compensate for signature variances due to channel and target motion effects; investigated enhanced performance magnetic tunnel junctions for low-frequency noise rejection and increased detection bandwidth and range; researched distributed processing and fusion of gunfire signatures from disparate sensors; and examined the efficacy of surface-enhanced Raman scattering (SERS) sensor elements based on paper and flexible substrates impregnated with noble metal nano-photonic materials. ***FY 2017 Plans:*** Will investigate detection and tracking algorithms using a high fidelity foliage penetrating radar target and clutter model; develop radio frequency interference mitigation algorithms; investigate low-frequency, quasi-static, magnetic-, and electric-field interactions between a sensor and its environment to improve overall sensor performance; investigate sensor and algorithmic methodologies to differentiate infrasound from wind-turbulence to better understand the phenomenology of noise generation and develop strategies for mitigating the effects of wind-turbulence; research distributed processing and fusion methods using shared decision-making processes over low-power, short-lifetime sensors with limited communication capabilities for efficient battlefield situational awareness to the dismounted Soldiers; and examine efficacy of a hybrid, surface-enhanced biosensor. ***FY 2018 Plans:*** Will investigate notch-filling techniques in the RF spectrum for wideband radar application; will investigate micro-Doppler effects and algorithms for threat unmanned air system (UAS) modeling and detection research; will apply infrasound propagation theory and develop new algorithms to enhance localization accuracy and classification in complex wind and flow environments and propagation channels; will develop modeling and simulation techniques and algorithms for electrical- and magnetic-field sensing of targets, terrain, power lines, sensors and sensor platforms influenced by complex field interaction; will explore distributed change detection by fusion of sensor and open source text; and will research adaptive distributed multiple target tracking over bandwidth constrained networks.			
Title: Multi-scale Modeling for Novel Materials	2.729	2.840	2.899
Description: Explore and develop multi-scale modeling techniques to support fundamental studies of electronic and structural materials properties from the atomistic to the continuum. Resulting models will be used to design and develop materials for more efficient, longer lifetime sensors and power and energy devices, and lighter materials for vehicle and soldier protection. This effort includes research that leverages two 5-year Collaborative Research Alliances (CRAs): the Materials in Extreme Dynamic Environments CRA and the Multi-scale/Multidisciplinary Modeling of Electronic Materials CRA. These CRAs are funded under PE 0601104A/Project VS2 (Multi-scale Materials Modeling Centers).			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Developed algorithms/theories that further advance the state-of-the art and understanding of electronic materials with regards to interactions of electrons, photons, phonons, defects and impurities; evaluated the comprehensive set of material characteristics and properties at length and time scales that govern high-rate deformation; evaluated the modeling of fracture and failure phenomena in metallic, polymeric, ceramic, and composite material systems through both computational and experimental techniques; and expanded computational modeling methods to exploit newly emerging high performance computing capability. ***FY 2017 Plans:*** Will create validation methods for new state-of-the-art algorithms developed for the understanding of electronic materials with regards to interactions of electrons, photons, phonons, defects, and impurities; investigate methods to quantify uncertainty for a comprehensive set of material characteristics and properties at length and time scales that govern high-rate deformation; develop scalable numerical algorithms for modeling of failure, fracture, and fragmentation phenomena in metallic, polymeric, ceramic, and composite material systems through computational and experimental techniques; and implement multi-scale computational material modeling methods on massively parallel computers. ***FY 2018 Plans:*** Will create numerical methods and algorithms to enable new high-fidelity multi-scale computer simulations of materials capable of taking full advantage of emerging large-scale heterogeneous computing environments; and will develop computational methodologies to advance the state-of-the-art of at-scale computer models of materials, from the electronic scale through atomistic- and meso-scale to continuum, to take full advantage of emerging large-scale heterogeneous computing environments.			
Title: Biological and Bio-inspired Materials and Devices Research	2.943	4.203	4.453
Description: Create synthetic biological materials for devices and sensors that can be used by the Army to improve force protection and reduce logistical burden. ***FY 2016 Accomplishments:*** Developed computational models of bacterial metabolism that included synthetically engineered pathways and used synthetic biology to manipulate that metabolism for production of commodity chemicals necessary for waste to energy applications; studied and developed fundamental synthetic biology tools enabling biomaterials discovery with enhanced features (e.g., integrated reporting and high temperature discovery) to allow for better understanding and control of biological material interfaces for sensor and electronic integration, bio-adhesives and other applications ***FY 2017 Plans:*** Will investigate the addition of complementary natural microorganisms to current experimental protocols for microbial-derived fuels (i.e., a microbial consortium), with the goal of improving system stability over time and robustness to food source variability for waste-to-energy applications; establish models of cell membrane potential to better understand its role in controlling and optimizing biological reactions; create advanced computational protocols to model synthetic peptides for material discovery and maturation for improved biosensors; investigate the diversity of synthetic peptide libraries and develop first generation			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
bioinformatic and modeling tools for genetically engineered peptides for inorganics and multifunctional materials; and extend peptide material discovery with integrated optical reporting to new material sets to enable active bio/abio heterogeneous interfaces. ***FY 2018 Plans:*** Will explore improved large-scale models of microbial consortia in concert with improved experimental protocols monitoring consortium evolution for future applications such as waste-to-energy; will identify second generation bioinformatic and modeling tools that integrate experimentally monitored dynamics of the diversity of synthetic peptide library development for inorganic and multifunctional materials; will establish synthetic biology methods to engineer cell systems for improved and programmable control of interactions of biological/abiological heterogeneous interfaces; will develop protocols for systems-level analysis of multi-organism communities; will extend metabolic and transcriptional network reconstruction to additional organisms; and will research available systems biology tools for use in microbial consortia members.			
Accomplishments/Planned Programs Subtotals	8.455	9.436	8.899

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H45 / *Air Mobility*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H45: *Air Mobility*	-	2.236	2.364	2.410	-	2.410	2.458	2.506	2.556	2.608	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research in aerodynamics for manned and unmanned rotary wing aircraft. The goal of this effort is to develop improved tools and methods to analyze, evaluate, and assess rotorcraft-unique aerodynamic properties in conventional helicopter and tilt-rotor aircraft. The efforts in this Project will result in a better understanding of rotorcraft aeromechanics and will result in improved performance, safety and, ultimately, improved combat effectiveness of the manned and unmanned rotorcraft in the future force. This Project supports the future force by providing research into technologies that can improve tactical mobility, reduce logistics footprint, and increase survivability for rotary wing aircraft.

Work in this Project provides the theoretical underpinnings for Program Element (PE) 0602211A (Aviation Technologies).

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 Aviation & Missile Research, Development and Engineering Center, Aeroflightdynamics Directorate at the National Aeronautics and Space Administration (NASA) Ames Research Center, CA and Langley Research Center, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Rotary Wing Aerodynamics	2.236	2.364	2.410
Description: Funding is provided for the following effort			
FY 2016 Accomplishments: Continued fundamental research in rotary-wing aeromechanics to lay the foundation for technologies with long-term relevance to future vertical lift encompassing areas such as automation; exploit high-performance computing to research three-dimensional structural dynamics and advanced flow control techniques; and conducted experimental and computational investigations to better understand interactional aerodynamics of multi-rotor configurations by developing pioneering flow measurement techniques and novel numerical algorithms/methods.			
FY 2017 Plans: Will leverage knowledge gained from earlier computational aero-science investigations (aimed at developing novel numerical methods) for rotorcraft blade structural load investigations; conduct experimental investigation of rotor blade structural loads; develop and improve flow measurement techniques such as infra-red thermography for transition, pressure sensitive paint for			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H45 / *Air Mobility*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
surface loads, and particle image velocimetry for flow field velocities; and explore interactional aerodynamic effects on multi-rotor configurations including the rotor downwash/outwash. ***FY 2018 Plans:*** Will conduct experimental investigations to better understand the flow field surrounding a rotor hub to enable drag reduction using active and passive flow control technology; will continue computational aero-science investigations on both high-fidelity and mid/low fidelity numerical methods including work on validation and developmental testing of the physical assumptions forming the building blocks of the underlying theory.			
Accomplishments/Planned Programs Subtotals	2.236	2.364	2.410

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H47 / *Applied Physics Rsch*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H47: *Applied Physics Rsch*	-	5.574	4.285	5.689	-	5.689	5.848	5.434	5.559	5.676	-	-

A. Mission Description and Budget Item Justification

This Project performs basic research on electronic materials and structures as well as technologies in energy harvesting and energetic materials, batteries and fuel cells to enable higher performance and more efficient electronic systems. This includes nanoelectronic devices for low-power and high-frequency applications; sensors, emissive nonlinear and nanophase electrodes, and electronic materials; advanced battery materials, thermoelectric devices, photovoltaic devices, as well as more efficient fuel cells for hybrid power; and the manipulation of cold atoms on a chip for improved gyroscopes and accelerometers for inertial navigation units in global positioning system (GPS)-denied environments, very sensitive gravitational sensors for detecting underground facilities, low-phase noise precision oscillators for low-velocity Doppler radar, and ultra-stable atomic clocks for GPS-denied environments, as well as for future space-based timing applications. These investigations will also impact the development of power sources and specialty electronic materials for the Army's future force, including improved wide band gap semiconductor performance for more electric platforms, nanomaterials for batteries and fuel cells, quantum dots for increased photovoltaic efficiency and advanced radar systems. Technical barriers affecting performance, weight, cost, and power consumption will be addressed.

Work in this Project supports key Army needs and provides the technical underpinnings to Program Elements (PE) 0602705A (Electronics and Electronic Devices)/ Project H94 (Electronics & Electronic Devices). Work in this project complements and is fully coordinated with research at the Army Armaments Research, Development, and Engineering Center (ARDEC); the Army Communications Electronics Research, Development, and Engineering Center (CERDEC); and the Army Natick Soldier Research, Development, and Engineering Center (NSRDEC).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Nanoelectronic Devices and Sensors	2.948	1.836	1.490
Description: Conduct research on advanced battery materials; fuel cells and reformers for Soldier and vehicle power; electronic materials structures and defects in high-temperature, wide-bandgap semiconductors for high-power electronic and photonic applications; materials for advanced nano- and micro-devices; and integration of nano-energetics and Micro-Electro-Mechanical Systems (MEMS) for fusing and micro-robotic applications.			
FY 2016 Accomplishments: Constructed an ultrafast laser spectroscopy experimental testbed to detect surface contamination by hazardous materials; investigated a detection method based on photothermal vibrometry using tunable quantum cascade laser (QCL) sources for surface contamination detection, and conducted ongoing investigations of other promising candidate spectroscopic detection technologies; analyzed processes and materials for the realization of thin film deposited three-dimensional (3D) piezoelectric			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
materials for novel and high performance MEMS actuators; developed processes and characterized on-chip energetic materials for optimization of slow reaction rates for energy generation and thermal source applications; developed growth techniques and fabrication processes for stacked two-dimensional (2D) materials optimized for radio frequency (RF) electronic properties and used in flexible substrates to enable vertical RF active devices resulting in higher frequency RF circuits (to increase performance with less size, weight and power); characterized devices and integrated circuits made using 2D electronic materials such as transition metal dichalcogenides in order to enable conformable, high performance electronics; assessed performance prospects for application of such materials for high frequency and low power analog, RF, and digital electronics for communications and sensing; and researched one-dimensional (1D) and 2D phenomena for alternative device architectures for operations in extreme environments. ***FY 2017 Plans:*** Will investigate the viability of photoacoustic sensing using tunable quantum cascade laser sources for chemical hazard detection at standoff distances; investigate electrical performance of stacked 2-D materials and develop 2-D flexible integrated circuit analysis methodologies for the design of low-power and flexible RF and electronic circuits; develop and validate thermal models for the design of on-chip, energetic thermal sources and other thermally responsive on-chip materials for zero-power actuation applications; and analyze the integration of high performance piezoelectric materials with multi-layer structures to enable tunable, adaptable RF MEMS devices and inertial sensors. ***FY 2018 Plans:*** Will investigate underlying reliability limitations of ultra-wide band gap materials and devices; will research and compare electron mobilities in state-of-the-art dielectrics on gallium nitride (GaN) for gate dielectric and passivation in 600-V class devices; will develop computational transport models for bipolar ionic conducting membranes for use in high energy density fuel cells using liquid fuels; will analyze techniques for improving piezoelectric material properties and integration strategies to enable tunable, adaptable RF MEMS devices and inertial sensors; will study radiative efficiency in microcavities for high power, single aperture near-ultraviolet (UV) lasers; and will study indium gallium nitride (InGaN on GaN) structures for improved gain in near-UV laser structures.			
Title: Fundamentals for Energy Efficient Electronic Components (previously Advanced Energy Efficient Science Research)	2.626	2.449	1.880
Description: This program addresses the power draw of RF front ends for communication and the digital back-end from electronic materials. This work explores new materials with inherently higher energy efficiencies, while improving upon the current state-of-the-art. These materials will be used in conjunction with advances in circuits and systems to provide improvements in power efficiencies, linearity and noise at the subsystem level which are unique needs of the military. Conduct materials, components, and multi-scale modeling research that will lead to advances in energy storage, harvesting, conversion, and efficiency for a wide range of Army applications such as Soldier and vehicle power, microgrids, communications, radar and electronic warfare. ***FY 2016 Accomplishments:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Investigated plasmonic arrays and effect of array structure on catalysis of oxygen reduction, carbon dioxide electroreduction and ethanol oxidation as routes to producing fuel on the battlefield; investigated the effect of electromagnetic radiation (EM) at several frequencies on catalysis rate and selectivity to determine impact on power generation; and investigated the use of metamaterials to enhance EM effects on catalysis for higher conversions to useful fuels. ***FY 2017 Plans:*** Will investigate structures that have plasmonic resonance in the infrared; fabricate aluminum gallium nitride (AlGaN) structures that are bandgap-matched with ultraviolet phosphors; investigate 3D GaN structures for beta-voltaic and beta-photovoltaic power sources; develop understanding of failure mechanisms and methods of assessing wide bandgap device reliability in extreme operating regimes that will enable reliable Army sub-systems with improved power, weight and size efficiencies; study robustness and long-term reliability and related failure mechanisms of the AlGaN/GaN metal-insulator-semiconductor interface under accelerated electric fields and elevated temperatures; use multi-scale modeling to improve battery energy density and fuel cell performance; investigate electronic materials classes showing high potential for improved efficiency and frequency response through modeling, simulation, and characterization of electronic performance and metrology; investigate materials growth and fundamental device fabrication processes for energy efficiency and reduced parasitic losses; and develop new thermodynamic cycles for increased power and energy density in pyroelectrics, and determine effective acoustic energy transfer modes for wireless power transfer. ***FY 2018 Plans:*** Will explore chip level integration of active devices made using 2D and surface conduction electron transport for high conductivity channels that enable more efficient RF performance; Will develop underlying principles for vertical GaN device/material issues (more efficient vs lateral). Will investigate high-electron-mobility transistor (HEMT) devices in multiple geometries.			
Title: Fundamentals for Precision Measurement for Contested Environments ***Description:*** Develop new materials, novel device architectures, and unique processing techniques to successfully maintain communication and information sharing protocols in GPS-denied, actively jammed, or austere environments. ***FY 2018 Plans:*** Will explore new materials and novel device architectures to reduce the phase noise and environmental sensitivity of microwave-photonic oscillators in order to improve the performance of the Army's radar and position, navigation, and timing (PNT) systems; will investigate a compensation locking concept in order to interlock oscillator cavities with different characteristics to increase long-term timing stability of the overall system.	-	-	0.539
Title: Fundamentals for Alternative Energy	-	-	1.780

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Explore novel concepts in energy generation and capture, and in technologies for efficient conversion of ambient energy to electrical energy for use and storage. Design novel structures to include microscale power devices for multimodal harvesting and efficient distributed power conversion. ***FY 2018 Plans:*** Will investigate atomic-nuclear effect by isomer depletion, and study the nuclear structure for enhanced energy release; will explore semiconductor structures by substrate and epitaxial growth conditions; will investigate new materials to optimize plasmonically augmented performance; will investigate the mechanism of plasmonic enhancement found in the structures built previously; will develop 3-D plasmonic arrays and examine alternative field effects to enhance plasmonic reactions and decouple the electron transfer process to further elucidate the mechanism and will investigate electrochemical oxidation of high energy density liquid fuels with carbon-carbon bonds at low temperatures.			
Accomplishments/Planned Programs Subtotals	5.574	4.285	5.689

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H48 / *Battlespace Info & Comm Rsc*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
H48: *Battlespace Info & Comm Rsc*	-	24.710	28.276	31.394	-	31.394	32.292	36.816	37.397	38.249	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to enable intelligent and survivable command and control, communication, computing, and intelligence (C4I) systems for the future force. As the combat force structure decreases and operates in more dispersed formations, information systems must be more robust, intelligent, interoperable, and survivable if the Army is to retain both information and maneuver dominance. This research supports the Army's Network Science initiative and addresses the areas of information assurance, signal processing for wireless battlefield communications, document and speech machine translation, and intelligent systems for C4I. Major barriers to achieving the goals are the inherent vulnerabilities associated with using standardized protocols and commercial technologies while addressing survivability in a unique hostile military environment that includes highly mobile nodes and infrastructure, bandwidth-constrained communications at lower echelons, resource-constrained sensor networks, diverse networks with dynamic topologies, high-level multi-path interference and fading, jamming and multi-access interference, levels of noise in speech signals and document images, new low-density languages, and information warfare threats. These C4I technologies must accommodate heterogeneous security infrastructures and information exchange/security mechanisms between multiple levels of security. The intelligent systems for C4I research focuses on providing the agent technology capabilities that will produce highly relevant tactical events for mounted or dismounted commanders, leaders and Soldiers; improve the timeliness, quality and effectiveness of actions; and speed the decision-making process of small teams operating in complex natural or urban terrain.

Work in this Project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602783A (Computer and Software Technology) / Project Y10 (Computer/Information Science Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Communications in Complex Dynamic Networks	1.848	1.963	1.110
Description: Perform research to provide communications capability for a fully-mobile, fully-communicating, and situationally-aware force operating in a highly dynamic, wireless, mobile networking environment populated by hundreds to thousands of networked nodes. ***FY 2016 Accomplishments:*** Researched theories, models and experimental approaches towards new communications networking capabilities (e.g., control and signal processing algorithms for adaptive hybrid networks comprised of microwave and very high frequencies (VHF) with active adaptations) in harsh tactical environments; investigated approaches to integrated agent-based node relocation and			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
communications planning that enhances network connectivity; and developed modeling and analysis methods that support the design of hybrid networks able to maintain communications in highly disruptive, hostile environments. ***FY 2017 Plans:*** Will investigate and create theories, models, and adaptive algorithms for robust and efficient communications under varied conditions using cognitive and dynamic spectrum access techniques in a hostile tactical environment; research new modeling and analysis methods for hybrid networks that support mobile networking infrastructures to ensure communications in highly disruptive and hostile environments; and define analytical tradeoffs between different performance metrics for multi-modal communications. ***FY 2018 Plans:*** Will create theories, algorithms, and models to enable cognitive hybrid networks that utilize radio frequencies (RF) (e.g. Very High Frequency (VHF) and ultra-high frequency (UHF)), as well as higher frequencies ranges in non-RF bands; will research novel energy efficient methods for controlling autonomous communications infrastructures to maintain network operations in disruptive environments; will develop adaptive point-and-track algorithms and techniques for the modeling and design of multiplexed systems for networking both RF and non-RF physical layer technologies; and will develop formal theories, models and algorithms for decentralized and distributed software-defined networking control plane architectures across heterogeneous mobile networks.			
Title: Data-to-Knowledge to Support Decision-Making ***Description:*** Design and implement a laboratory-scale common information processing infrastructure, inclusive of cloud computing, for networking processes that aids the transformation of data into actionable intelligence to support decision-making under uncertainty. Perform research to utilize real-time, tactical, soldier-centric information for improved decision-making and situational awareness. Perform research in support of rapidly enhancing long-duration, complex, dynamic decision-making capabilities of individual Warfighters and units through the integration of cognitive augmentation and course of action recommender technologies. ***FY 2016 Accomplishments:*** Developed a framework and algorithms for multi-modal information fusion of representative tactical elements from text, video and imagery; investigated the impact to situational awareness when using integrated multi-modal analytics versus independent analytics; studied the value of information construct as a measure of the contribution of multimodal analytics; and investigated algorithms for intelligent mission planning and task allocation for heterogeneous teams of mobile platforms in tactical environments. ***FY 2017 Plans:*** Will study and evaluate the effectiveness of multi-media information processing techniques on user understanding while adapting the presentation of information to various user parameters, including mission and physiological measures; experiment with methods for integrating user/mission concepts (e.g., user fatigue or humanitarian versus mine-clearing missions) to adapt how	2.430	4.503	5.055

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
and when information is provided to the user. Measures of effectiveness will include decrease in communications delay and increase in situational awareness. ***FY 2018 Plans:*** Will explore techniques for utilizing active and passive feedback from information consumers to enhance and customize multi-media information processing, knowledge presentation and querying for improved decision-making and situational awareness; will research text and video analytic approaches to associate information from text with information derived from video sources to improve the collection, processing and exploitation of tactical battlefield data.			
Title: Information Protection for Mobile Dynamic Networks ***Description:*** Perform research on protecting information in highly mobile, wireless tactical environments, where networks must operate under severe bandwidth, energy, and processing constraints, and without reliance on centralized security services. Beginning in fiscal year 2015, includes work previously conducted under Network Science for Mobile Ad Hoc Networks (MANETs) and Tactical Communications. ***FY 2016 Accomplishments:*** Investigated techniques for novel, stealthy communications that are less likely to be detected and intercepted by the adversary than conventional radio frequency communications; investigated methods for mission-focused, network analysis and prediction of cyber risks; and designed innovative techniques to collect, detect and actively mitigate low-observable, highly sophisticated cyber threats in complex heterogeneous networks comprised of wireless and wired technologies. ***FY 2017 Plans:*** Will investigate emerging technologies and their underlying communication protocols focusing on computational complexity; establish techniques to empirically quantify the complexity of a protocol for future application in network security risk assessments; research and derive fundamental methods to automatically generate provably-secure networking protocols that are suitable for deployment on resource-constrained devices and wireless/wired networks; and explore machine learning and statistical methods to improve situational awareness through event and data reasoning. ***FY 2018 Plans:*** Will investigate distributed, energy efficient techniques to enhance network survivability in the presence adversarial attacks at both the physical (RF) and network layers (cyber); will develop quantitative models of information semantics trust and quality; will create models, theories and algorithms for secure, content-based software-defined networking in dynamic coalition environments; will investigate and create secure techniques for distributed composition, positioning, and adapting of information services based on user context and state, device processing capabilities, and security policies; will explore and quantify cyber risk accurately in real-time to provide security and mission assurance; will explore dynamically risk, exploit likelihood, and impact of vulnerability exploitation, as cyber sensor observations are received for a system with known vulnerabilities; will investigate, detect, analyze, and assess temporal and spatial causality of cyber events representing attacker activities, attack provenance, exploits, and	5.634	5.992	4.704

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
vulnerabilities, and investigate methods to attribute the authorship of source code and binary samples using machine learning techniques.			
Title: Multi-Cultural Computational Linguistics ***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of- the-art techniques in machine translation and natural language processing. ***FY 2016 Accomplishments:*** Identified tractable elements of social meaning reflected in text, based on sociolinguistic theory, and developed algorithms to extract basic elements from social media; examined contribution of social information to entity- and event-based information extracted from text; evaluated and extended Natural Language Processing (NLP) semantic underpinnings for spatial and temporal representation and linked them with logical formalisms for reasoning and action planning; and investigated the role of pragmatics in both supporting language interaction with autonomous systems, and interpreting social meaning extracted from text. ***FY 2017 Plans:*** Will explore techniques for extending NLPconcepts to social media analytics for author/programmer identification, summarization, and enhanced video analytics. ***FY 2018 Plans:*** Will investigate machine learning techniques that support rapid, high quality text analysis in sparse data environments; and will investigate knowledge representation techniques for automated dialect identification, linguistic analysis, and summarization for low-resource languages and social media data.	1.069	1.136	1.158
Title: Advanced Computing Architectures and Algorithms ***Description:*** Investigate advanced computing and high performance computing (HPC) networking architectures, memory/storage architectures, algorithms and visualization techniques to support advanced battle command applications for C4I systems. ***FY 2016 Accomplishments:*** Developed novel programming models using emerging programming languages for dynamically evolving mobile heterogeneous computing/networking architectures to solve high fidelity battle command applications; and developed validation methods for these mobile heterogeneous computing/networking devices. ***FY 2017 Plans:*** Will develop programming methods to support the next generation of computing hardware systems (e.g., heterogeneous, parallel, and non-traditional computing architectures such as neuro-synaptic); research new algorithmic methods for tactical HPC to address power, performance, and portability in emerging computational resources; research and create novel capabilities	3.562	4.116	4.186

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
based on increased computing capacity; and explore and evaluate novel, soldier-centric distributed computing and information architectures at the tactical edge for real-time human uniqueness assessment applications. ***FY 2018 Plans:*** Will identify gaps in the next generation computing hardware systems in relation to power, performance, portability, and programmability; will create interdisciplinary mathematical algorithms and models for execution on advanced and high performance computing systems; will investigate the use of traditional high-level to low-level compiler transformations and approaches to reduce the time for algorithm deployment on advanced systems; will perform fundamental research into novel applications that will benefit from the deployment of tactical high performance computers for increased Soldier effectiveness and algorithms devoted to scalable and temporal data analytics for machine learning, real-time detection, and predictive analytics.			
Title: Quantum Information Sciences ***Description:*** Perform research to enable quantum networks, which necessitates research in efficient light / matter interfaces and long-lived, robust quantum memories. Additionally, the study of quantum techniques for sensing and ultra-precise navigation, timing, and communications will be undertaken. Conventional techniques for sensing magnetic fields, gravity, and timing have reached a plateau in their performance, and will be severely impacted in future contested-battlefield environments. This research brings new insights regarding the use of quantum science to enhance Warfighter effectiveness. ***FY 2016 Accomplishments:*** Investigated quantum node-to-node communications along optical fibers and free-space via entangled single photon generation and capture; evaluated the quantum effects and entanglement (i.e., two particles together describe a single quantum state and can't be independently measured or the state of the whole changes) processes of laser-cooled atoms and studied and characterized unique trapping processes to hold and exploit the quantum properties of ions; and studied frequency conversion processes to link disparate quantum systems that generate single photons at different wavelengths of light (e.g., microwave or ultraviolet to visible or infrared). Regardless of the mode of communications, quantum tagging and/or encryption may be used to provide robust information security and viability. ***FY 2017 Plans:*** Will investigate use of integrated photonics and nanotechnology as potentially highly compact components in a quantum network; investigate solid-state systems for controlled, high-rate photon emission, and hybrid ion/neutral atom, solid-state entangled systems as potential interfaces between mixed quantum state systems, which is essential to realizing noise reduction in networked quantum sensors relative to classical systems; establish network protocols with enhanced quantum capacities and rates that integrate classical networking, and assess associated fidelities and the role of error correction in a distributed entangled system; investigate a versatile quantum controller for managing input and output of quantum memory and nodes; and pursue on-chip, Bell-state measurements between quantum memories and repeaters for distributed quantum information systems. ***FY 2018 Plans:***	5.277	5.359	5.402

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will investigate optical nanofibers with strong evanescent fields embedded in cold atom systems; cold-atom ensembles in optical cavities; nanophotonic integration with solid-state defects; and solid-state stoichiometric crystals in cryogenic environments; additionally, qubit manipulation will be investigated in ion trap systems and solid-state defects, and an advanced control system for qubit manipulation will be employed for benchmark standardization; methods for coupling these different platforms via wavelength conversion will be examined, and experimental systems will be analyzed theoretically and the enhancements to sensing using distributed, entangled sensors will be studied theoretically and computationally; and will investigate protocols and algorithms for quantum networks and increasing quantum channel capacity using exotic spatial modes of light.			
Title: Experimental Methods in Network Science	4.890	5.207	4.443
Description: Supports in-house Network Science studies in conjunction with the Network Sciences Collaborative Technology Alliance and Distributed Analytics and Information Science for United States / United Kingdom (U.S. / U.K.) Coalition Operations Information (PE 0601104A).			
FY 2016 Accomplishments: Conducted experimental and theoretical investigations of novel in-network information discovery, storage, pre-processing, integration and routing approaches that enhance quality and trust in information in the presence of disruptions and kinetic and cyber attacks; characterized and developed theoretical models of behaviors of heterogeneous networks that combine traditional radio frequency communication links with novel channels that are more stealthy and exhibit different propagation features; developed theoretical foundations for security properties in complex heterogeneous networks; and extended and refined mathematical methods and models that anticipate dynamic changes in collaboration and decision making in networks comprised of human and artificial agents.			
FY 2017 Plans: Will investigate novel techniques to model, characterize, and control information delivered through multi-genre networks (e.g., communications, information, or socio-cognitive) based on the semantics and context of information requests, and requisite composite quality-of-information measures; derive theories, representations, and models for discovering patterns in network data, to include inferring new phenomena from incomplete and noisy network data, and predicting properties of multi-genre networks; research methods to measure and enhance human trust in decision-making contexts involving information provided by networked sources, both human and automated systems, and experimentally verify them; explore methods for simulating and emulating the impact of quality-of-information on decision-making in networks comprised of humans and physical and virtual agents; and create models and tools for the formal study, verification, and analysis of software-defined, information-centric algorithms that support interoperability, adaptability, and resilience of heterogeneous networks.			
FY 2018 Plans: Will investigate methods for network design that consider tradeoffs between current optimality and long-term behavior as well as adversarial dynamics; will explore the impact of quality-of-information and semantics knowledge on distributed decision-			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
making in physical and virtual agents as network size increases; will develop optimal methods to configure multi-genre networks in the presence of highly dynamic operational environment based on the information quality requirements derived from semantic understanding of the mission; will develop novel techniques to model and influence the evolution of complex adaptive groups and networks, and the diffusion of opinions in dynamic multi-genre networks; and will develop formal theories, techniques and frameworks to enable multi-level integrated fusion of disparate information sources in context of decision support objectives in coalition operations.			
Title: Assured Operations in the Physical, Social and Cyber Domain ***Description:*** Conduct research that will enhance the survivability of information by radically dispersing and continuously moving data across a multitude of inter-networked devices. This effort seeks to address the growing demands on information assurance, reliability and transmission in resource constrained environments. Theories and methods will be developed for securing information across heterogeneous devices/sources and networks, detecting and creating information obfuscation and deception techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. ***FY 2018 Plans:*** Will identify and extend models that characterize the complex trade-offs inherent in radical dispersion of information among mobile tactical edge devices, such as communications, energy consumption, and security; will investigate approaches to minimize impact of dispersion on timely, secure, and efficient re-gathering of information, especially semantic-based techniques, that support situational awareness that is timely and mission relevant; will formulate requirements for formal models, theories and methods to execute and manage successful obfuscation of information within an environment of highly dispersed information; and will explore algorithms for adversarial-context-adaptive aggregation and presentation of information from distributed sources.	-	-	4.283
Title: Mobile Network Modeling ***Description:*** This research focuses on novel computational models, data structures, computational architectures, and techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldiers' information needs, modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber-attacks. Also to be considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information ***FY 2018 Plans:*** Will develop scalable, high fidelity models for high capacity aerial networks in contested and benign environments; will develop HPC enabled finite difference time domain (FDTD) based approach to directly solve Maxwell’s equations in the time	-	-	1.053

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
domain in order to provide high fidelity propagation loss models in complex environments, e.g., through large buildings, urban canyons, indoor/outdoor, tree canopy and tunnels; will develop heterogeneous network models that encapsulate the diverse characteristics and configurations of nodes supporting multimodal (RF and non–RF) waveforms based on actual multi-user channel measurements; and will develop appropriate metrics and analytical tools to characterize node- and network-level performance metrics such as data throughput, security, priority, and latency.			
Accomplishments/Planned Programs Subtotals	24.710	28.276	31.394

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H52 / *Equip For The Soldier*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H52: *Equip For The Soldier*	-	1.113	1.133	1.156	-	1.156	1.178	1.204	1.228	1.252	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to achieve technologies for the Soldier of the future. This research is focused on core technology areas which include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat ration research. Research efforts are targeted at enhancing the mission performance, survivability, and sustainability of the Soldier by advancing the state-of-the-art in the sciences underlying human performance, clothing, and protective equipment to defend against battlefield threats and hazards such as ballistics, chemical agents, lasers, environmental extremes, and ration shortfalls.

Work in this Project provides theoretical underpinnings for Program Element (PE) 0602786A (Warfighter Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas and the Army Modernization Strategy.

Work in this Project is performed and managed by the Army Natick Soldier Research, Development, and Engineering Center (NSRDEC), Natick, MA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Equipment for the Soldier	1.113	1.133	1.156
Description: This Project supports basic research to achieve technologies that support the Soldier of the future. Research areas include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat rations.			
FY 2016 Accomplishments: Explored enhancement of cognitive skills via trans-cranial direct current stimulation (t-DCS) and examined associated neural mechanisms responsible for skill improvement, with the goal of understanding whether t-DCS can complement Soldier training in improving cognitive and motor skills required for enhanced battle space awareness; examined a novel in-vitro gut fermentation model to gain fundamental understanding of dietary component influence on gut health as it relates to improving Soldier performance through nutrition.			
FY 2017 Plans: Explore the feasibility of creating materials with seemingly dissimilar functionalities such as water-requiring catalysis and water repellency; understand the effects of a three-dimensional (3D) surface structure on material multifunctional performance via the			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H52 / *Equip For The Soldier*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
use of nanoparticles and nanoparticulate films; explore the thermal responsive behavior of silver nanowire enhanced hydrogels to determine the feasibility of integration into protective materials that manage thermal properties such as body heat loss. ***FY 2018 Plans:*** Will assess the use of single-layer graphene as a universal substrate for flexible, conformable sensors with future application to textiles, wearable materials, food safety, and Soldier performance sensing platforms; create materials with orthogonal functionalities using nanoparticles and thin films to understand the molecular and surface structural phenomena which define compatibility; continue to explore the effects of silver nanowire in hydrogel substrates on conductive and thermal properties with a focus on 3D architecture arrangements.			
Accomplishments/Planned Programs Subtotals	1.113	1.133	1.156

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H57 / *Single Investigator Basic Research*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
H57: *Single Investigator Basic Research*	-	84.464	94.519	96.081	-	96.081	101.690	105.185	106.679	110.878	-	-

A. Mission Description and Budget Item Justification

This Project fosters extramural basic research to create and exploit new scientific discoveries and technology breakthroughs, primarily from universities, that will improve the Army's transformational capabilities. The Army Research Office of the Army Research Laboratory (ARL) maintains a strong peer-reviewed scientific research program through which leap-ahead technological solutions may be discovered, matured, and transitioned to overcome the technological barriers associated with next generation capabilities. Included are research efforts for increasing knowledge and understanding in fields related to long-term future force needs in the physical sciences (i.e., physics, chemistry, life sciences, and social sciences), the engineering sciences (i.e., mechanical sciences, electronics, materials science, and environmental science , and information sciences (i.e., mathematical sciences, computing sciences, and network sciences). Targeted research programs in nanotechnology, training and simulation, smart structures, multifunctional and micro-miniature sensors, intelligent systems, countermine, compact power, and other mission-driven areas will lead to a future force that is more strategically deployable, more agile, more lethal, and more survivable. The breadth of this basic research program covers approximately 800 active, ongoing research grants and contracts with leading academic researchers and approximately 1,600 graduate students yearly, supporting research at nearly 210 institutions in 50 states.

Work on this Project is performed extramurally by the ARL located in Research Triangle Park, NC.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Basic Research in Life Sciences	9.392	8.868	5.605
Description: Pursues fundamental discoveries in life sciences with the ultimate goal of facilitating the development of novel biomaterials to greatly enhance Soldier protection and performance. More specifically, i) molecular genetics research pursues fundamental studies in molecular and systems biology, and genetics, ii) neurosciences research investigating the physiology underlying perception, neuro-motor output, and potential methods of monitoring cognitive states during activity, iii) biochemistry research focuses on studies in structural and cell biology, metabolic processes, and biophysics, iv) research in microbiology pursues studies in microbial physiology, ecology, and evolution, v) social science research aims to elucidate the social, cultural, and other influences to human actions, and vi) auditory and signal processing research to map the cognitive implications of multisensory information integration.			
FY 2016 Accomplishments: Researched and designed neuro-cognitive computational models that detect a single-sound source(amongst multiple audible stimuli) to determine whether it is possible to link brain data to the segregated/isolated sound sources from noisy environments (may lead to new applications for effective auditory prostheses, automatic speech recognition, and other tools for enhanced Soldier auditory situational awareness in distracting environments); screened analogs of cellular cyclic diguanylate to identify and characterize a key potential pathway that mediates the formation of bacterial persister cells, a unique state that is known to			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
allow bacteria to survive exposure to antibiotics or environmental changes (may lead to new methods for the rapid and efficient treatment of wounds or systemic infections, particularly those caused by antibiotic-resistant bacteria); determined whether damage after acute myocardial infarction can be reduced by modulating oxygen demand (may lead to a metabolic-reduction strategy to reduce mortality on the battlefield); and evolved artificial enzymes, synthesized by assembling metal catalysts on protein scaffolds, to provide site-selectivity and precision not possible with traditional chemical catalysts (may provide new synthetic routes for advanced, well-defined materials including functionalized polymers and responsive materials, such as new fabrics to protect the Soldier and coatings to strengthen materiel). ***FY 2017 Plans:*** Will develop an analytical method to non-invasively characterize and predict the adaptation of neural circuits (may provide the critical and fundamental groundwork for improved rehabilitation from traumatic brain injury); explore the relationships between ApoE (a protein critical for cholesterol metabolism), mitochondrial function, and brain function (may have implications in the prevention and treatment of traumatic brain injury); investigate mechanisms of protein repair and maintenance that enables some organisms to produce hydrogen continuously in the presence of light (may enable improved hydrogen-producing engineered systems that could ultimately could be used to convert hydrogen to electricity through field-ready hydrogen fuel cells); and characterize and modify bacterial micro-compartments for potential use as an engineered organelle (specialized structure within a cell) (may provide a platform for the production of polymers or antimicrobials that normally require significant infrastructure to produce synthetically). ***FY 2018 Plans:*** Will develop a yeast-based system using a non-canonical amino acid incorporation technique to impart chemical modifications into putative adhesive proteins for the generation and selection of novel adhesive properties that, if successful, may enable new adhesive proteins for future uses ranging from next-generation therapeutics or transdermal drug delivery patches on or near the battlefield; will investigate and validate new candidate brain circuits, predicted to be involved in sleep and wake cycles, by identifying the distribution and dynamics of transcription-factor binding (as a proxy to assess gene expression), that if successful may reveal physiological functions of sleep-regulatory regions in a manner that has never been done before and, in the long term, may enable non-invasive methods for reducing sleep deficit and sleep need for Soldiers who operate in conditions not conducive to restful sleep; will investigate the potential of the insect-specific cysteine in acetylcholinesterase as a unique, unexplored, and viable target to develop insecticides with reduced insecticide resistance and minimal toxicity to mammals for the control of disease vectors, that if successful this should lead to new and more effective methods to control the spread of diseases such as malaria and Zika virus; will identify the proteins and pathways in the bacterium A. baumanii, responsible for maintaining cell viability under conditions of desiccation to review new methods for the engineering of bacterial cells capable of surviving harsh environmental conditions, that if successful may enable the development of sustainable in-field bio manufacturing processes.			
Title: Basic Research in Environmental Sciences	1.474	1.550	0.578

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Basic research in the environmental sciences is needed for the Army to operate effectively because terrestrial and atmospheric conditions and processes affect virtually all aspects of Army activities. The earth's surface environment is a multifaceted and dynamic system, and there is an increasing need for multidisciplinary approaches to address important research questions within the atmospheric and terrestrial sciences. ***FY 2016 Accomplishments:*** Performed analysis of hill slopes using high-resolution topography to test the hypothesis that sharp breaks in topographic scaling metrics exist across climate and erosion rate gradients to generate high resolution information about terrain, vegetation, drainage, and erosion and have implications for change detection. ***FY 2017 Plans:*** Will develop a novel micro-optical sensor platform for the characterization and monitoring of atmospheric gases and aerosols (may lead to new methods for the characterization of aerosol particle shape and composition for rapidly identifying biological warfare agents); and explore and demonstrate a valid approach for short-term dating of heated structures and sediment burial events based on natural mineral luminescence (may provide a crucial tool for calibrating various detection methods for Improvised Explosive Devices (IEDs) and tunnels). ***FY 2018 Plans:*** Will design and utilize chamber experiments to determine partition coefficients for volatile organic compounds (VOCs) between soil, air, and airborne particles under various temperatures, and relative humidity settings that mimic real world conditions, that if successful, will provide data that may ultimately enable new tools for protecting the Soldier and other first-responders from exposure to toxic chemicals, or to sequester and remove VOCs; will design and synthesize simulated soil using synthetic colloids, demonstrate tunable inter-particle attraction to then examine the mechanical properties and flow of earth surface materials such as soils in dynamic environments that if successful may ultimately lead to future methods for safer infrastructure development, economical erosion control, efficient route planning.			
Title: Basic Research in Chemical Sciences ***Description:*** Basic research to achieve advanced energy control, improved threat detection, and novel responsive materials for Soldier protection. Research efforts will lead to: light-weight, reliable, compact power sources, more effective, lower vulnerability propellants and explosives for tailored precision strikes with minimum collateral damage, new approaches for shielding the Soldier and Army platforms from ballistic, chemical, and biological threats, and reducing signatures for identification by the enemy, and advance warning of explosive, chemical, and biological weapons and dangerous industrial chemicals. ***FY 2016 Accomplishments:*** Investigated and characterized the decomposition mechanisms in methyl nitrate, an important high-energy material, which may lead to the engineering of explosives that are safer for transport and use by the Soldier; elucidated the basic mechanisms by	9.184	12.950	13.761

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
which ion concentration and ion type affect the ordering and properties of micrometer-sized droplets of liquid crystals and the potential for these mechanisms to provide large-scale measurable changes (may lead to new capabilities for sense-and-respond chemical systems including self-healing, self-cleaning, and adaptive materials); synthesized new polymers composed of functional block copolymer membranes containing a high density of tailored pores and characterize the kinetics of the membrane transport properties to changes in external stimuli (may enable new applications in sensing, water purification, and breathable chem/bio protective clothing); and identified and characterized the active sites and intermediates in the electrochemical and photocatalytic reactions that occur in metal / semiconductor electrodes (may improve energy generation and storage). ***FY 2017 Plans:*** Will explore the fundamental aspects of oxygen and hydrogen transport gas diffusion electrodes (may enable new higher-performing power generation and energy storage technologies); devise new methods to synthesize infinite coordination polymers, that are a class of materials that possess tailorable properties and high surface areas (may provide novel materials with applications in sensing and catalysis); evaluate the role of the recently-discovered chemical reaction pathway termed “roaming mechanisms” in the decomposition of energetic molecules such as explosives (may enable improved control and development of next-generation propellants and explosives); and push the current boundaries of mechanical-chemical reactivity by designing and demonstrating new modes for activating molecules called mechanophores, which convert mechanical to chemical energy using pre-defined mechanisms (may lead to regenerative materials and controlled drug delivery). ***FY 2018 Plans:*** Will devise a new approach to fabricate precise conjugated polymers with controlled monomer sequences that in the long term, if successful, may lead to new semi-conducting materials with applications in sensing and detection; will establish the relationship between the 3D interphase structure, the interface impedance, and the electrochemical behavior of all-garnet solid-state systems, to enable the characterization of different sources of interfacial resistance and advance the current understanding of the solid-solid electrode/electrolyte interface that, if successful, could lead to new solid-state high-performance batteries with increased safety and reduced weight; will devise new methods to fabricate multifunctional nanostructures with features that can be dynamically regulated in space and time that in the long term, if successful, may ultimately lead to novel materials with applications in protection such as dynamic camouflage; will prepare a population of molecular hydrogen and determine the quantum state of the ensemble using multiphoton ionization-mass spectrometry that, if successful, may provide results ultimately leading to new methods in quantum computation for ultra-secure communication.			
Title: Basic Research in Physics ***Description:*** Focuses on research in many subfields of physics, including condensed matter physics, optical physics, atomic and molecular physics and quantum information, with an emphasis on discovering new realms of quantum and optical phenomena. Pursuit of fundamental physics in these subfields provides new opportunities for future developments in superior optics, ultra-sensitive sensors, and novel electronic architectures for classical and quantum computing.	16.295	18.678	17.861

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Developed new imaging methods such as non-linear optical spectroscopies for detecting spin-orbit coupling in advanced materials (may lead to new electronic technologies for sensors and computational hardware); investigated novel photon-photon interactions in a strongly-interacting cold atomic gas (may enable the first observation of the crystallization of a gas of strongly interacting photons, and in the long term, may lead to improvements in computation, measurement, and sensing); developed robust techniques for quantum sensing and measurement to overcome the fragility of quantum information due to unwanted environmental interactions (may provide unprecedented computation and communication capabilities); and characterized the unique electron dynamics of a particular class of magnetic materials known as ferroplasmons and develop theories to effectively model this behavior (may lead to lighter and smaller electronic components). ***FY 2017 Plans:*** Will characterize and devise methods to control the unique structural, orbital, and magnetic order in a particular structure of oxygen-containing compounds called isovalent oxide superlattices (may lead to unique advances in computing, passive sensors, and low-power electronics); systematically study and simulate the long-range interaction of quantum defects in materials (may lead to the development of new materials with properties previously inaccessible by traditional synthesis methods); utilize recently developed quantum algorithms for quantum chemistry to investigate new algorithms (may provide tools for the next-generation of communication devices); and develop a comprehensive theoretical framework of photonic metamaterials that control light in ways impossible with any natural material (may lead to a new class of lightweight electronics and photonics, such as low-power lasers and new imaging techniques). ***FY 2018 Plans:*** Will investigate a new class of photonic structures called photonic topological metamaterials that, if successful, will provide for better control of light in materials and in the long term will enable the design and creation of metamaterials to bend light in ways previously impossible and with lower loss, potentially providing new tools for microscopy, sensing, and power harvesting; will induce and demonstrate superconductivity in a material in which electrons behave in a way not achievable in traditional semiconductors, that in the long term may enable new electronics with dramatically-reduced power consumption; will use ultra-cold atoms in highly-excited states, called Rydberg atoms, to achieve quantum simulation of the Ising model of optical lattices (gaseous-phase atoms in a specialized ordered state) whereby certain atoms are in competition for spin state, that if successful may provide a method for predicting and measuring defects in materials, enabling the rapid development of new materials with desired properties; will demonstrate entanglement between neutral atoms and microwave photons in a superconducting cavity that, if successful, may enable the development hybrid quantum systems for use in ultra-secure communication devices.			
Title: Basic Research in Electronics and Photonics	10.706	11.260	8.634

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Pursues discoveries in electronic sensing, optoelectronics, solid state and high frequency science, electromagnetics, microwaves, and power electronics for situational awareness, communications, information processing, electro-magnetic warfare, and power efficiency. ***FY 2016 Accomplishments:*** Established infrared and optical response in a carbon nanotube-oxide-metal rectenna for room temperature infrared detection; showed coaxial nanolasers scalable to deep-subwavelength dimensions suitable for on-chip interconnects; initiated metasurface control of THz radiation emission (direction and beam width) without external antenna, used variable surface wave propagation for chemical and biological agent sensing; and created a novel gallium nitride graphene hot electron transistor structure with THz frequency response for high data rate communications capable of transmitting greater amounts of data in a similar timeframe. ***FY 2017 Plans:*** Will show that thermal field gradients can be used to create additional stress in flexoelectric materials for improved energy harvesting and self-powered wireless sensors; show route to high modulation bandwidth surface emitting lasers with oxide-free vertical cavity approaches for high bandwidth photonic circuits; demonstrate radio frequency filters with unmatched quality factors nearing 400 (a factor of 5 better than the best previously reported, for ground mobile wireless communications); and create a gallium nitride based semiconductor/biomolecular platform for investigating guided growth of neuronal cells and hybrid functional neural circuits with both regular electronics and artificial neuronal circuit components for brain/machine interfaces. ***FY 2018 Plans:*** Will investigate photocurrent generation in new nanohybrid, carbon-based systems for ultraviolet (UV) and infrared (IR) detection; will create AlGaN nanowire arrays for deep UV electrically controlled lasers; will identify complementary metal–oxide–semiconductor (CMOS) nano-electrode arrays that interface with mammalian neuronal networks for potential restoration of neural functions; will create new capabilities for beam steering, beam forming, and waveform control in the terahertz range, by use of electrically switchable metasurfaces.			
Title: Basic Research in Materials Sciences ***Description:*** Research that provides innovations in materials design and process through the elucidation of fundamental relationships linking composition, microstructure, defect structure, processing and properties of materials. Revolutionary materials provide support for the Army in firepower, mobility, communications, personnel protection, infrastructure and installations, and will directly affect virtually all mission areas. ***FY 2016 Accomplishments:*** Enabled control of chemical and electrochemical reactions through the rational design of material architectures that control the spatial and temporal pathways of precursors, intermediates, and products in order to achieve dramatically enhanced efficiency and extraordinary energy production and storage; created stable free-standing single monomer thick novel two-dimensional	6.974	7.334	7.882

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
(2D) crystalline organic polymer nanosheets and covalent organic frameworks with unprecedented physical properties to enable tunable band gaps and high carrier mobility and enable polymer electronics; and developed a fundamental understanding of how to propagate a molecular-level detection event to a macroscopic material property change across multiple length and time scales to achieve revolutionary sensors with record sensitivity and selectivity. ***FY 2017 Plans:*** Will establish a new generation of spin-based devices based on optimized spin-orbit coupling heterostructures, such as nanoscale terahertz oscillators and ultrafast, low power spin logic/memory (for potential applications in non-volatile memory, high-speed logic and information processing, chemical sensing, and high-frequency communications); and utilize driven periodic excitation to systematically explore, demonstrate, and stabilize hidden phases of materials with unique physics and properties, enable the theoretical predictive capacity for such hidden phases, and synthesize strongly correlated (thin film) materials based upon these phases (for disruptive electrical, optical, thermal and magnetic applications). ***FY 2018 Plans:*** Will establish the design and directed assembly of nano-building blocks into complex, hierarchical 3D architectures capable of long-range control over multifunctional behavior and smart/dynamic responses using an additive 3D material assembly approach (for applications in manufacturing, novel electronics and communications); will create new systems exhibiting the physics of anyons (a type of quasiparticle that only occurs in two-dimensional systems) and topologically protected states (for unique communication, sensing and logic applications); and will develop a novel theory-experiment feedback loop to accelerate discovery of optimized novel polymer nanocomposites (PNCs) (for structural, durability, and light-weighting applications).			
Title: Basic Research in Computing Sciences ***Description:*** Provides the backbone for performing complex, multi-system analysis, modeling and simulation for understanding information systems. Advancements in computer sciences have a direct impact on enhancing the Warfighters' decision-making, situation awareness, command and control, as well as on the overall performance of weapon, intelligence, transportation and logistics systems. ***FY 2016 Accomplishments:*** Established novel representations, non-commutative information theory, and dimensionality reduction of multimodal data that enabled effective large scale multimodal data analyses, particularly image/video data analytics to extract actionable intelligence that supported Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR); created new techniques for the optimal realization of real-time multi-core systems as well as future hybrid and exascale systems through the asymptotic analysis of scheduling approaches and new energy efficient algorithms and architectures for efficient and timely processing of Army big data analytics and timely field information processing; investigated metrics for determining information	7.660	8.558	6.761

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
trustworthiness and for detecting deception in social data; and established new analytical models that quantify the resiliency of computing systems. ***FY 2017 Plans:*** Will create methods to allow message-passing distributed applications to efficiently solve problems in which data and/or memory requirements far exceed the amount of physical memory available in the underlying computer system (for efficient and timely processing of Army big data analytics, and efficiently solving large Army problems on computer clusters); establish unified visual data representation and methods for face recognition using low quality images and videos taken from unconstrained and multi-spectrum visual sources to achieve reliable performance of face recognition; establish guiding principles for cyber system maneuvering; and establish models and quantification metrics to analyze and evaluate the effectiveness of cyber system adaptation for better defense. ***FY 2018 Plans:*** Will create a new set of algorithms and software environments to perform scientific and geometric computations on heterogeneous processors to address issues related to load balancing between central processing unit (CPU) and graphics processing unit (GPU) cores, programmability, and power management that can be applied to enhance data processing capabilities for Army big data challenges; will establish new methodologies for modeling multimodal neural activity to design closed-loop adaptive algorithms for optimized brain-computer communication; and will develop novel cyber system adaptation techniques that will make Department of Defense (DoD) cyber systems more resilient and robust against potential cyber attacks.			
Title: Basic Research In Network Sciences ***Description:*** Focuses on gaining an understanding of the fundamental aspects of how networks develop, function, and adapt to the environment and the rate of information flow in man-made and naturally occurring networks. This understanding will have a direct impact on net-centric force operations, such as better communication system design and operations, and more efficient logistics or communications support. ***FY 2016 Accomplishments:*** Researched design mechanisms for deriving consensus, use in crowd-sourcing based solutions for resource allocation problems; studied how to design teams to optimize performance and diversify capabilities by building mathematical models that explain and predict how teams organize, exchanged information, build knowledge, influence, adapt, learn, and build consensus, resulting in actionable findings that create effective teams; studied how information from social networks was used to design and build adaptive, predictive solutions for managing load, mobility, and connectivity of communication networks; developed new control theory that facilitated task allocation and efficient exploration by autonomous teams; and developed spectral methods that determined important properties of random graphs and different classes of dynamics on networks related to flows/advection and	8.250	10.578	11.574

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
consensus processes that enabled the shaping and manipulation of networks to achieve dynamically reconfigurable desired information processing and energy distribution properties. ***FY 2017 Plans:*** Will investigate traffic flows under various conditions of communications service degradation to determine effect on the message throughput and delay; research interactions between systems requiring finite delay to improve real-time video and facilitate robotic control over disadvantaged communications networks; research modeling and control of finite-sized, far-from-equilibrium systems and bio-inspired information for perception and sensory motor control; research quantifiable informative models of team behavior as dynamical systems interacting over multiple networks to advance the network science of teams, and examination of the antecedents and effects of knowledge hoarding on team performance; and research modeling and detection of spurious and deceptive data in decisions based on crowd-sourcing. ***FY 2018 Plans:*** Will compare the performance of a reservoir computer, a novel neuromorphic self-timed computer architecture to state-of-the-art time series analysis and prediction methods using nonlinear Gaussian process regression to understand dynamics of systems with multiple time scales, multivariate data, and whether a hybrid reservoir Gaussian regression architecture surpasses the performance of either algorithm alone; will develop new algorithms and tools to design/re-design teams for improved performance over time, and discover the underlying mechanisms behind cyber flash mob behaviors as a manifestation of interconnected networks; will investigate the use of the software defined networking paradigm to adapt to rapidly changing network conditions without operator intervention to enable delay intolerant communications (voice, real-time video, and facilitate robotic control), and improve overall throughput to maximize situational awareness; and discover game theory principles in the world of biochemistry as it relates to strategies for leading tumor cells to degrade to a benign state.			
Title: Basic Research in Mechanical Sciences ***Description:*** Focuses on improved understanding of propulsion and combustion for improved efficiency and fuel flexibility, energetics initiation for insensitive munitions, fluid dynamics for rotorcraft, complex dynamic systems for novel sensors, energy generation and multi-dimensional systems, and solid mechanics especially at high strain rates in composite materials for novel armor and protection systems. ***FY 2016 Accomplishments:*** Gained understanding of dynamic responses of reactive metallic alloys (RMA) -- how they deform, fracture and combust to enable novel energetic material behaviors; developed microstructure-failure-strength relationships at mesoscales in lightweight metallic systems under dynamic loading conditions and bridge the gap between atomistic and continuum simulations for fundamental understanding of the processes governing the strength and toughness properties of solids; determined effectiveness of near-Kolmogorov & Kolmogorov scale forcing of shear layers for re-distributing energy from large scale turbulent structures to	6.671	6.977	6.556

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
small scales dominated by viscous dissipation for improved understanding of flow separation and control; and determined the biophysical principles underlying muscle's capability to store, dissipate, generate, and transfer energy. ***FY 2017 Plans:*** Will develop scientific principles for a new framework to enable new capabilities for programming deformable structures to perform dexterous interactions (deformable structures provide more accurate modeling); perform experimental measurements and develop theoretical models for the dynamics of anisotropic (i.e., non-spherical) particles in turbulent flows in order to elucidate and describe small-scale vorticity (i.e., curl of the velocity field) mechanisms in large-scale flows; develop reduced models for the combustion of alkane based fuels using a novel computational approach based on the synergy between atomistic simulations and network analysis of complex systems; and develop conceptual and analytical-computational models, based on the energy dissipated by interface fracture simulated by artificial equivalent shear viscosity and capable of effectively representing failure in complex composite materials subjected to high-strain rate dynamic loading. ***FY 2018 Plans:*** Will investigate an electrokinetic instability mechanism as an explanation for observed banding of microparticles which may lead to a novel process for microscale self-assembly of particles based on surface charge characteristics rather than bulk properties for novel material characteristics; will develop a detailed liquid-phase decomposition mechanism of RDX (a white solid explosive) which includes only elementary reactions which in turn will be used to predict the burn-rate and flame structure of RDX and the burn-rate modifier for future design of enhanced energetic materials; will derive a hierarchy of tractable analytical models of actuated elastica to enable distributed estimation and control of the intrinsic curvature and contact deformation/ adhesion properties of continuous media which will lead to enhanced robotic mobility; will investigate mechanics of dynamically growing crack interacting with an interface and associated stress wave attenuation in transparent layered material for potential development of blast resistant transparent material systems for future soldier system protection.			
Title: Basic Research in Mathematical Sciences	5.893	5.700	5.750
Description: Pursue the creation of new mathematical tools and methods for performing complex, multi-system analysis and modeling to enhance soldier and weapon-system performance. More specifically, the focus is on creating mathematical principles and practical algorithms for stochastic analysis and control, analysis and control of biological systems, numerical computation of infinite-dimensional systems, and modeling of irregular geometric and social phenomena. ***FY 2016 Accomplishments:*** Initiated basic research efforts that developed a theory of information at the quantum level that developed advanced geometric models of social processes as an alternative to network models, and developed mathematical models that achieved a two-way flow of information in the computational modeling of materials. These new mathematical areas brought new modeling capabilities in secure communications, the prediction of collective behavior, and enable designer materials. ***FY 2017 Plans:***			

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Will conduct basic research efforts to outline the major areas of the fundamental laws of quantitative biology, and develop fractional-order mathematical models (used in the study of anomalous behavior of dynamical systems) and corresponding computational methods for sharply-featured flows. Development of these new mathematical areas is expected to bring new modeling and predictive capabilities into biology, littoral flows, and in fluid-structure applications, such as turbines and windmills. ***FY 2018 Plans:*** Will initiate and conduct basic research efforts to develop the stochastic mathematics that underlie and enable the analysis of mean field games, and develop interdisciplinary approaches to reduce the order of the huge systems of equations generated for modeling the control of open quantum systems. Development of these new mathematical areas is expected to provide new mathematical tools to social scientists for modeling strategic decisions in reasoning about cultural norms and emergence of non-state adversarial groups among large populations and enable the design of more efficient quantum computation algorithms.			
Title: Basic Research in Simulation and Training ***Description:*** Advances in simulation and training require basic research to understand neuronal changes that occur in the brain during successful and unsuccessful simulations and training. An interdisciplinary approach involving chemistry, computer science, engineering, mathematics, physics, and network science will be required to understand the molecular, cellular, developmental, structural, functional, and computational aspects of the brain during learning, simulation, and training. It will be necessary to determine how neural circuits develop and are arranged physiologically in individuals to produce cognitive computations during simulation and training. This research will also include extensive studies to discover and map the neural circuitry that enables cognitive adaptation, and the dynamic mechanisms of neural network modification need to be established. ***FY 2016 Accomplishments:*** Furthered the research in the design of mathematical models and experimental methods that map how the brain processes and integrates data received from all senses simultaneously (e.g., auditory, visual, olfactory), and determined the implications of this process in human decision making. In the long term, this research will provide tools to select individuals best suited for particular tasks and the development of more rapid and cost-effective methods to train warfighters for a range of complex tasks. ***FY 2017 Plans:*** Will elucidate the neural mechanisms underlying the perception of camouflaged objects (may provide new simulation methods for camouflaging personnel and material, and new training methods to help observers detect hidden objects); and research the neural code underlying auditory attention by mapping activity in multiple auditory-related sites simultaneously (may provide a new paradigm for enhancing Warfighter performance and caring for injured personnel). ***FY 2018 Plans:*** Will perform data fusion of electroencephalogram and functional magnetic resonance imaging data to yield spatial and temporal resolution of brain activity during search tasks, to test candidate mechanism developed in prior year in which data suggested area of brain was previously thought not to be involved in visual search may have role in camouflage-breaking, that in the long term,	1.965	2.066	2.032

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if validated, may provide new simulation methods for camouflaging personnel and materiel, and new training methods to help observers detect hidden objects; will develop and validate new models of risks of error in human interaction in complex systems to determine risk points at which human behavior undermines system performance that in the long term, if successful, may lead to new automated methods to detect and mitigate human error in complex systems that could otherwise lead to catastrophic failures.			
Title: Expeditionary Materials Processing Science ***Description:*** Basic research coupling materials, innovative design, and manufacturing science to enable conversion of resources for meeting an expeditionary Army's requirements. This research will enable predictive material-to-materiel models for high-confidence, certifiable article production, high-fidelity expeditionary and versatile material-to-materiel processing capabilities, and a new generation of materials responsive to applied field for shape shifting and phase transformation. ***FY 2018 Plans:*** Will demonstrate proof-of-concept through design, synthesis, and validation of adaptive compounds that elicit activated remodeling via mechanochemistry to create synthetic materials with stress-responsive behavior analogous to that observed in biological systems. If successful, this approach may provide a method for creating materials that enhance protection for the Soldier by strengthening or changing shape in response to external stresses.	-	-	5.117
Title: Basic Research in Social Sciences ***Description:*** Social science research focuses on generating fundamental understanding of how social dynamics unfold, taking into account individual-level biophysiological factors contributing to social interaction (e.g., genetics, health, cognition, perception), group processes (e.g., interpersonal forces that determine influence, power, conformity), and the impacts of social institutions (e.g., economic processes, legal/governance structures, religious/belief systems, kin networks), with attention to the interconnections among these levels of analyses, and to the physical and natural environments in which human social dynamics are situated. This scientific understanding will improve situational awareness for Warfighters and analysts, improving efficacy of decision-making to achieve mission objectives. ***FY 2018 Plans:*** Will research to improve measurement and modeling of social dynamics by tying biometric measurement (e.g., facial thermography, neural imaging, nervous system monitoring, voice acoustic sensing) to interpersonal dynamics and perception networks in small and large groups in localized and dispersed environments; develop new analytic approaches to capture interdependence of actions and precursors of action as well as spatial and temporal dependencies across levels of analyses (i.e., individual-to-group-to-society) to improve predictive accuracy of models of social interaction; advance ecological modeling approaches developed to capture organizational and group dynamics to better understand human social dynamics at population levels; assess impact of media and information technology on cross-cultural diffusion of information, opinion, and influence.	-	-	3.970
Accomplishments/Planned Programs Subtotals	84.464	94.519	96.081

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H66 / *Adv Structures Rsch*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H66: *Adv Structures Rsch*	-	2.008	2.061	3.108	-	3.108	3.153	3.197	3.240	3.285	-	-

A. Mission Description and Budget Item Justification

This Project funds basic research for improved tools and methods to advance structural health monitoring capabilities and enable condition-based maintenance for sustainment of rotorcraft and ground vehicles. This research also enables the design and use of composite structures that can better address the cost, weight, performance, and dynamic interaction requirements of future platforms identified by the Army Modernization Strategy. Ultimately, these technologies result in safer, more affordable vehicles with a greatly reduced logistics footprint. This Project is a collaborative Army and National Aeronautics and Space Administration (NASA) effort that includes structures technology research into: structural integrity analyses; failure criteria; inspection methods which address fundamental technology deficiencies in both metallic and composite Army rotorcraft structures; use of composite materials in the design and control of structures through structural tailoring techniques; rotorcraft aeroelastic modeling and simulation; helicopter vibration (rotating and fixed systems); and the design and analyses of composite structures with crashworthiness as a goal. The problems in structural modeling are inaccurate structural analysis and validation methods to predict durability and damage tolerance of composite and metallic rotorcraft structures and inadequate structural dynamics modeling methods for both the rotating and fixed system components to address reliability issues for future aircraft. The technical barriers include a lack of understanding of failure mechanisms, damage progression, residual strength, high-cycle fatigue, the transfer of aerodynamic loads on the rotor to the fixed system, and impact of these unknown loads on aircraft components. Technical solutions are focused on: advanced fatigue methodologies for metallic structures, improved composites technology throughout the vehicle, long-term investigation of integrated stress-strength-inspection, advanced methods for rotor system vehicle vibratory loads prediction, improved methods to predict vehicle stability, and improved analyses to address Army Aviation requirements. These advancements will extend service life, reduce maintenance costs, enhance durability, and reduce the logistics footprint of existing and future Army vehicles. This is the only basic research Project supporting investigations for rotorcraft and ground vehicle structures within the Department of Defense.

Work in this Project supports key Army needs and provides the technical underpinnings to Program Element (PE) 0602211A (Aviation Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by the Army Research Laboratory (ARL) at Aberdeen Proving Ground, MD and NASA Langley Research Center, Hampton, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Structural Analysis and Vibration Methods	2.008	2.061	-
Description: This research explores new structural analyses and validation methods to achieve more accurate predictions of durability and damage tolerance in composite and metallic rotorcraft structures and evaluates structural dynamics modeling methods to address critical reliability issues in the rotating and fixed system components of future aircraft.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H66 / *Adv Structures Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Investigated (experimentally and theoretically) the electrical, thermal, magnetic, and mechanical property changes for structural materials and composites under complex loading conditions for the purpose of assessing the practicality of damage-detection sensing modes, and for developing damage progression models; and researched novel processes to enhance the electrical, thermal, mechanical and magnetic performance. ***FY 2017 Plans:*** Will develop innovative theoretical models that accurately predict material crack growth and structural fatigue life for use in increasing the fatigue-failure resistance of metallic and composite structural components for Army platforms; and investigate and identify materials damage precursors in structures by utilizing material electrical, thermal, mechanical, and/or magnetic response to enable strategies to extend the life of critical structural components by tailoring usage based upon early damage detection.			
Title: Air Vehicle Structures & Dynamics Research ***Description:*** Conduct basic research in advanced analytical methodologies and techniques for understanding and predicting the health and performance of rotorcraft structures. Develop and experimentally validate technologies, models, and approaches to increase the reliability, useful life, or performance of components in vertical takeoff and landing systems. ***FY 2018 Plans:*** Will investigate rotor blade morphing technology by comparing and improving analytical predictions with data collected from low-speed wind tunnel tests as an approach to reducing vibration and potentially enable swashplate-less flight; will investigate structure fatigue models to correlate damage indicators and more accurately predict the remaining useful life of structural components; and will improve theoretical computational algorithms to more accurately predict structural durability and damage tolerance.	-	-	2.104
Title: Reconfigurable Platform Mechanics & Propulsion ***Description:*** Conduct basic research in reconfigurable platform mechanics and propulsion science technologies to enable high-speed Vertical Take-Off and Landing (VTOL). Investigate reconfigurable technologies for improved performance, stability, and handling qualities ***FY 2018 Plans:*** Will investigate aeromechanic characteristics of morphing structures and reconfigurable propulsion concepts such as engine cycles and propulsor drive system configurations.	-	-	1.004
Accomplishments/Planned Programs Subtotals	2.008	2.061	3.108

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H66 / *Adv Structures Rsch*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H67 / *Environmental Research*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H67: *Environmental Research*	-	0.877	0.928	1.036	-	1.036	1.056	1.076	1.099	1.121	-	-

A. Mission Description and Budget Item Justification

This Project focuses basic research on innovative technologies for industrial pollution prevention (P2) that directly supports the Army production base and weapon systems and also addresses non-stockpile chemical warfare (CW) site remediation. Work in pollution prevention invests in next generation manufacturing, maintenance, and disposal methods that will result in significantly reducing the usage of hazardous and toxic substances and their associated costs. The goal is to decrease the overall life-cycle costs of Army systems by 15-30% through the application of advanced pollution prevention technologies. Non-stockpile CW efforts include establishing the ecotoxicity of CW compounds, environmental fate and effect of CW compounds in soils and biodegradation of CW compounds. Pollution prevention thrusts include: environmentally acceptable, advanced, non-toxic processes to manufacture lightweight alternative structural materials to enhance weapon system survivability; clean synthesis of more powerful and improved energetic compounds to eliminate the use of hazardous materials and minimize the generation of wastes; and surface protection alternatives to hazardous paints, cadmium, chromium, and chromate conversion metal and composite surfaces.

Work in this Project complements and is fully coordinated with the Army Environmental Requirements Technology Assessment (AERTA) requirements and contains no duplication with any effort within the Military Departments.

The cited work provides the technical underpinnings for Program Element 0602618A (Ballistics Technology).

Work in this Project is performed by the Army Armament, Research, Development and Engineering Center, Picatinny, NJ.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Industrial Pollution Prevention	0.877	0.928	1.036
Description: This effort conducts research on innovative environmentally-friendly technologies that support the warfighter (focusing on pollution prevention technologies).			
FY 2016 Accomplishments: Performed research involving hazardous materials and wastes generated from production of energetic materials, additive manufacturing, and weapon systems; investigated efforts to enhance technologies to support Soldier systems; and investigated selected projects to comply with the Office of the Secretary of the Army's environmental initiatives.			
FY 2017 Plans: Will investigate and perform basic research for the reduction of hazardous materials generated from energetic materials formulations, additive manufacturing, and weapon systems designs focusing on pollution prevention technologies. This includes			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H67 / *Environmental Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
investigating new innovative energetic materials, as well as analyzing selected projects and their respective technologies for their compliance to the Office of the Secretary of the Army's environmental initiatives. ***FY 2018 Plans:*** Will investigate and perform basic research on the development of novel energetics for the reduction of hazardous materials in the processing of energetics. Additional research will include the investigation of airborne lead reduction for Army weapon systems as well as investigating new advanced surface coating products to minimize human health, environmental and long-term sustainable risks.			
Accomplishments/Planned Programs Subtotals	0.877	0.928	1.036

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army				Date: May 2017
Appropriation/Budget Activity 2040 / 1		R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*		Project (Number/Name) S13 / *Sci BS/Med Rsh Inf Dis*

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
S13: *Sci BS/Med Rsh Inf Dis*	-	10.951	11.318	11.039	-	11.039	11.272	11.509	11.501	12.253	-	-

Note

In Fiscal Year (FY) 2017: Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases research area and the Vaccines for Prevention of Malaria research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines

A. Mission Description and Budget Item Justification

This Project fosters basic research leading to medical countermeasures for naturally occurring diseases impacting military operations. Basic research for this project provides an understanding of the mechanisms that make organisms infectious and mechanisms that render the human body response effective, preventing diseases caused by infectious agents. Understanding the biological characteristics of infectious organisms also enables the development of point-of-care and laboratory-based diagnostic tools (used to identify the nature and cause of a particular disease). Understanding of disease transmission by insects and other organisms helps in developing new interventions to prevent transmission of such diseases. Infectious disease threats from malaria, diarrhea, and dengue (a severe debilitating disease transmitted by mosquitoes), common where Warfighters are stationed across all Unified Combatant Commands, are the highest priorities for basic research.

Research conducted in this Project focuses on the following four areas:

(1) Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases
(2) Bacterial Disease Threats
(3) Viral Disease Threats
(4) Vector Identification and Control

Work is managed by the Medical Research Materiel Center (MRMC) in coordination with the Naval Medical Research Center (NMRC). The Army is responsible for programming and funding all Department of Defense naturally occurring infectious disease research requirements, thereby precluding duplication of effort within the Military Departments.

Work in this Project complements and is fully coordinated with Program Element (PE) 0602787A (Medical Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology, focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Walter Reed Army Institute of Research (WRAIR) and NMRC, Silver Spring, MD, and their overseas laboratories.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases	3.872	-	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: This effort is to better understand the biology of malaria and leishmaniasis (a skin-based disease transmitted by sand flies predominantly exhibited as skin sores) parasites and to gain the necessary foundation for discovering medical countermeasures to protect military personnel from infection. Malaria, which can cause fatal and chronic disease, is the most significant military infectious disease threat. Because the malaria parasite becomes resistant to drugs over time, it is necessary to continually search for parasite weaknesses that can be exploited by different drugs and vaccines. In FY17 this research area and the Vaccines for Prevention of Malaria research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines. ***FY 2016 Accomplishments:*** Optimized the safety and effectiveness of next generation malarial prophylaxis (measures taken to prevent health problems) candidate drugs based on lead candidates identified in FY15, through structural modifications of selected compounds (Triazine and Pyrimidinylguanidine); and will identify new lead candidates.			
Title: Vaccines for Prevention of Malaria ***Description:*** This effort is to better understand and identify new proteins in the design of candidate vaccines for various types of malaria including the severe form of malaria (Plasmodium falciparum) and the less severe but relapsing form (Plasmodium vivax). A highly effective vaccine could reduce/eliminate the use of anti-malarial drugs and also reduce the development of drug resistance to current/future drugs. In FY17 this research area and the Drugs to Prevent/Treat Parasitic Diseases research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines. ***FY 2016 Accomplishments:*** Identified and characterized mechanisms of protective immunity elicited by new candidate malaria protein-based antigens; define a strategy to develop a candidate vaccine against falciparum malaria that contains several different kinds of antigens, to improve vaccine effectiveness; and identify new recombinant (artificially produced via genetic engineering) protein-based vaccine candidate(s) against vivax malaria.	2.493	-	-
Title: Basic Research on drugs and vaccines against parasitic diseases ***Description:*** Malaria, which can cause fatal and chronic disease, is the most significant military infectious disease threat. This effort seeks to better understand the biology of malaria and leishmaniasis (a skin-based disease transmitted by sand flies predominantly exhibited as skin sores) parasites and to gain the necessary foundation for discovering medical countermeasures to protect military personnel from infection. Because the malaria parasite becomes resistant to drugs over time, it is necessary to continually search for parasite weaknesses that can be exploited by different drugs and vaccines. This effort seeks to better understand small molecule therapeutics and prophylactics, to overcome drug resistant organisms and identify new proteins in the design of candidate vaccines for various types of malaria including the severe form (caused by Plasmodium falciparum) and the less severe but relapsing form (caused by Plasmodium vivax). In FY17 the Prevention/Treatment of Parasitic Diseases research	-	6.583	6.188

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
area and the Vaccines for Prevention of Malaria research area are merged into one task area titled Parasitic Diseases – Drugs and Vaccines. ***FY 2017 Plans:*** Will identify new formulations (increase/decrease drug quantity in single administered dose, change chemical structure to increase circulating dose) of selected compounds Will identify new lead candidates from the 8-aminoquinoline class of compounds used to treat malaria. Will continue to identify and select additional methods to formulate new recombinant (artificially produced via genetic engineering) protein-based vaccine candidate(s) against vivax malaria (the most common of four types of malaria species) to initiate assessment of its immunogenicity (ability to provoke an immune response) in small animals. ***FY 2018 Plans:*** Will assess new lead candidates from the Triazine class of compounds. Will identify and assess new lead candidates from the pyrimidinylguanidine class of compounds (a newly discovered family of similar chemical compounds that are active against malaria parasites in experimental animals) and a new primaquine-like compound used to prevent or treat malaria. Will continue to monitor for emergence of drug resistant malaria in Asia, Africa and South America. Will fabricate newly discovered malaria proteins (artificially produced via genetic engineering) to characterize their ability to prevent malaria in experimental animals. Will continue to identify new formulations or delivery methods of malaria proteins for inclusion into malaria vaccines.			
Title: Bacterial Disease Threats ***Description:*** This effort is to better understand the biology of bacterial organisms and their effects on humans, how to prevent wound infections, prevent/treat diarrhea (a significant threat during initial deployments), and scrub typhus (a debilitating mite-borne disease that has in recent history been the leading rickettsial disease to impact US military operations and is developing resistance to currently available antibiotics). ***FY 2016 Accomplishments:*** Identified and explore various methods to develop a combination vaccine against three bacterial agents (Campylobacter, Shigella, and enterotoxigenic E. coli.) that together are responsible for most diarrhea cases in deployed Warfighter's; and continue epidemiological studies on various deployed populations with regard to disease-causing microorganisms of the digestive system. These epidemiological studies aid the planning and evaluation of strategies to prevent diarrhea in deployed Warfighters. Define indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea. The correlates of protection aid in vaccine development; Continue to identify additional therapies and tools for preventing and treating wound infection and improving wound healing; and evaluate novel technologies for treatment and prevention of multi-drug resistant bacteria most commonly encountered in trauma-associated infections. ***FY 2017 Plans:***	1.496	1.532	1.582

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will continue to identify new antigen (substance that causes your immune system to produce antibodies) targets and explore their immunogenicity potential for the development of vaccines against Campylobacter, Shigella, and enterotoxigenic E. coli. (ETEC) which together are responsible for most of the cases of diarrhea in deployed Warfighters. Will continue to perform epidemiological studies in various deployed populations to identify relevant types of pathogens to inform vaccine development and include these in vaccine formulations. Will continue to identify indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea in order to predict vaccine effectiveness in humans. Will continue identification and characterization of potential therapeutics and/or diagnostic targets within the host or pathogen associated with multi-drug resistant wound infections and/or biofilm (a group of microorganisms that stick to each other, on a surface) formation. ***FY 2018 Plans:*** Will characterize the newly-identified antigens (substances derived from the agent which stimulate immune systems to produce antibodies) from Campylobacter, Shigella, and ETEC which together are responsible for most of the cases of diarrhea in deployed Warfighters. Will review epidemiology data from deployed populations to determine which pathogens should be included in future vaccines. Will continue to discover/identify indicators of vaccine effectiveness (correlates of protection) identified in animal models of bacterial diarrhea for protection from disease.			
Title: Viral Threats Research ***Description:*** This effort is to better understand highly lethal or incapacitating viruses, including those that cause hemorrhagic diseases (viral infection that causes severe internal bleeding) such as dengue hemorrhagic fever (life-threatening form if disease caused by the Dengue virus, transmitted by mosquitoes) and Hantaviral pulmonary syndrome (caused by hantavirus infection resulting in internal bleeding; can be transmitted by exposure to rodents or their droppings). Basic research includes understanding risk to the Warfighter of contracting a viral disease based on its prevalence in the respective area of operations, viral biology (structure, function, life cycle of the virus and its ecological factors), the disease process, and disease interaction (symptomology) with the human body. ***FY 2016 Accomplishments:*** Assessed host and viral determinants of dengue fever disease severity among populations at risk; continue to explore innovative vaccine designs, adjuvant systems and delivery methods for a dengue virus vaccine; and continue studies to identify and evaluate the role of human cells and antibodies in developing medical countermeasures to prevent and/or treat diseases caused by hantaviruses and other lethal viruses (i.e. Crimean Congo Hemorrhagic Fever (CCHF) virus. ***FY 2017 Plans:*** Will continue to identify regions of the virus particles that induce protective immune response against all four serotypes of dengue fever virus; Will study the role of human cells and antibodies recovered from patients vaccinated during dengue vaccine trials in Asia and Latin America and dengue human infection model studies conducted in the United States to identify new methods of vaccine formulations. Will investigate the possible role of nonspecific defense mechanisms that come into play immediately	1.595	1.653	1.688

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
or within hours of a pathogen's appearance in the body to develop protective countermeasures. Will identify viral sequence based determinants (particles that cause infection) obtained from dengue viruses recovered from patient populations enrolled in expanded (FDA) safety/efficacy/dosing study in humans to understand protection mechanisms. Will identify and validate viral particle neutralization assay that will be used to measure neutralizing antibodies against Hantavirus. Will determine an optimal delivery device for the Hantavirus vaccine. ***FY 2018 Plans:*** Will continue to characterize the role of human cells and antibodies recovered from patients vaccinated during dengue vaccine trials in Asia and Latin America and dengue human infection model studies conducted in the United States to identify new methods of vaccine formulations. Will continue assessment of host immune responses against dengue virus proteins from patient populations enrolled in expanded Food and Drug Administration (FDA) safety/efficacy/dosing vaccine studies and dengue virus challenge studies in humans to understand protection mechanisms. Will use molecular approaches (recombinant Deoxyribonucleic Acid (DNA) based techniques) to determine structures of protective antibodies against dengue. Will identify vaccine technologies to produce antibody products that might be used to prevent or treat disease by lethal viruses such as Hantavirus, South American and African Hemorrhagic viruses.			
Title: Vector Identification and Control ***Description:*** This effort conducts research to investigate the biology of biting arthropods (i.e. mosquitoes and sand flies) and other vectors (organisms that transmit disease) and their control. This effort also expands identification of infectious disease pathogens in vectors and disease surveillance capabilities in the field. This research will help to direct new interventions into preventing disease transmission. ***FY 2016 Accomplishments:*** Leveraged worldwide capabilities utilizing an information exchange program involving site visits to museums (e.g. United Kingdom (UK)/ Museum Natural History, London; Belgium/Royal Museum of Central Africa, Tervuren) to compare and exchange insect type specimens assisting development of tools to identify wild-caught insects; complete the Identification Guide to the Culex mosquitoes of East, West and Central Africa; leverage studies with the Defense War Fighter Program and Global Emerging Infectious Systems to develop novel pesticide application strategies and passive repellent systems/strategies for vector control. ***FY 2017 Plans:*** Will explore the current gaps in the area of vector control. Will explore the latest technology in vector-borne disease risk assessment tools to manage data and support decision making for vector control operations. Will explore integrated vector control strategies, new insecticides or unique formulations, application equipment, and non-chemical control methods. Will identify novel molecular markers or antigens that can be used to produce better detection tools. This will be a crucial component for the successful development of multiplexed detection assays to identify multiple pathogens in a vector population. ***FY 2018 Plans:***	1.495	1.550	1.581

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will identify unique biological markers (e.g., proteins, genes) that can be used to produce improved detection tools that can identify multiple pathogens in a vector population. Will identify technology in vector-borne disease risk assessment tools to manage data and support decision making for vector control operations. Will explore integrated vector control strategies to include new insecticides or unique formulations, application equipment, and non-chemical control methods.			
Accomplishments/Planned Programs Subtotals	10.951	11.318	11.039

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S14 / *Sci BS/Cbt Cas Care Rs*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
S14: *Sci BS/Cbt Cas Care Rs*	-	8.923	5.699	5.296	-	5.296	5.610	6.559	7.042	7.077	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine was located in this Project. The Clinical and Rehabilitative Medicine basic research effort moves to Project ET6 starting in FY17.

A. Mission Description and Budget Item Justification

This Project supports basic research to understand the fundamental mechanisms of severe trauma to advance treatment and surgical procedures to save lives and improve medical outcomes for the Warfighter. Experimental models are developed to support in-depth trauma research studies. This Project includes studies of predictive indicators and decision aids for life-support systems, studies to heal and repair burned or traumatically injured hard and soft tissues of the eye, face, mouth, and extremities, control of severe bleeding, and traumatic brain injury (TBI). Such efforts will minimize lost duty time and provide military medical capabilities for far-forward medical/surgical care of injuries.

Research conducted in this Project focuses on the following five areas:
(1) Damage Control Resuscitation
(2) Combat Trauma Therapies
(3) Combat Critical Care Engineering
(4) TBI
(5) Clinical and Rehabilitative Medicine (moves to Project ET6 in FY17)

Work in this Project complements and is fully coordinated with Program Element (PE) 0602787A (Medical 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 Walter Reed Army Institute of Research (WRAIR), Silver Spring, MD; the United States Army Dental Trauma Research Detachment (USADTRD) and the United States Army Institute of Surgical Research (USAISR), Joint Base San Antonio, TX.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Damage Control Resuscitation	1.262	1.644	1.669
Description: This effort conducts studies to define and identify cellular processes and metabolic (biochemical activity) mechanisms associated with blood clotting to understand the relationships between the human immune processes and bleeding in trauma.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Performed cell-based (in vitro) studies of drugs to assess their ability to protect cells and tissues from harmful effects of severe blood loss. ***FY 2017 Plans:*** As follow on to the FY16 work, will perform cell-based (in vitro) studies of small-volume cytoprotectant (protect cells from freezing effects) drugs as resuscitation adjuncts. Will characterize response of capillary function in tissue from traumatic bleeding and explore applications of stem cell technology for treatment of traumatic bleeding. ***FY 2018 Plans:*** Will use cell culture (cells grown under controlled conditions) techniques to understand the potential blood-clotting and anti-inflammatory effects of stem cells. Will use cell culture methods to screen small-volume cytoprotectant (protect blood-deprived cells from further damage and restore normal function) drugs. Will characterize response of tissue capillary (smallest of the body's blood vessels) function to traumatic bleeding.			
Title: Combat Trauma Therapies ***Description:*** This effort conducts studies of trauma to tissues and organs, including dental (facial and oral) injuries, extremity wounds and fractures, and burns, and ways to mitigate and/or repair this damage. ***FY 2016 Accomplishments:*** Developed models that identified optimal combinations of skin components for transplantation as a potential means to repair severe facial injuries. As follow on to FY15 work, study molecular, cellular and structural skin components to identify mechanisms to optimize healing, appearance and function following traumatic injury of hard and soft tissues. ***FY 2017 Plans:*** Will perform genetic analyses of bacteria to aid in developing improved products to prevent or treat infected facial, mouth, and extremity wounds. Will identify combinations of antiseptics and antimicrobial peptides (constituent parts of proteins) that interact together to eliminate bacterial infections in wounds of the face, mouth, and extremities. ***FY 2018 Plans:*** Will build upon work from FY17 to perform genetic analyses of wound bacteria to aid in identifying improved products to prevent or treat infected facial, mouth, and extremity wounds. Will continue to identify wound healing agents (including re-purposed drugs and combination products) that mitigate wound infection. Will begin work to identify ways to reduce injury progression and mitigate eschar (dead necrotic tissue formed on the surface of the skin after burn injury)-induced inflammation, and/or resolve dysregulated (impairment of a physiological regulatory mechanism) inflammation in burn wounds when early debridement (surgical removal of dead tissue) is not possible.	3.132	1.889	1.432
Title: Combat Critical Care Engineering	0.551	0.857	0.868

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: This effort conducts basic science studies of vital sign (e.g. heart rate, blood pressure, blood oxygen concentration) responses to trauma as predictors of medical outcomes and as a basis for developing life-saving interventions. This effort also conducts basic science studies to support development of technologies to preserve function of vital organs following traumatic injury. ***FY 2016 Accomplishments:*** Validated sensitivity and specificity of blood-loss prediction algorithm under differing clinical and environmental conditions, for example heat, cold, low oxygen, and stress; start basic research examining potential use of stem-cell (primitive cells that give rise to more specialized cells of the body) based therapy for treatment of lung injury; and start basic research to explore means to safely provide oxygen to, and remove carbon dioxide from casualties with severe lung injuries without further damaging the lungs. ***FY 2017 Plans:*** Will develop physiological models to aid in solving current pre-hospital clinical problems as identified by the Committee on Tactical Combat Casualty Care. Will develop models to address airway management and early detection of tension pneumothorax (a trapping of air in the space between the lung and chest wall that if untreated will collapse the lung and push the heart and windpipe against the other side of the chest) and to address pain management in far forward areas and during transport. ***FY 2018 Plans:*** Will progress FY17 efforts to identify new methods to improve prehospital airway management and detection of tension pneumothorax (a life threatening condition caused by a collapsed lung). Will advance work from FY17 to develop animal models in which to study impact of pain and pain drugs on resuscitation and stabilization outcomes following traumatic injury. Will perform research to identify lung stem cells that may be used to treat lung injuries.			
Title: Traumatic Brain Injury ***Description:*** This effort conducts basic research in poly-trauma (multiple injuries)/TBI model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI. ***FY 2017 Plans:*** Will continue work from FY16 to apply systems biology methods to identify new proteins that appear in blood as result of TBI. Will examine metabolic changes (changes in the way the neuron assimilates nutrients and converts them to energy to support nerve function) as mechanisms or markers of TBI. Will develop models of acute, severe TBI in combination with severe bleeding and lung injury supporting studies to determine if these other injuries and their subsequent treatment may worsen TBI outcome. ***FY 2018 Plans:***	-	1.309	1.327

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will apply systems biology methods to identify new proteins that appear in blood as a result of TBI. Will examine metabolic changes (changes in the way the neuron assimilates nutrients and converts them to energy to support nerve function) as mechanisms or markers of TBI.			
Title: Clinical and Rehabilitative Medicine ***Description:*** This effort conducts basic studies of mechanisms of tissue growth and traumatic injury to gain an understanding that will assist or facilitate the healing or transplantation process. The focus is placed on severe trauma to the limbs, head, face (including eye), genitalia (organs of reproduction), and abdomen. In FY15 and 16 the funding for this research effort is in Project S14. The Clinical and Rehabilitative Medicine basic research effort has a separate Project starting in FY17 (ET6). ***FY 2016 Accomplishments:*** Analyzed the cellular mechanisms and functional deficits of eye trauma injuries; advance promising therapies for eye trauma wounds into the applied research phase and correlate the epidemiology of eye trauma with clinical outcomes; and explore innovative strategies to regenerate and reconstruct hard (e.g. bone) and soft (e.g. skin and muscle) tissues to enable promising approaches to advance into the applied research phase through directed experimentation in the lab and in animal models to address injury of the extremities, face, genitalia, and abdominal regions. Advance novel immunomodulation (modification of the immune response / immune system functioning) technologies to treatment model development to enable improved outcomes in hand and face transplant procedures.	3.978	-	-
Accomplishments/Planned Programs Subtotals	8.923	5.699	5.296

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S15 / *Sci BS/Army Op Med Rsh*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
S15: *Sci BS/Army Op Med Rsh*	-	6.492	6.688	7.116	-	7.116	6.443	9.654	9.093	8.710	-	-

A. Mission Description and Budget Item Justification

This Project fosters basic research on physiological and psychological factors that limit Warfighter effectiveness and on characterization of health hazards generated by military systems that result as a consequence of military operations; includes research on the neurobehavioral aspects of post-traumatic stress; develops concepts for medical countermeasures to prevent or mitigate the effects of muscle and bone injury to include reducing the effects of sleep loss and other stressors on Warfighter performance. The hazards of exposure to directed energy, repetitive use, fatigue, heat, cold, and altitude are also investigated under this Project.

Research conducted in this Project focuses on the following four areas:

(1) Injury Prevention and Reduction
(2) Physiological Health
(3) Environmental Health and Protection
(4) Psychological Health and Resilience

Work in this Project complements and is fully coordinated with Program Element (PE) 0602787A (Medical 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 Walter Reed Army Institute of Research (WRAIR), Silver Spring, MD; United States Army Institute of Surgical Research (USAISR), Joint Base San Antonio, TX; and the United States Army Research Institute of Environmental Medicine (USARIEM), Natick, MA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Injury Prevention and Reduction	1.458	1.304	1.229
Description: This effort identifies biological patterns of change in Warfighters during states of physical exertion, identifies physiological (human physical and biochemical functions) mechanisms of physical injury and exertion that will predict musculoskeletal (muscle, bone, tendons, and ligaments) injury. Also includes the characterization of ocular injury pathways resulting from blast exposure in small animal models.			
FY 2016 Accomplishments: Identified the mechanism of nerve remodeling to enhance functional neuromuscular (central nervous system control of muscle functioning) adaptation following muscle injury and determine the effect of inflammatory processes on muscle repair / regeneration, incomplete healing and subsequent risk of re-injury; and identify possible points of intervention to minimize			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
musculoskeletal injuries or re-injury based on modifiable and non-modifiable risks. Collect ocular injury data from blast exposure in multiple animal species for the development of scaling models. ***FY 2017 Plans:*** Will use computational modeling to reveal mechanisms of control of the inflammatory and regenerative response to tissue damage. Will identify musculoskeletal damage markers that provide damage/injury resolution assessment and validation of those markers in mouse models of musculoskeletal injury. Will develop non-invasive tools capable of supporting decisions for treatment, prognosis and return to duty following tissue injury with applicability far forward. Will develop blast injury scaling laws for the eyes across species (including mice, rabbits and humans), which enables the development of a surrogate human ocular injury model. ***FY 2018 Plans:*** Will use computational analysis and modeling to define the inflammatory and regenerative response to tissue injury. Will formulate blast injury scaling laws for the eyes across species, completing studies on larger animals (rabbits, pigs), with the ultimate goal of developing a surrogate human ocular injury model. Will identify biochemical, physiological, and genetic markers of pro- and anti-inflammatory events in skeletal muscle and bone using cell, animal, and human models for eventual transition to clinical trials. Will identify molecular, pharmacological, and (or) nutritional interventions to reduce musculoskeletal injury and promote repair.			
Title: Physiological Health ***Description:*** This effort conducts research on the physiological mechanisms of sleep, fatigue, and nutrition on Warfighter performance and well-being. ***FY 2016 Accomplishments:*** Identified nutrients (carbohydrates, proteins, fats, vitamins, etc.) that could regulate the recovery of muscle cells after musculoskeletal injury; identify factors affecting the absorption of nutrients that contribute to bone structure and function; determine the impact on gut health of only eating operational rations; identify the brain neurochemistry (the interaction between small molecules and cells via signaling between and within cells) and functional pathophysiology (molecular and cellular signature of disease) associated with repeated blast exposures; and identify biomarkers (indicator of a process, event, condition or change within the body) of sleep debt and recuperation. ***FY 2017 Plans:*** Will continue to assess nutritional approaches that can enhance resistance to stress and augment tissue repair, wound healing and recovery from brain function. Will determine the feasibility of a prophylactic (preventative treatment) nutrient or dietary nutrient cocktail for preventing the deleterious effects of impact, acceleration, and/or blast –induced head injury in a rodent model. Will identify differences in baseline sleep pattern and duration, in the home environment, between mild traumatic brain injury (mTBI) patients, non-mTBI (controls) Warfighters and Warfighters who've recovered from mTBI. ***FY 2018 Plans:***	1.957	3.466	3.611

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will characterize role of sleep in resilience to, and recovery from, mTBI events. Will characterize the impact of blast and/or impact-acceleration on the gut microbiome. Will investigate the impact of nutritionally optimized products on indicators of immune function in laboratory studies.			
Title: Environmental Health and Protection ***Description:*** This effort conducts research on the physiological (human physical and biochemical functions) mechanisms of exposure to extreme heat, cold, altitude, and other environmental stressors. This effort establishes scientific evidence for specific and sensitive diagnostics of exertional heat illness to optimize Warfighter performance in austere environments. ***FY 2016 Accomplishments:*** Used animal models and cellular-based tests to identify biomarkers of organ damage; and evaluate specific molecular pathways of heat injury and establish the time course, type and extent of organ damage following heat injury. ***FY 2017 Plans:*** Will use animal models to characterize improved (sex-specific and sensitive) circulating biomarkers of organ damage for diagnostics and assessment of severity of heat injury. Will establish scientifically based clinical criteria for return-to-duty status following heat illness. ***FY 2018 Plans:*** Will use animal models to identify novel circulating biomarkers of organ damage following exertional heat injury (EHI) and exertional heat stroke (EHS) for the diagnosis and assessment of severity of heat injury. Will discover biomarkers that are specific to the type and extent of organ damage during EHI/EHS exposure and recovery. Will determine the predictive power of various clinical biomarkers for the type and extent of organ damage that is observed at 7 days of recovery. Will target biomarkers for EHI/EHS assessment to characterize sensitivity and specificity in military working dogs.	0.824	0.821	1.053
Title: Psychological Health and Resilience ***Description:*** This effort conducts research into the basic mechanisms of the ability to overcome traumatic events including determination of underlying neurobiological mechanisms (nervous system control of cellular and molecular processes) related to Post-Traumatic Stress Disorder (PTSD) and depression. ***FY 2016 Accomplishments:*** Identified if Omega-3 fatty acids are capable of affecting vulnerability to and recovery time following a concussion; and establish a core set of procedures and outcome measures defining a validated animal model of PTSD appropriate for identifying candidate compounds and methods of PTSD treatment. ***FY 2017 Plans:***	2.253	1.097	1.223

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will utilize an animal model to screen compounds for the treatment of PTSD, their ability to inhibit adverse memory formation and related disorders. Will identify vulnerable factors and diagnostic indicators of PTSD and co-existing mental health problems that overlap or complicate PTSD. Will explore and identify candidate compounds that can be administered in a prophylactic manner or post-trauma to mitigate the adverse biological and behavioral effects of trauma in an animal model. Will develop analytic techniques to evaluate neuroendocrine assays (clinical tests that evaluate relevant hormonal and neurotransmitter levels within the body) for stress effects. ***FY 2018 Plans:*** Will screen for additional compounds for the treatment of PTSD in an animal model, including investigating the ability of the compounds to inhibit adverse memory formation and related disorders. Will identify additional vulnerable factors and diagnostic indicators of PTSD and co-existing mental health problems that overlap or complicate PTSD. Will use an established rat model of mTBI with or without the addition of stress to identify nutritional and other targets for improved resolution or resilience to the trauma. Will identify at least two novel compounds that are active at the nociceptin/orphanin peptide (NOP) receptor (a receptor involved in the regulation of numerous brain activities, particularly instinctive and emotional behaviors) for their ability to mitigate the adverse behavioral effects of traumatic stress and for their impact on PTSD-related symptoms in an animal model.			
Accomplishments/Planned Programs Subtotals	6.492	6.688	7.116

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T14 / *BASIC RESEARCH INITIATIVES - AMC (CA)*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	40.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Defense Research Sciences.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017
Congressional Add: Program Increase	40.000	-
FY 2016 Accomplishments: Program increase for Defense Research Sciences		
Congressional Adds Subtotals	40.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) T22 / *Soil & Rock Mech*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
T22: *Soil & Rock Mech*	-	4.334	4.520	4.606	-	4.606	4.695	4.788	4.883	4.982	-	-

A. Mission Description and Budget Item Justification

This Project fosters basic research to correlate the effects of the nano- and micro-scale behavior on the macroscale performance of geological and structural materials to provide a foundation for the creation of future revolutionary materials and to revolutionize the understanding of sensor data within heterogeneous geological systems. This research encompasses geologic and structural material behavior, structural systems, and the interaction with dynamic and static loadings. Research includes underlying physics and chemistry that control the mechanics and electromagnetic behavior of geological and structural materials, new techniques that provide measurements at the fundamental scale, and fundamental theories for relating nano- and micro-scale phenomena to macro-scale performance.

Work in this Project provides the basis for applied research in Program Element (PE) 0602784A (Military Engineering Technology), Project T40 (Mobility/Weapons Effects Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering science and technology focus areas.

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Military Engineering Basic Research	2.078	2.169	2.212
Description: Conduct fundamental research to determine how physical and chemical characteristics of materials affect their interactions with environment.			
FY 2016 Accomplishments: Determined the physical and chemical mechanisms that allow geopolymers to bond strongly to glass, ceramics, and metallic alloys with specific surface compositions; characterized the chemical structures that are involved in gels and thermal effects on gels; and provided fundamental theory for moisture effects on wave propagation in heterogeneous unsaturated soils.			
FY 2017 Plans: Will investigate soil moisture and density effects on signal to noise ratios in fiber optic sensors, signal diversity, and signal fading; quantify the transitions in soil stiffness with increasing saturation; and investigate the effect of soil organic matter and iron oxide content on quartz infrared response in natural soils.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T22 / *Soil & Rock Mech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will construct a mechanistic process synthesis model for graphene-carbon nanotube metal nano-composites; will investigate new mass and energy transfer models across land-atmosphere boundaries; will evaluate novel wave breaking shape prediction models with in-situ experiments; and will conduct surf zone transit experiments using an experimental vessel.			
Title: Materials Modeling for Force Protection ***Description:*** Conduct fundamental research on material interactions at the micro- and nano-scales to determine how they affect macroscale properties ***FY 2016 Accomplishments:*** Investigated how the material interface prevents delamination for composites during impact and penetration loading; investigated the fundamental mechanisms of concrete composition that inhibit damage initiation and spread; determined calcium carbonate bonding strength in homogeneous mortar; and provided fundamental understanding of deformation and damage mechanisms provided by in-situ nano-mechanical testing and pre- and post-test characterization for metallic materials that exhibit strain rate insensitive stress-activated phase transformations and twinning. ***FY 2017 Plans:*** Will improve the understanding of damage in ultra-high performance concrete and will devise new methods to provide quantitative information about damage evolution; assess chemical and biological agent degradation potential by studying the photocatalytic activity of a biosynthetic polymer composite; and investigate the degradation mechanisms of sample composite systems. ***FY 2018 Plans:*** Will investigate and validate fuzzy logic tools to improve understanding of data fusion frameworks for predictive models; will characterize in-vivo and in-vitro microtubule morphologies to investigate relationships between microscale structure and macroscale material performance; will create synthetic analogues of alkali-silica reaction gels; and will determine silica fume effects on hydration, rheology, and hardened properties in cementitious materials.	2.256	2.351	2.394
Accomplishments/Planned Programs Subtotals	4.334	4.520	4.606

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T23 / *Basic Res Mil Const*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T23: *Basic Res Mil Const*	-	1.679	1.747	1.781	-	1.781	1.815	1.850	1.887	1.929	-	-

A. Mission Description and Budget Item Justification

Work in the Project fosters basic research and supports facilities research initiatives. The objective of Army installations basic research is to investigate, identify, and quantify the fundamental scientific principles that can be used to predict or influence the development of high performance facilities and sustainable installations, both fixed and contingency. Such basic research provides the requisite long term cost effective training and sustainment platforms for Army mission accomplishment. These efforts provide basic research leading to improved design in a range of facilities to optimize facility mission performance, enhance facility security, reduce design and construction errors and omissions, reduce resource requirements, and reduce the environmental burdens over the facility's life. This Project provides leap-ahead technologies to solve military-unique problems in the planning, programming, design, construction, and sustainment of deployed facilities, and energy and utility infrastructure.

Work in this Project provides the basic research basis for applied research in Program Element (PE) 0602784A (Military Engineering Technology) / Projects T41 (Military Facilities Engineering Technology) and T45 (Energy Technology Applied to Military Facilities).

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

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Facilities Research	1.679	1.747	1.781
Description: Conduct fundamental research on innovative infrastructure technologies to optimize facility mission performance, through enhanced security and reduction in resource requirements, design errors and omissions, and environmental burdens.			
FY 2016 Accomplishments: Identified microbial and chemical distribution in a biofilm correlated to points of corrosion; assessed transport kinetics of self-assembling vesicles for photocatalytic hydrogen evolution in aqueous solutions; and interpreted the vortical structure thermal field with shape memory alloy materials used for inducing vortices to enhance solid-fluid and thermal interactions.			
FY 2017 Plans: Will replicate key nanostructural and chemical composition features present in natural cicada wings to study parameters leading to self-cleaning, anti-fouling surfaces; and tune bacteriophage-based nanofibers to understand fundamental properties leading to piezoelectric energy generation.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T23 / *Basic Res Mil Const*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will fabricate nanopillar arrays on silicon substrates using nanosphere lithography and functionalize nanopillars with organic and inorganic compounds to investigate bactericidal properties; will create controlled oxide growth method and investigate thickness effect on adhesion; and will tune bacteriophage and crystalized nanofibers to understand how energy scavenging operates.			
Accomplishments/Planned Programs Subtotals	1.679	1.747	1.781

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T24 / *Signature Physics And Terrain State Basic Research*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T24: *Signature Physics And Terrain State Basic Research*	-	1.619	1.649	1.685	-	1.685	1.720	1.755	1.792	1.828	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to increase knowledge in the areas of terrain state and signature physics. It investigates the knowledge base for understanding and assessing environmental impacts critical to battlespace awareness. Projects include fundamental material characterization, investigation of physical and chemical processes, and examination of energy and mass transfer applicable to predicting state of the terrain, which control the effects of the environment on targets and target background signatures and mobility, in support of the materiel development community. The terrain state area of terrestrial sciences investigates weather-driven terrain material changes and the sensing and inferring of subsurface properties. The signature physics area of terrestrial sciences focuses on understanding the dynamic changes to electromagnetic, acoustic, and seismic signatures, and energy propagation in response to changing terrain state and near surface atmosphere.

Work in this Project provides a foundation for applied research in Program Element (PE) 0602784A (Military Engineering Technology)/ Project 855 (Topographical, Image Intel and Space) and T42 (Terrestrial Science Applied Research).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering science and technology focus areas.

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Analysis for Signal and Signature Phenomenology (Previously titled - Terrain State and Signature Physics)	1.619	1.649	1.685
Description: Conduct fundamental research to examine the effects of environmental parameters on electromagnetic, acoustic, and seismic signatures as well as energy propagation with regard to terrain state and near surface atmosphere.			
FY 2016 Accomplishments: Determined controls on the broadband complex relative permittivities (a measure of resistance) of mixtures containing high salt content, such as ammonium nitrate, to determine the characteristic maximum frequency-domain that will establish the scientific basis for a subsurface geophysical technique for detection; established proof of subsurface target detection through new electromagnetic methodology by understanding the causes of asymmetric dispersive resonance within full diffraction signatures from buried targets; and investigated high-frequency wave propagation methods to determine in-situ near-surface micro-pore geometry parameters in surface materials (forest litter, soil, and snow) to improve Army sensor systems by adjusting to changes in environmental conditions.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T24 / *Signature Physics And Terrain State Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will formulate theory and numerical modeling approaches for sound propagation along long range and slanted paths through forests, with realistic representation of the vegetation and layered structure, to enable future capability for predicting long range acoustic and other wave propagation through dense forests and multi-tiered canopies; research broadband radio frequency (RF) spread spectrum scattering in mountainous terrain to understand effects of terrain geometry and vegetation on band structure that may lead to prediction of viable frequencies for improved communications in mountainous regions; and investigate the statistical evolution of signatures (target source) and their probability of detection, given imperfect knowledge of the battlefield environment, to improve physics-based estimates of sensor and communication system performance. ***FY 2018 Plans:*** Will investigate seismic and acoustic wave transmission and reflection at the land-water boundary to characterize lake or river boundary effects on wave propagation; will derive empirical expressions of the boundary effects by wave type, wave shape, polarization, and amplitude; and will determine if the liquid water contents of frozen soils can be detected remotely (e.g., with airborne sensors) by exploiting polarization phenomena.			
Accomplishments/Planned Programs Subtotals	1.619	1.649	1.685

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T25 / *Environmental Science Basic Research*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T25: *Environmental Science Basic Research*	-	6.744	7.081	6.708	-	6.708	6.845	6.990	7.139	7.797	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research to investigate fundamental scientific principles and phenomena necessary to ensure efficient development of the technologies needed to address Army sustainment issues in the restoration, compliance, conservation, and non-industrial pollution prevention areas. These efforts include: investigating and monitoring contaminated sites, including chemical contamination and unexploded ordnance (UXO) detection and discrimination; better characterization of contaminants through improved risk-based assessment; destruction, containment, or neutralization of organics resulting from military activities in water, soil, and sediments; adhering to applicable federal, state, and local environmental laws and regulations; monitoring and controlling noise generation and transport; protecting and enhancing natural and cultural resources; reducing pollution associated with military activities; and the study of ecosystem genomics and proteomics in support of the Army's Network Science initiative.

Work in this Project provides a fundamental basis for applied research in Program Element (PE) 0602720A (Environmental Quality Technology)/Project 048 (Industrial Operations Pollution Control Technology), Project 835 (Military Medical Environmental Criteria) and Project 896 (Base Facilities Environmental Quality).

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

Work in this Project is performed by the Army Engineer Research and Development Center (ERDC), Vicksburg, MS.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Environmental and Ecological Fate of Explosives, Energetics, and Other Contaminants	2.700	3.781	3.446
Description: Conduct fundamental research to examine the effects of Army relevant compounds on the environment			
FY 2016 Accomplishments: Experimentally determined the fundamental environmental cues required to develop a workable multi-modular agent-based model decision network; determined the rate controlling physiological mechanisms in order to formulate a systems biology model which will improve ability to rapidly assess and predict the effects of individual chemicals and mixtures of chemicals; and described the fundamental relationship of perturbed biological pathways by toxicity of military materials and other chemicals across species.			
FY 2017 Plans: Will devise theoretical relationships between geomorphic specific nutrient and available water thresholds controlling the environmental persistence of munition constituents in soils as a foundation for site-specific predictions of munition constituents fate; will quantify chemical kinetic parameters for insensitive munition retention on soil mineral surfaces that can be used for			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
predicting the long-term fate of inorganic and organic military relevant contaminants in the environment; and will determine mechanisms of zone migration and zone dispersion in a microfluidic separation (i.e. traveling-wave electrophoresis) that will lead to improved performance for separation and enrichment of toxicants, biomolecules, and military-specific compounds. ***FY 2018 Plans:*** Will correlate munition constituent environmental fate processes with soil horizon types and compare models to results from intact soil columns; understand fundamentals of photo-degradation pathways and kinetics of insensitive munitions formulations and individual components through a combination of computational chemistry methods, controlled lab experiments, and outdoor sample analysis; and construct and test an estrogen responsive promoter memory circuit and create and test an arsenic responsive yeast memory circuit.			
Title: Fundamental Understanding of Explosives, Energetics and UXO in the Environment ***Description:*** Conduct fundamental research to increase the understanding of the physical and chemical characteristics of insensitive munitions ***FY 2016 Accomplishments:*** Assessed the basics of physiological response to and toxicity of the IMX-101 mixture constituents and provided intensive characterization of the molecular and metabolic mechanisms for previously observed non-additive toxicity. ***FY 2017 Plans:*** Will increase understanding of insensitive munition photo-degradation pathways and kinetics through computational chemistry methods, lab experiments, and field sample analysis; and increase understanding of mechanistic sorption properties of insensitive munitions compounds on the surface of polysaccharide polymers, so the sorption properties can be tuned for selective binding of munitions compounds. ***FY 2018 Plans:*** Will determine chemical kinetic parameters for each insensitive munitions compound on different natural soils; functionalize and characterize cellulose and chitin using electron donating molecules; determine role of electrode surface area in electrode charging; and determine mechanisms of zone dispersion and their limits.	2.200	1.054	1.066
Title: Training Land Natural Resources ***Description:*** Conduct fundamental research on the molecular interactions of plants and animals with environmental stimuli. ***FY 2016 Accomplishments:***	0.959	1.327	1.249

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Investigated molecular mechanisms behind foreign species invasion and interpret findings to preventative and proactive strategies towards the management and containment of these species on military lands. ***FY 2017 Plans:*** Will decode the molecular basis of frog olfaction for amphibian conservation to provide an understanding of chemical cues that frogs can sense; will join a tunable genetic memory capability to a novel odor-based reporter to create a bio-alarm usable in austere environments; and will examine the relationship of climate and habitation to biodiversity to enable better predictions of climate change. ***FY 2018 Plans:*** Will understand anuran olfactory receptor-odorant interaction at the molecular level; define and assess the composition and stability of the lizard microbiome; and determine effects of contaminants on microbiome composition.			
Title: Network Science ***Description:*** Conduct fundamental research to examine the behavior of environmental networks to inform data models and algorithms ***FY 2016 Accomplishments:*** Evaluated the basic effects of noise (e.g., extraneous molecules, temperature) and resources on performance of synthetic networks through direct observation and modeling with statistical comparison of the performance of different synthetic circuits. ***FY 2017 Plans:*** Will investigate how biological signals propagate through a highly interconnected network of alternative paths and barriers, such as noise, signal degradation, competing responses, or physical obstructions. ***FY 2018 Plans:*** Will understand information propagation through imperfect biological networks and how biology adapts to overcome obstacles; and determine the relationship between path length, information flow, and perturbation parameters in full-scale networks.	0.885	0.919	0.947
Accomplishments/Planned Programs Subtotals	6.744	7.081	6.708

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	6.947	8.764	8.847	-	8.847	9.546	11.112	11.281	11.516	-	-

A. Mission Description and Budget Item Justification

This Project supports basic research in areas that expands the autonomous capabilities, utility, and portability of small robotic systems for military applications, with a focus on enhanced intelligence, biomimetic functionality, and robust mobility, to permit these systems to serve as productive tools for dismounted Soldiers. It enables future systems to support and unburden Soldiers by integrating technologies with an understanding of cognitive and physical needs, and the missions of the humans and (non-human) agents operating on the battlefield. The ability of the Warfighter to command a suite of small unmanned systems (e.g., air, ground, and hybrid vehicles) reduces exposure of the Soldier to harm and improves the efficiency by which a dismounted unit achieves tactical objectives such as securing a targeted zone. Example missions requiring enhanced autonomy, manipulation, and man-portability include rapid room clearing and interior structure mapping; detection of human presence, chemical/biological/nuclear/radiological/explosive (CBNRE), and booby-traps; surveillance; and subterranean passage detection and exploration. Because of their relatively small size, light weight, and service in dismounted environments, small unmanned systems have unique challenges in perception, autonomous processing, mobility mechanics, propulsive power, and multi-functional packaging that transcend similar challenges associated with large unmanned systems. The Army Research Laboratory (ARL) conducts research in related disciplines, including machine perception, intelligent control, biomimetic robotics, manipulator mechanics, and propulsive power and drives to foster the development of technologies for lightweight, small-volume, robotics applications for harsh environments. Machine perception research includes the exploration of lightweight ultra-compact sensor phenomenology and the maturation of basic machine vision algorithms that enable small unmanned systems to more fully understand their local environment. Intelligent control research includes the maturation of autonomous processing capabilities and the advancement of artificial intelligence techniques that lead to reliable autonomous behavior in a large-displacement, highly-dynamic environment and permit unmonitored task performance. Research in biomimetic robotics and manipulator mechanics includes the advancement of mechatronic and biomimetic appendages to enable agile high-speed locomotion, dexterous task-performance, and environmental-manipulation; and the maturing of nonlinear control algorithms to support robust, stable mobility. Propulsion power research includes investigations of engine cycles and alternative hybrid energy conversion techniques to provide compact, lightweight, quiet, low-emission, high-density power sources that support highly-portable unmanned systems capable of performing long-endurance missions.

Work in this Project supports key Army needs and provides the technical underpinnings to several Program Elements (PEs) to include PE 0601104A (University and Industry Research Center)/Project H54 (Micro-Autonomous Systems Technology Collaborative Technology Alliance) and PE 0602622A (Chemical, Smoke and Equipment Defeating Technology)/Project 552 (Smoke/Novel Effect Munition).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas.

Work in this Project is performed by ARL at the Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Robotics Autonomy and Human Robotic Interface Research	1.905	2.012	1.899

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: In-house research with a focus on enabling robust autonomous mobility for small robotic systems, including autonomous operations in Global Positioning System (GPS) denied areas, planning, behaviors, intelligent control, and the interface of perception technologies to accomplish Army missions in the area of unmanned systems. These efforts include research activities in micromechanics conducted in association with the Micro Autonomous Systems and Technology Collaborative Technology Alliance (PE 0601104A/Project H54). ***FY 2016 Accomplishments:*** Explored the use of neuromorphic control (software systems that implement models of neural systems) employing analog elements to enable robust low-level control of microsystems; examined hybrid mobility concepts to enable robust maneuver in three dimensional environments, including biomimetic utilization of appendages, to achieve both functionality and efficiency; and explored control strategies to enable rapid, dynamic manipulation of objects. ***FY 2017 Plans:*** Will explore novel methods for learning and abstract reasoning to enhance understanding of the local environment by an intelligent unmanned vehicle; and explore novel methods for embedded control to facilitate intelligent manipulation of objects in the environment and modes of mobility. ***FY 2018 Plans:*** Will explore techniques for recognizing novel behaviors and circumstances that support generalized learning and long-term adaptability. Will continue efforts towards creating machine understanding of the purpose or intent for objects and behaviors. Will also explore the bridging of a cognitive architecture and control technology for disparate robotic systems.			
Title: Intelligent Systems ***Description:*** Pursue in-house research that supports and unburdens Soldiers in a flexible, robust, survivable and comprehensive manner. This work will address the cognitive requirements of humans and (non-human) agents, both hardware and software based, operating individually or in collaboration, on the battlefield. Emphasis will be placed on perception, reasoning, and collaboration techniques that can apply to and transfer between a broad range of systems (such as: adaptive communication and data collection networks; cyber defense, crowd-sourcing and information retrieval software agents; and predictive and explanatory decision support systems). ***FY 2016 Accomplishments:*** Researched the use of language as a construct for a robot architecture in the development of a common model for the physical (e.g., weather, terrain/structure, and other elements that affect mobility and speed) and operational (e.g., mission description, commander's intent, friendly and enemy forces disposition, and non-combatant participants) environment; explored the use of semantic understanding and learning to enhance robotic behavior and perceptual capabilities; and explored the use of	5.042	5.152	5.346

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
abstractions (i.e., using common model with smaller number of descriptors to convey complex picture or concept) to enable effective communication between teammates, both human and machine, with reduced bandwidth requirements. ***FY 2017 Plans:*** Will assess the scalability of semantic labeling of objects and behaviors to permit a more detailed description of the environment; expand research on collaborative problem solving across a set of human, robotic and software agents; explore concepts for exploiting most relevant imagery and video for enhanced system autonomy; develop control algorithms to better enable real-time decision-making; and explore intelligent control strategies that couple sensing, control algorithms, and actuation for unique mobility modes applicable to small unmanned vehicles (e.g., legged mobility, hybrid ground/air). ***FY 2018 Plans:*** Will develop novel techniques to simplify the semantic labeling methodology and increase its scalability using an on-line learning framework; and will develop intelligent system algorithms for prioritizing decisions based on the context of mission objectives.			
Title: Unmanned Air Vehicle Research ***Description:*** Conduct basic research focused on topics that contribute to the body of knowledge required to create future intelligent unmanned air systems that can effectively team with manned aircraft. Emphasis will be placed upon topics of control and aeromechanics that will expand the flight envelope for unmanned systems, manipulation of objects, and specialized topics relating to perception, reasoning, and creation of a common model of the surrounding environment and planning for behaviors in adversarial environments at high tempo.. ***FY 2017 Plans:*** Will explore algorithms and concepts for perception, planning, and reasoning that will enable manned-unmanned teaming for unmanned air vehicles; and examine control techniques for the manipulation of objects by unmanned air platforms. ***FY 2018 Plans:*** Will explore application of a cognitive architecture to manned-unmanned teaming of aircraft systems by initially using virtual environments.	-	1.600	1.602
Accomplishments/Planned Programs Subtotals	6.947	8.764	8.847

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T64 / *Sci BS/System Biology And Network Science*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
T64: *Sci BS/System Biology And Network Science*	-	2.814	2.974	3.025	-	3.025	3.079	3.139	3.203	3.268	-	-

A. Mission Description and Budget Item Justification

This Project fosters research investigations through a systematic approach using iterative computer simulation with mathematical modeling and biological information to analyze and refine biological studies. Information gained from these studies has the potential to provide a better understanding of the overall biological system and its molecular network of interactions, leading to improved early strategic decision-making in the development of preventive and treatment solutions to diseases. This approach establishes a model for application of computational biology processes and knowledge of biological networks to discover medical products that prevent and/or treat diseases or medical conditions.

The cited work provides theoretical underpinnings for Program Element (PE) 0602787A (Medical Technology).

Work in this Project is performed by the Medical Research Materiel Command (MRMC), Fort Detrick, MD / Biotechnology High Performance Computing Software Applications Institute (BHSAI), Frederick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Network Sciences Initiative	2.814	2.974	3.025
Description: This effort involves the use of mathematical models and data search algorithms to extract medical information from large-scale genomics (generated from the study of cellular genetic makeup, protein structures and function, and whole organism responses) to improve understanding, prevention, diagnostics, and treatments of traumatic brain injury (TBI), post-traumatic stress disorder (PTSD), uncontrolled bleeding, infections, and exposure to environmental stressors and hazards.			
FY 2016 Accomplishments: Develop new models of (a) underlying mechanisms of blast-induced TBI and (b) susceptibility to stress-related bone fracture in male and female Warfighters related to the high level of repeated physical activity experienced during basic combat training (BCT); and improve and refine algorithms and models for (a) identification of drug targets and drugs for conditions such as infectious disease, trauma-inducted coagulopathy, and biofilm-producing bacteria, (b) upper respiratory airflow patterns for the non-invasive diagnosis of lung diseases, and (c) standard vital-sign data to enable the non-invasive prediction of heat-stress injury to allow for timely counteractive measures.			
FY 2017 Plans: Will improve and refine algorithms to identify the susceptibility to stress-related bone fracture in male and female Warfighters related to the high level of repeated physical activity experienced during BCT; will develop computational algorithms to investigate			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T64 / *Sci BS/System Biology And Network Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
the association of genetic factors with neurological disorders, e.g., PTSD; will refine models to (a) predict drug targets for enhancing antibiotic sensitivity in wound pathogens that tend to be more antibiotic-resistant because they form biofilms, (b) identify key determinants that guide the evolution of viruses, and (c) identify molecular biomarkers of viral, e.g., Ebola virus, infection; will improve models to (a) identify cellular mechanisms of the inflammatory response, (b) predict blood coagulopathy genetic risk factors, and (c) investigate the underlying mechanisms of trauma-induced coagulopathy coupled with blood flow. ***FY 2018 Plans:*** Will design algorithms to identify the impact of load-carriage and activity intensity in stress-related bone fracture in Warfighters during basic combat training. Will formulate computational algorithms to investigate the association of genetic factors with neurological disorders, e.g., PTSD. Will develop models to (a) predict drug targets for enhancing antibiotic sensitivity in wound pathogens that tend to be more antibiotic-resistant because they form biofilms (a group of microorganisms that stick to each other and adhere to a surface), (b) understand how antibody responses may lead to neutralization or enhancement of viral infection, and (c) identify molecular biomarkers of viral infection. Will develop algorithms to model blood clotting processes under coagulopathic (inability for blood to clot) conditions and assess the ability of pharmacological (drug) interventions to mitigate trauma-induced coagulopathy (blood's ability to form clot is impaired).			
Accomplishments/Planned Programs Subtotals	2.814	2.974	3.025

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) VR9 / *Surface Science Research*			
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
VR9: *Surface Science Research*	-	2.134	2.256	2.293	-	2.293	2.337	2.383	2.431	2.481	-	-

A. Mission Description and Budget Item Justification

This Project fosters basic research to establish and maintain a core capability to enable a molecular level understanding of properties and behaviors of materials relevant to the Army; by developing understanding and ability to manipulate nanostructured materials as a means to tune properties which meet desired performance requirements; by advancing the scientific understanding of surface properties and interfacial dynamics of complex materials; and by providing scalable processes grounded in a molecular understanding of materials. This Project funds basic research in the characterization of chemical and biochemical phenomena occurring at or near solid surfaces and interfaces; the interactions between chemical reactions and transport processes on surfaces; theory and modeling of processes at complex surfaces; and the synthesis and characterization of catalysts that function at the nanoscale. Investment in basic research centered on the surface science disciplines will enable growth of a knowledge base that will result in improved understanding of the interactions of complex materials in real world environments.

The cited work provides the theoretical underpinnings for Program Element (PE) 0602622A (Chemical, Smoke and Equipment Defeating Technology).

Work in this Project is performed by the Army Edgewood Chemical and Biological Center (ECBC), Research, Development and Engineering Command, in Aberdeen, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018**
Title: Surface Science Research	2.134	2.256	2.293
Description: The activities in this program are related to performing basic research in chemistry, biology, and physics on fundamental problems related to surfaces, interfacial dynamics, thin film materials, chemical-biological catalysis and opto-electronic/sensory technologies.			
FY 2016 Accomplishments: Conducted fundamental research related to the creation and synthesis of novel materials that allows for the precise control of chemical and biochemical phenomena occurring at surfaces and interfaces to include the effects of transport; research catalytic chemical reactions and transport processes on surfaces; further develop theory and multiscale modeling of processes at complex surfaces; and make physical measurements of surface structure, morphology, and properties.			
FY 2017 Plans: Will conduct fundamental research on the processes required to control transport of species across liquid-solid boundaries; research mechanisms associated with liquid-phase extraction of absorbed molecular species from polymers; and investigate techniques to enhance the charge transfer efficiency from a given absorbing molecule or material into semiconductor nanoparticles using theory and modeling of processes at complex nanostructured surfaces.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** VR9 / *Surface Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will conduct fundamental research on chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces; the effects of binding energy, reactions, transport and deposition; study the interactions between chemical reactions and transport processes on surfaces; theory and modeling of processes at complex surfaces; and experimental work focused on the systematic understanding of surface structure, morphology and surface group properties.			
Accomplishments/Planned Programs Subtotals	2.134	2.256	2.293

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A