Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army											Date: February 2016	
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
Total Program Element	-	249.855	279.118	253.116	-	253.116	256.042	264.693	272.327	276.863	-	-
305: *ATR Research*	-	1.970	2.029	2.057	-	2.057	2.093	2.130	2.172	2.215	-	-
31B: *Infrared Optics Rsch*	-	3.273	2.843	4.213	-	4.213	4.261	4.314	4.372	4.433	-	-
52C: *Mapping & Remote Sens*	-	1.990	2.030	2.057	-	2.057	2.092	2.130	2.172	2.215	-	-
53A: *Battlefield Env & Sig*	-	2.610	3.754	3.808	-	3.808	3.873	3.944	4.020	4.100	-	-
74A: *Human Engineering*	-	14.235	13.176	13.342	-	13.342	14.023	14.482	14.797	15.078	-	-
74F: *Pers Perf & Training*	-	5.131	5.459	5.540	-	5.540	5.635	5.737	5.852	5.969	-	-
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	0.000	0.000	4.201	-	4.201	4.531	4.617	4.714	4.809	-	-
F20: *Adv Propulsion Rsch*	-	4.054	4.161	4.220	-	4.220	4.290	4.368	4.452	4.541	-	-
F22: *Rsch In Veh Mobility*	-	0.685	0.707	0.718	-	0.718	0.732	0.745	0.760	0.775	-	-
H42: *Materials & Mechanics*	-	9.054	8.603	8.731	-	8.731	8.879	9.040	9.218	9.402	-	-
H43: *Research In Ballistics*	-	8.602	8.410	8.531	-	8.531	8.676	8.834	9.007	9.187	-	-
H44: *Adv Sensors Research*	-	9.564	8.659	9.436	-	9.436	9.771	10.276	10.936	11.194	-	-
H45: *Air Mobility*	-	2.247	2.328	2.364	-	2.364	2.403	2.448	2.495	2.545	-	-
H47: *Applied Physics Rsch*	-	5.178	5.722	4.285	-	4.285	4.238	4.338	3.861	3.926	-	-
H48: *Battlespace Info & Comm Rsc*	-	24.596	25.463	28.276	-	28.276	28.668	29.105	29.624	30.168	-	-
H52: *Equip For The Soldier*	-	1.049	1.119	1.133	-	1.133	1.153	1.173	1.197	1.221	-	-
H57: *Single Investigator Basic Research*	-	78.575	87.001	94.519	-	94.519	94.284	99.007	102.166	103.423	-	-
H66: *Adv Structures Rsch*	-	2.000	2.033	2.061	-	2.061	2.095	2.133	2.174	2.217	-	-
H67: *Environmental Research*	-	0.901	0.913	0.928	-	0.928	0.943	0.961	0.979	0.999	-	-
S13: *Sci BS/Med Rsh Inf Dis*	-	10.924	11.181	11.318	-	11.318	11.503	11.722	11.952	12.191	-	-
S14: *Sci BS/Cbt Cas Care Rs*	-	10.183	9.758	5.699	-	5.699	5.540	5.636	5.743	5.857	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army											Date: February 2016		
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*	-	6.721	6.599	6.688	-	6.688	6.801	6.924	7.060	7.201	-	-
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	18.250	40.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
T22: *Soil & Rock Mech*	-	5.537	4.456	4.520	-	4.520	4.597	4.681	4.773	4.868	-	-
T23: *Basic Res Mil Const*	-	2.045	1.722	1.747	-	1.747	1.777	1.809	1.844	1.881	-	-
T24: *Signature Physics And Terrain State Basic Research*	-	1.981	1.627	1.649	-	1.649	1.675	1.706	1.740	1.775	-	-
T25: *Environmental Science Basic Research*	-	7.061	6.980	7.081	-	7.081	7.202	7.336	7.480	7.630	-	-
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	6.730	7.233	8.764	-	8.764	8.988	9.680	11.242	11.407	-	-
T64: *Sci BS/System Biology And Network Science*	-	2.306	2.930	2.974	-	2.974	3.025	3.080	3.141	3.204	-	-
VR9: *Surface Science Research*	-	2.403	2.222	2.256	-	2.256	2.294	2.337	2.384	2.432	-	-

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: PB 2017 Army	Date: February 2016
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A *I 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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	248.283	239.118	242.896	-	242.896
Current President's Budget	249.855	279.118	253.116	-	253.116
Total Adjustments	1.572	40.000	10.220	-	10.220
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	40.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	8.000	-			
• SBIR/STTR Transfer	-6.428	-			
• Adjustments to Budget Years	-	-	10.220	-	10.220

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2015	FY 2016
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Program Increase*	8.000	40.000
Congressional Add: *Science, Technology, Engineering, and Math (STEM) Pilot Program*	2.250	-
Congressional Add Subtotals for Project: T14	10.250	40.000
Congressional Add Totals for all Projects	10.250	40.000

Change Summary Explanation

FY 2015: Congressional increase for University Research Initiatives, PE PE 0601103, Project D58 - totaled $20M. Army reprogrammed $8M of the congressional increase for proper execution of congressional intent - (i.e., for Single Investigator).

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
305: *ATR Research*	-	1.970	2.029	2.057	-	2.057	2.093	2.130	2.172	2.215	-	-

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 including tagging, tracking, and locating (TTL) of non-traditional targets. 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 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 2015	FY 2016	FY 2017
Title: ATR Algorithms	1.970	2.029	2.057
Description: Investigate new algorithms to improve aided/unaided target detection and identification.			
FY 2015 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Investigated methods for automatic human and vehicle activity detection and classification, and multimodal biometrics for improved situational understanding and reduced Soldier workload; researched methods to select relevant data for enhanced decision making; and developed machine learning algorithms for scene understanding. ***FY 2016 Plans:*** Expand investigation of human and vehicle activity detection methods to include joint exploitation of text and video data; extend biometric research techniques to enable automated face recognition using low resolution imagery and multimodal data sets; investigate methods for synthesizing scene understanding from multi viewpoint imagery including 3D models for face recognition; investigate image processing methods for detecting unmanned aerial systems (UAS) in electro-optical/infrared (EO/IR) data for use in counter-unmanned aerial systems (CUAS); and investigate 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 three-dimensional (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.			
Accomplishments/Planned Programs Subtotals	1.970	2.029	2.057

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
31B: *Infrared Optics Rsch*	-	3.273	2.843	4.213	-	4.213	4.261	4.314	4.372	4.433	-	-

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) avalache photdiodes (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 opto-electronic 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) limiting 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 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 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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Electro-Optic Materials Research, RF Photonics for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR), and Photonics Research for Electronic Warfare	3.273	2.843	4.213

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Description: Conduct research into IR FPAs, RF photonics, and IR countermeasures to increase situational awareness in open and complex terrains; improve target detection, identification, and discrimination; and enhance missile threat IR countermeasure (IRCM) protection. ***FY 2015 Accomplishments:*** Grew and characterized new long-wave IR (LWIR) bulk semiconductor materials used in new detector designs with potential for low-cost, high performance applications; investigated the physical limitations in a variety of RF-photonic signal generation, transport, and processing schemes to optimize system resolution and bandwidth for C4ISR applications (e.g., position, navigation, and timing applications) that require very high phase precision; investigated optical and physical properties of novel semiconductor metamaterial and metastructure devices for applications such as chip scale chem/bio sensors and lighter and cheaper radios; and studied electro-optical (EO) modulator based on nano-crystal silicon for next generation high speed chip scale communication. ***FY 2016 Plans:*** Study 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 reduce system cost; study diode performance of semiconductor materials composed of indium arsenide antimonide (InAsSb) for improved long wavelength IR performance; research and advance opto-electronic oscillator technology for fiber-based acoustic sensor applications and better than global positioning system (GPS) clock precision; study photonics integration for biological and chemical sensing applications; and perform studies and develop/provide fundamental technologies to build ultraviolet (UV) sources (e.g., light emitting diode and laser) 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.			
Accomplishments/Planned Programs Subtotals	3.273	2.843	4.213

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 31B / *Infrared Optics 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: PB 2017 Army									Date: February 2016			
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
52C: *Mapping & Remote Sens*	-	1.990	2.030	2.057	-	2.057	2.092	2.130	2.172	2.215	-	-

A. Mission Description and Budget Item Justification

This project increases knowledge of terrain with a focus on improving the generation, management, analysis/reasoning, and modeling of geospatial data, and the exploitation of multi-sensor 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 battlefield. Results of this research are used to extract and characterize natural and man-made features from reconnaissance imagery in near-real time; to exploit terrain analysis and reasoning techniques; and to explore the potential of space technology and tactical geospatial sensor technology to provide real-time terrain intelligence, command and control, and targeting support. This research uses terrain and environmental 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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Sensor Phenomenology and Spatial-Temporal Pattern Discovery	1.990	2.030	2.057
Description: Funding provided for the following research.			
FY 2015 Accomplishments: Investigated aerosol effects on the integrity of Light Detection and Ranging (LiDAR) signals to improve signal and data collection capabilities; explored methods of describing objects in massive unstructured datasets through novel machine learning techniques to advance Big Data capabilities; investigated multi-source signal decomposition and characterization from single acoustic sensors to increase monitoring capabilities; and theorized metrics for the quantification of adaptive capacity of human populations resulting from environmental change to monitor instability.			
FY 2016 Plans: Investigate algorithms to index and query massive amounts of data with spatial and temporal context; theorize and explore framework of pattern learning tasks to rapidly analyze geospatial and temporal data; investigate quantifiable relationships between plant physiology and soil crust biology; explore relationship between biogeochemistry of permafrost in arctic soils and remote			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
sensing signatures; and explore 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 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.			
Accomplishments/Planned Programs Subtotals	1.990	2.030	2.057

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
53A: *Battlefield Env & Sig*	-	2.610	3.754	3.808	-	3.808	3.873	3.944	4.020	4.100	-	-

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 and the Army Modernization Strategy.

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 2015	FY 2016	FY 2017
Title: Predictive Modeling of the Boundary Layer	2.610	3.754	3.808
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 2015 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Finalized and implemented an experimental hybrid data assimilation approach into microscale and mesoscale numerical weather prediction models to improve fine-scale weather forecast performance; researched options for implementing a computationally efficient Weather Research and Forecasting-based Weather Running Estimate-Nowcast (WRE-N) model to produce localized probabilistic forecast grids suitable for tactically-deployed unit hosting; explored novel approaches for developing an agile feedback loop that incorporates model-driven sensing and collection, and uses boundary layer sensing for near real-time model adaptation and corrected predictions; and determined feasibility of atmospheric energy harvesting for small scale applications. ***FY 2016 Plans:*** Investigate boundary layer aerosol fate chemistry (i.e., how an aerosol moves and transforms in the atmosphere/environment) in support of chem/bio detection methods, transport and dispersion; investigate boundary layer aerosol effect on surface energy budget; use the field observed data to improve both the WRE-N and the microscale numerical model accuracy for complex terrain, especially for thermal driven flows due to differential heating; initiate 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 can be predicted and parameterized better in microscale and mesoscale models; develop a data assimilation approach for WRE-N and extend finest mesh to hundreds-of-meters grid spacing; begin efforts to integrate WRE-N and Atmospheric Boundary Layer Environment (ABLE), and develop improved surface energy budget and multi-scale turbulence models that will enhance 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.			
Accomplishments/Planned Programs Subtotals	2.610	3.754	3.808

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 53A / *Battlefield Env & Sig*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army									Date: February 2016			
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
74A: *Human Engineering*	-	14.235	13.176	13.342	-	13.342	14.023	14.482	14.797	15.078	-	-

Note

Not applicable for this item

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).

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

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), Human Research and Engineering Directorate, Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Research to Characterize and Enhance Soldier Performance	1.686	1.628	-
Description: Characterize and enhance human auditory performance of the dismounted warrior in complex environments while protecting the hearing of the Soldier. ***FY 2015 Accomplishments:*** Conducted Soldier-oriented research to understand the auditory conditions that lead to misinterpretation of auditory events in a complex sensory environment; quantified and described spatial range across which detection of auditory location changes are unlikely to be detected; and characterized the environmental elements and contexts that may be vulnerable to misinterpretation. ***FY 2016 Plans:*** Conduct Soldier-oriented research to understand the auditory conditions that determine recognition and identification of relevant auditory events; and expand 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.			
Title: Soldier Performance	1.686	1.629	-
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 2015 Accomplishments:*** Further developed the human performance information processing models addressing network challenges using formal mathematical approaches and task-network modeling and simulation to integrate information across network layers for better information management and planning; established a theoretical foundation for human networking behavior yielding testable predictions for laboratory experiments (modeling effort); continued the development of object recognition of places and objects (cognitively-inspired intelligent robotic technology); leveraged the results of industry efforts in shape recognition features; conducted experiments in realistic contexts with human interaction; conducted experiments to fill data voids and developed models describing and able to predict the key simulation parameters affecting perception, cognition, and physical performance independently (simulation and training); and outlined experimentation required to determine simulation parameters affecting			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
the interactions across perception, cognition, and physical performance. Included preliminary Training and Soldier performance research to identify and evaluate performance models, metrics and environments for determining Soldier behavior. This work will be continued under a new R2 bullet beginning in Fiscal Year (FY) 2016. ***FY 2016 Plans:*** Continue to investigate integrative aspects of key psychosocial factors of cyber security to understand behaviors of attackers, defenders, and users in operational settings; create 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 enhance 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).			
Title: Translational Neuroscience ***Description:*** Integrating neuroscience with traditional approaches to understanding Soldier behavior to enable systems designs that maximize Soldier performance. ***FY 2015 Accomplishments:*** Developed and refined active machine learning algorithms for improving the task performance of brain-based technologies that combine neural signals extracted from the Soldier with semi-autonomous computer systems; examined effects of environmental context on cognitive brain state assessments; explored analytical approaches for interpreting brain activity in unstructured tasks; and investigated how different signal processing approaches affect the detection of brain network signal estimates in order to support future development of brain-based technologies. ***FY 2016 Plans:*** Develop algorithms to detect changes in brain state during long-term performance of a task for a non-invasive brain-computer interface; collect novel neurophysiological datasets based on real-world measurements of stress and fatigue; collect innovative structural imaging data from a large cohort (N>100) of participants to quantify sensitivity of measurement and variability between individuals; and investigate 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.	4.398	3.579	3.639
Title: Human System Integration – Cybernetics	4.828	5.119	5.157

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017

Description: Apply a cybernetic approach (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 communication 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 2015 Accomplishments:
Determined areas of convergence for cognitive, social, information and computational sciences to develop and apply the cybernetic approach to human centered design of complex systems; invoked neural, information, and social-cybernetic modeling approaches to identify and begin to address the human system integration gaps that exist at the millisecond time scales and/or in the team- level interactions; examined issues in the design and implementation of cybernetic systems that will enable leveraging of the human nervous system's abilities to integrate, interpret, and utilize multimodal information in the sensory-perceptual-motor decision-making cycle; conducted research using novel paradigms, such as wearable computing and augmented reality technologies to identify key temporal and context parameters in multi-sensory integration; and laid the foundation for scaling up to societal-level cybernetics.

FY 2016 Plans:
Examine computational models consistent with cybernetic principles, including feedback models of adaptive mechanisms in human multisensory integration for sensor and motor systems control; implement and study novel neuro-inspired 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; design a multimodel platform to support human multisensory basic and applied research efforts in augmented reality and perception; examine critical parameters of multisensory displays to enhance and support human perceptual performance in human-system interactions; explore novel methodologies for identifying and integrating variables in cybernetic models to improve human-system communication; explore novel methods for the design of novel, dynamic, and adaptive human-system interactions through methods for mutual human-system communication 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, 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

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
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.	-	-	3.306
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance & behavior. Determine the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to effect performance similar to the 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 that is representative of the operational environment. Implementation of the guidelines will enhance training effectiveness. ***FY 2015 Accomplishments:*** Explored the varying levels of immersive environments (real environment, first person game, fully immersive) and varying levels of physical and cognitive stress (induced by varying levels of physical and cognitive stimuli) to determine ability of Soldiers to perceive and act on information. Used results from these studies to augment models of Soldier performance and behavior as a function of training environment. If those models are insufficient, begin development of new models, based on empirical data, predicting Soldier behavior based on training environment. ***FY 2016 Plans:*** Explore effects of mobility platform and training environment on route selection during training scenarios; manipulate level of information in the environment to determine how information influences route selection, traversal time, and other Soldier performance parameters; use results from these studies to augment current models or develop new models of Soldier performance and behavior (using empirical data to predict Soldier behavior based on training environment). ***FY 2017 Plans:***	1.637	1.221	1.240

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
Accomplishments/Planned Programs Subtotals	14.235	13.176	13.342

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: PB 2017 Army										Date: February 2016		
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
74F: *Pers Perf & Training*	-	5.131	5.459	5.540	-	5.540	5.635	5.737	5.852	5.969	-	-

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 2015	FY 2016	FY 2017
Title: Personnel Measures (previously Human Behavior)	1.800	1.834	1.900
Description: Funding is provided for basic research to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development. ***FY 2015 Accomplishments:*** Initiated the development of measurement theory and performance-based measurement methods to improve selection, classification, and assignment. ***FY 2016 Plans:*** Investigating 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.			
Title: Climate, Readiness, and Resilience (previously Human in Complex Organizations)	3.331	3.625	3.640

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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 2015 Accomplishments:*** Initiated research to develop group and organizational measures of organizational cohesion, resilience, and effectiveness. ***FY 2016 Plans:*** Investigating 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.			
Accomplishments/Planned Programs Subtotals	5.131	5.459	5.540

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	0.000	0.000	4.201	-	4.201	4.531	4.617	4.714	4.809	-	-

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 i.e. eye and facial tissues, and transplant technology. 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.

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 Institute of Surgical Research (USAISR), Joint Base San Antonio, TX; and the Armed Forces Institute of Regenerative Medicine (AFIRM), Multiple Institutions across the US.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Clinical and Rehabilitative Medicine	-	-	4.201
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), abdomen and burns.			
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 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			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
Accomplishments/Planned Programs Subtotals	-	-	4.201

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
F20: *Adv Propulsion Rsch*	-	4.054	4.161	4.220	-	4.220	4.290	4.368	4.452	4.541	-	-

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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Thermal Materials	2.376	2.431	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 2015 Accomplishments: Conducted thermo-mechanical fatigue experiments on new bulk ceramic materials, polymer composites, and metal alloys to enable reduced production/maintenance costs, and to achieve increased performance factors with improved temperature capability; developed advanced computational damage models; and conducted mechanical diagnostics experiments to improve the understanding of failure progression and diagnostics in drive train mechanical components, such as gears and bearings.			
FY 2016 Plans: Formulate and validate 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			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
surfaces. This work provides 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 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 2015 Accomplishments:*** Evaluated transient spray and combustion characteristics of heavy fuel injectors under simulated engine conditions to optimize engine combustion, performance, and efficiency; and developed more accurate and reliable modeling and simulation tools to predict spray and combustion characteristics under complex fluid dynamics conditions that enable effective design of small engines for a range of Army applications. ***FY 2016 Plans:*** Evaluate liquid and vapor partitioning in transient spray phenomenon to discover injection-kinetic dependency of spray and combustion events, analyze droplet size distributions in transient spray, and assess ignition, combustion intensity and radical dependency on transient spray; characterize spray and combustion processes of JP-8, Jet A, and alternative jet fuels for fuel property correlation with spray and combustion parameters; and research modeling and simulation methodologies (both semi-empirical and physics-based) that predict spray and combustion characteristics under complex fluid dynamics conditions.	1.678	1.730	-
Accomplishments/Planned Programs Subtotals	4.054	4.161	4.220

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F20 / *Adv Propulsion Rsch*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
F22: *Rsch In Veh Mobility*	-	0.685	0.707	0.718	-	0.718	0.732	0.745	0.760	0.775	-	-

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 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 2015	FY 2016	FY 2017
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency	0.685	0.707	0.718
Description: Funding is provided for the following effort: ***FY 2015 Accomplishments:*** Researched new physics based analytical tools for more accurately and rapidly predicting vehicle terrain interaction effects; and explored new methodologies/relationships for improving intelligent mobility including latency. ***FY 2016 Plans:*** Research 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); continue to explore new methodologies/relationships for improving autonomous mobility including latency; and research 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: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
Accomplishments/Planned Programs Subtotals	0.685	0.707	0.718

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: PB 2017 Army									Date: February 2016			
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
H42: *Materials & Mechanics*	-	9.054	8.603	8.731	-	8.731	8.879	9.040	9.218	9.402	-	-

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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2015**	**FY 2016**	**FY 2017**
Title: Microscopic/Nanostructural Materials	2.348	2.341	2.375
Description: Devise new materials and design capabilities based upon fundamental concepts derived at the microscopic and nanostructural levels for the future force.			
FY 2015 Accomplishments: Created numerical models and experimental techniques to design energy-absorbing, adaptive, damage-tolerant nanocomposites; developed new paradigms for thermodynamically stable nanostructured materials systems that overcome traditional property trade-offs; and pursued revolutionary new polymeric building block materials for structural, membrane, sensor, and power/energy applications.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Develop computational capabilities and methods to explore grain boundary structure-property relationships for predicting the strength and failure response of metals and ceramics; and continue 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.			
Title: High Deformation Rate Materials ***Description:*** Develop fundamental understanding necessary to design, process and characterize materials specifically intended for high loading rate applications, as in armor and armaments.. ***FY 2015 Accomplishments:*** Developed multiscale, multidisciplinary models and related experimental techniques to elucidate fundamental physics of materials response to include: thermoelastic, yield, failure, and fracture behavior at high deformation rates; created novel experimental research tools to enable the study of these high deformation rate phenomena with greater resolution; incorporated microstructural and high deformation response into robust multiscale computational codes; and began to create new materials specifically designed to enhance performance at high deformation rates in applications ranging from armor to new armaments. ***FY 2016 Plans:*** Enhance multiscale, multidisciplinary materials research to include 1) 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 transition microcracks at small length scales to macrocracks 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.	3.407	3.107	3.153
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 2015 Accomplishments:***	3.299	3.155	1.089

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Developed an integrated computational materials science capability that clarifies relevant physical mechanisms and enables the rational design of small scale (nanoscale) and bio-inspired building blocks; utilized thermodynamic and kinetic studies of self-assembly processes to design, create, and characterize nanostructured surfaces and interfaces; and created and utilized small scale materials characterization techniques to further the fundamental understanding of small scale materials and processes. ***FY 2016 Plans:*** Explore fundamental effects of alloying elements on atomic level structure and resulting properties and dynamic (high-rate) response to enable new lightweight alloys; develop novel modeling capabilities to capture physics at small scales in protective fibers and composite materials; and begin new foundational research on next-generation protective fibers with controlled nano/ microscale structure. ***FY 2017 Plans:*** 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.			
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.	-	-	2.114
Accomplishments/Planned Programs Subtotals	9.054	8.603	8.731

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H43: *Research In Ballistics*	-	8.602	8.410	8.531	-	8.531	8.676	8.834	9.007	9.187	-	-

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 and the Army Modernization Strategy.

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 2015	FY 2016	FY 2017
Title: Advanced Energetics Initiative	3.516	3.155	3.203
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 2015 Accomplishments:*** Exploited material micro/nanostructure, high pressure synthesis, and managed energy release mechanisms to develop energetic materials with two to ten times the energy content of conventional explosives; further advanced theory required to develop accurate descriptions and models of condensed phase processes, quantum mechanical reactive potential energy surfaces, shock impact, initiation and detonation phenomena, and ignition and combustion; and further developed synthetic capabilities to produce high-nitrogen containing materials. ***FY 2016 Plans:*** Explore novel high-nitrogen carbon, hydrogen, nitrogen and oxygen (CHNO) synthesis methodologies to create unique energetic molecular structures while maintaining stability of reactive properties; expand investigation and explore novel extended solid energetic materials, in particular poly-carbon monoxide (CO), including alternatives to high pressure synthesis methods; and			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
develop 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.			
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 2015 Accomplishments:*** Further developed computational aerodynamics capabilities, coupled with the development of next-generation guidance, navigation, and control solutions to enable new paradigms in maneuverability to achieve ultrahigh precision. ***FY 2016 Plans:*** Investigate dynamics and controls of extreme aerodynamic maneuvers and assess transient effects and potential for maneuver without the use of sensors; and begin to explore and create 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).	1.659	1.730	2.020
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 2015 Accomplishments:*** Established capabilities to extract electron temperature data from time resolved imaging spectroscopy measurements of shaped charge jet induced plasma for comparison to numerical simulation predictions; developed hierarchical multiscale methodology for transfer of relevant information from mesoscale computation to macroscale constitutive and failure models; and developed	3.427	3.525	2.558

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
coupled finite element and physiological numerical modeling methods to evaluate the dynamic response of the human head as a structure under short-time blast loading to enable effective design of protection concepts. ***FY 2016 Plans:*** Develop analytic and numerical methods and associated experiments for rigorous coupling of electro-magnetics and solid dynamics models; explore the validity of phase-field methods to track coupled deformation mechanisms in polycrystalline solids under rapid deformation; and assess accuracy and ability of multi-scale computations that account for material-scale mechanisms during penetration events. ***FY 2017 Plans:*** 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.			
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.	-	-	0.750
Accomplishments/Planned Programs Subtotals	8.602	8.410	8.531

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: PB 2017 Army									Date: February 2016			
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
H44: *Adv Sensors Research*	-	9.564	8.659	9.436	-	9.436	9.771	10.276	10.936	11.194	-	-

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 the Data-to-Decisions (D2D) concept, 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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2015**	**FY 2016**	**FY 2017**
Title: Adaptive, Active, and Intelligent Optical Systems	1.755	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Description: Adaptive, active, and intelligent optical systems for high-data-rate military communications and directed energy applications. ***FY 2015 Accomplishments:*** Completed the optimization of the pointing, acquisition, and tracking sub-systems of the Free-Space Optical (FSO) networked multi-gigabit communication system; conducted a performance evaluation of the FSO and its related control software; and developed a visible light multispectral quantum imager capable of imaging through turbulence and demonstrate its capability in turbulence and low light field experiments to beyond one kilometer.			
Title: Improving Sensor and Photonics Research (Nano) ***Description:*** Create more survivable and secure sensors and displays; improve hazardous material monitoring; and investigate new magnetic- and electric-field sensor technologies for personnel, activity, and improvised explosive device (IED) detection. ***FY 2015 Accomplishments:*** Researched methods to improve acoustic classification robustness in diverse environments; studied a physics-based tracker algorithm for extremely long-range infrasound (low-frequency sound) detections; researched methods to improve magnetic tunnel junction sensor sensitivity and interface for reading non-erasable magnetic permeability bits of stored information; and investigated signal processing algorithms for exploiting flexible and adaptable low frequency ultra-wideband (UWB) waveforms that support stepped frequency radar technology. ***FY 2016 Plans:*** Research design of electrically-small antennas using adaptive metamaterials and adaptive surfaces; develop foliage penetrating (FOPEN) tree clutter model; develop 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; investigate enhanced performance magnetic tunnel junctions for low-frequency noise rejection and increased detection bandwidth and range; research distributed processing and fusion of gunfire signatures from disparate sensors; and examine 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-	2.925	2.850	2.393

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
Title: Multi-scale Modeling for Novel Materials ***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 2015 Accomplishments:*** Continued to perform fundamental studies to identify and model the physics and atomic interactions that define their structural, mechanical, electronic, and optical properties and characteristics and control material deformation, progressive/catastrophic failure, and phase response across length scales; validated multi-scale experimental techniques and characterization methods; continued to develop advanced computational models for multiscale modeling of electrochemical systems; investigated and develop scalable interdisciplinary data models to address spatial one-way coupling of software on massively parallel petaflop systems, and multi-core computing systems; and conducted research in multi-scale computational sciences and coupled different modeling paradigms at the algorithm level. ***FY 2016 Plans:*** Develop 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; evaluate the comprehensive set of material characteristics and properties at length and time scales that govern high-rate deformation; evaluate the modeling of fracture and failure phenomena in metallic, polymeric, ceramic, and composite material systems through both computational and experimental techniques; and expand 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.	2.925	2.795	2.840
Title: Biological and Bio-inspired Materials and Devices Research	1.959	3.014	4.203

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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 2015 Accomplishments:*** Investigated the underlying biology that enables natural and synthetic biological materials and systems to monitor, control, enhance, and predict bacterial metabolism and products for improved logistics and force protection; studied novel synthetic recognition reagents in response to new and emerging threats that possess superior performance, stability and adaptability; and researched hybrid biological/electronic/photonic materials capabilities based on bio-engineered cellular machinery or specific properties of bio-interfacial chemistry. ***FY 2016 Plans:*** Develop computational models of bacterial metabolism that include synthetically engineered pathways and use synthetic biology to manipulate that metabolism for production of commodity chemicals necessary for waste to energy applications; and study and develop fundamental synthetic biology tools enabling biomaterials discovery with enhanced features (e.g., integrated reporting and high temperature discovery) to allow for understanding and control of biological material interfaces for sensor and electronic integration, bioadhesives 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 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.			
Accomplishments/Planned Programs Subtotals	9.564	8.659	9.436

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H45: *Air Mobility*	-	2.247	2.328	2.364	-	2.364	2.403	2.448	2.495	2.545	-	-

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 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 2015	FY 2016	FY 2017
Title: Rotary Wing Aerodynamics	2.247	2.328	2.364
Description: Funding is provided for the following effort			
FY 2015 Accomplishments: Continued computational aero-science investigations aimed at developing novel numerical methods for rotorcraft unique flow phenomena and continue fundamental aeromechanics experiments; conducted an experimental investigation of rotor wake physics including worm-like flow instabilities; investigated flow phenomena in unsteady flow separation; and developed and improve testing techniques for aerodynamics/fluid flow such as pressure sensitive paint and particle image velocimetry.			
FY 2016 Plans: Continue 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 conduct 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:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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 surface loads, and particle image velocimetry for flow field velocities; and explore interactional aerodynamic effects on multi-rotor configurations including the rotor downwash/outwash.			
Accomplishments/Planned Programs Subtotals	2.247	2.328	2.364

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H47: *Applied Physics Rsch*	-	5.178	5.722	4.285	-	4.285	4.238	4.338	3.861	3.926	-	-

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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Nanoelectronic Devices and Sensors	2.934	3.326	1.836
Description: Conducts research for advanced battery materials; fuel cells and reformers for Soldier and vehicle power; electronic materials structures and defects of high-temperature, wide-bandgap semiconductors for high-power electronic applications; materials for advanced nano and micro devices; cold-atom chip devices for advanced sensors and ultra-stable atomic clocks; and integration of nanoenergetics and Micro-Electro-Mechanical Systems (MEMS) for fusing and micro-robotic applications. ***FY 2015 Accomplishments:*** Investigated transport of cold atoms along chip-scale wires for applications in inertial navigation in GPS denied environments and for applications in environmental sensing, including magnetometry; investigated integration of three-dimensional (3D) piezoelectric materials and processes with flexible substrate and circuit technologies for radio frequency (RF) MEMS and millimeter scale			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
robotics; studied and characterize the growth and electrical properties of stacked two-dimensionalo (2D) electronic materials for application to RF and/or logic devices; refined the early development of on-chip energetic materials and processing for supplying slow, high temperature thermal sources; and investigated composition and effect of additives on solid-electrolyte interphase formation on silicon anodes for lithium ion batteries. ***FY 2016 Plans:*** Construct an ultrafast laser spectroscopy experimental testbed to detect surface contamination by hazardous materials; investigate detection method based on photothermal vibrometry using tunable quantum cascade laser (QCL) sources for surface contamination detection and conduct ongoing investigations of other promising candidate spectroscopic detection technologies; analyze processes and materials for the realization of thin film deposited 3D piezoelectric materials for novel and high performance MEMS actuators; develop processes and characterize on-chip energetic materials for optimization of slow reaction rates for energy generation and thermal source applications; develop growth techniques and fabrication processes for stacked 2D materials, optimization for RF electronic properties and use of flexible substrates to enable vertical RF active devices resulting in higher frequency RF circuits (to increase performance with less size, weight and power); characterize devices and integrated circuits made using 2D electronic materials such as transition metal dichalcogenides in order to enable conformable, high performance electronics; assess performance prospects for application of such materials for high frequency and low power analog, RF, and digital electronics for communication and sensing; and research one-dimensional (1D)/2D novel phenomena for alternative device architectures for operation 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.			
Title: Advanced Energy Efficient Science Research ***Description:*** 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 2015 Accomplishments:*** Studied the physical limits of wide-band gap materials for direct photoelectrochemical production of hydrogen for use as fuel; investigated the effect of plasmonic arrays on the catalysis of oxygen reduction and ethanol oxidation as alternative methods	2.244	2.396	2.449

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
for fuel production; and developed advanced superconducting materials by metal organic chemical vapor deposition (MOCVD) processes to aid in energy conversion. ***FY 2016 Plans:*** Investigate 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; investigate the effect of electromagnetic radiation (EM) at several frequencies on catalysis rate and selectivity to determine impact on power generation; and investigate 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.			
Accomplishments/Planned Programs Subtotals	5.178	5.722	4.285

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: PB 2017 Army										Date: February 2016		
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
H48: *Battlespace Info & Comm Rsc*	-	24.596	25.463	28.276	-	28.276	28.668	29.105	29.624	30.168	-	-

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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Communications for Tactical Networks	1.816	1.934	1.963
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 2015 Accomplishments:*** Conducted analysis, simulations, and experiments to develop new communications networking capability in harsh tactical environments (e.g., exploitation of low frequency communications, mobility and autonomy to maintain connectivity, and mapping connectivity regions to blend with mobility planning and sensing); developed quality of information (QoI) theories based upon			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
human-in-the-loop analysis; and developed mathematical representations for the QoI of static and dynamic data and its effectiveness for situational awareness. ***FY 2016 Plans:*** Research theories, models and experimental approaches towards new communications networking capability (e.g., control and signal processing algorithms for adaptive hybrid networks comprised of microwave and lower very high frequency (VHF) frequencies with active adaptations) in harsh tactical environments; investigate approaches to integrated agent-based node relocation and communications planning that enhances network connectivity; and develop 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.			
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. ***FY 2015 Accomplishments:*** Researched the effect of context-dependent information exploitation on the situation awareness of intelligence analyst and soldiers at the edge by constraining the problem domain in an effort to reduce computational complexity and increase accuracy of specific baseline algorithms; experimentally validated the value of information construct within a tactical military decision support system; and investigated algorithms for intelligent exploration and focused data collection in relevant environments using collaborative mobile platforms. ***FY 2016 Plans:*** Develop a framework and algorithms for multi-modal information fusion of representative tactical elements from text, video and imagery; investigate the impact to situational awareness when using integrated multi-modal analytics versus independent analytics; study the value of information construct as a measure of the contribution of multimodal analytics; and investigate algorithms for intelligent mission planning and task allocation for heterogeneous teams of mobile platforms in tactical environments. ***FY 2017 Plans:***	2.392	2.545	4.503

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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 and when information is provided to the user. Measures of effectiveness will include decrease in communications delay and increase in situational awareness.			
Title: Information Protection for Mobile Ad-Hoc Networks (MANETs) ***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 MANETs and Tactical Communications. ***FY 2015 Accomplishments:*** Developed security processes and techniques to provide information protection in mobile dynamic environments, where mobile devices are connected to coalition networks serving as forward-deployed devices at the edge; developed techniques to minimize energy required to support security functions; developed security protocols and processes for using tactical cloudlets as a shared resource among Warfighters and coalition forces; and developed and characterized algorithms for detection and analysis of adversarial malicious operations on networks that involve the above mentioned complexity of mobility, resource constraints, inconsistency and shared resources. ***FY 2016 Plans:*** Investigate techniques for novel, stealthy communications that are less likely to be detected and intercepted by the adversary than conventional radio frequency communications; investigate methods for mission-focused, network analysis and prediction of cyber risks; and design 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.	5.836	5.902	5.992
Title: Multi-Lingual Computing Research ***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of- the-art techniques in machine translation and natural language processing.	1.053	1.120	1.136

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
FY 2015 Accomplishments: Identified and extracted event-based information from large amounts of text written in different genres in different languages and dialects to support temporal and spatial relation analyses in situational awareness; and examined the extension of linguistics analysis techniques to image processing. ***FY 2016 Plans:*** Identify tractable elements of social meaning reflected in text, based on sociolinguistic theory, and develop algorithms to extract basic elements from social media; examine contribution of social information to entity and event-based information extracted from text; evaluate and extend Natural Language Processing (NLP) semantic underpinnings for spatial and temporal representation and link with logical formalisms for reasoning and action planning; and investigate 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.			
Title: Advanced Computing ***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 Command, Control, Communications, Computer, and Intelligence (C4I) systems. ***FY 2015 Accomplishments:*** Explored novel models to represent advanced computing/networking coupled with real-time battlefield information processing while meeting tactically relevant turn-around and scheduling requirements and constraints; and extended models to include power and performance metrics as part of the wider knowledge base in forming an application signature-processor pairing that can be used to perform intelligent processor selection on a case-by-case basis. ***FY 2016 Plans:*** Develop novel programming models using emerging programming languages for dynamically evolving mobile heterogeneous computing/networking architectures to solve high fidelity battle command applications; and develop 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	3.499	3.562	4.116

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
Title: Quantum Information Sciences	4.802	5.277	5.359
Description: Perform research to enable new techniques for ultra-precise navigation, timing, communications and imaging using atomtronics and spintronics, which are quantum measurement and sensing devices based upon atoms and spin respectively, instead of electrons. 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 2015 Accomplishments:*** Studied physics of compact (i.e., wrist-watch scale) atom chips (an atom chip uses quantum properties of atoms to sense gravity and acceleration) needed for a precise position/navigation/timing (PNT) sensor; studied fundamental atomic physics of quantum repeaters, for an eventual hybrid quantum communication system, based on transmission of single photons that are quantum mechanically entangled with quantum memories; and obtained new insights into "writing" and "reading" laser-cooled rubidium atoms to store and later retrieve a single photon from the atomic ensemble over long haul optical fiber. ***FY 2016 Plans:*** Investigate quantum node-to-node communication along optical fibers and free-space via entangled single photon generation and capture; evaluate 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 study and characterize unique trapping processes to hold and exploit the quantum properties of ions; and study 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.			
Title: Network Science Technology Experimental Center	5.198	5.123	5.207

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Description: Supports in-house Network Science studies in conjunction with the Network Sciences Collaborative Technology Alliance (PE 0601104A) ***FY 2015 Accomplishments:*** Expanded the wireless emulation capabilities to include the interactions among communication, social, and information networks; developed techniques for modeling the performance of hybrid networks; and developed, analyzed and validated composite trust management techniques and metrics that consider the interactions between social, information and communication networks. These efforts provided improved understanding of tactical network behaviors, improved network designs, secure information flows and enhanced decision-making. ***FY 2016 Plans:*** Conduct 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; characterize and develop 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; develop theoretical foundations for security properties in complex heterogeneous networks; and extend and refine 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.			
Accomplishments/Planned Programs Subtotals	24.596	25.463	28.276

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
H52: *Equip For The Soldier*	-	1.049	1.119	1.133	-	1.133	1.153	1.173	1.197	1.221	-	-

Note

Not applicable for this item

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Equipment for the Soldier	1.049	1.119	1.133
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 2015 Accomplishments: Examined thermal degradation mechanisms in selected natural materials as basis for potential flame/fire protection approaches; created nonwoven electrospun composites of unique composition and examined their properties and material behavior to provide foundation for robust, Soldier-based sensing of pathogens in food and ambient environment.			
FY 2016 Plans: Explore enhancement of cognitive skills via trans-cranial direct current stimulation (t-DCS) and examine 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; examine a novel in-vitro gut fermentation			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
model to gain fundamental understanding of dietary component influence on gut health as it relates to improving Soldier performance through nutrition. ***FY 2017 Plans:*** Will 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 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.			
Accomplishments/Planned Programs Subtotals	1.049	1.119	1.133

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H57: *Single Investigator Basic Research*	-	78.575	87.001	94.519	-	94.519	94.284	99.007	102.166	103.423	-	-

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 and life sciences), the engineering sciences (i.e., mechanical sciences, electronics, materials science and environmental science (i.e., atmospheric and terrestrial sciences)), 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 900 active, ongoing research grants and contracts with leading academic researchers and approximately 1,600 graduate students yearly, supporting research at nearly 250 institutions in 50 states.

Work is this project supports key Army needs and provides the technical underpinnings to Program Elements (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 priority focus areas and the Army Modernization Strategy.

Work in this project is performed extramurally by ARL, Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Basic Research in Life Sciences	8.004	9.782	8.868
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.			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017

FY 2015 Accomplishments:

Identified the genetic networks and epigenetic factors that enable the survival of bacteria in extreme stress conditions, which may reveal new insight into stress resilience and survival in eukaryotic organisms, and ultimately enable the engineering of microorganisms better suited to rugged industrial production conditions; expanded studies of previously-demonstrated DNA assembly method to determine whether diverse nanostructured shapes can be carved from a common 3D DNA block, which may provide a future template for generating hybrid materials with the advantages of both biological and synthetic systems; characterized the molecular dynamics and evolution of associative memory in bacteria, which will be an important step towards understanding microbial adaptation potential for use as a potential tool to be exploited for microbial forensics analyses; and devised a model for the automated synthesis of neuro-cognitive computational models derived from brain activity to determine whether it is possible to mathematically link functional brain data to cognitive states, which could ultimately lead to new applications for assessing and improving Soldier mental performance such as battlefield training, and treatment of disorders such as post-traumatic stress disorder (PTSD).

FY 2016 Plans:

Research and design 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); screen 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 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); determine 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 evolve 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

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
a cell) (may provide a platform for the production of polymers or antimicrobials that normally require significant infrastructure to produce synthetically).			
Title: Basic Research in Environmental Sciences ***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 2015 Accomplishments:*** Exploited recent theoretical and experimental advances in soft-matter physics to isolate and examined the granular dynamics of fluid-driven sediment transport, focusing on bed load transport in rivers. ***FY 2016 Plans:*** Perform 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).	1.450	1.527	1.550
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 2015 Accomplishments:*** Investigated and characterized the ionic states of energetic compounds (will enable the design of safer (e.g. during transport and storage), more powerful explosives and propellants); identified fundamental mechanisms and properties that control the assembly and dissociation of supramolecular systems upon influence of external stimuli, such as toxic chemicals, enzymes, or changes in pH (will lead to new capabilities for protection from, and inactivation of, chemical and biological warfare agents and toxic industrial	7.736	9.567	12.950

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
chemicals); synthesized polymeric materials employing unique building motifs with the goal of creating a self-assembled complex ensemble - the ensemble's response to a variety of conditions that are used to determine how the state of the system can be controlled in a nonlinear manner (may lead to new materials or coatings that can detect and repair defects); and probe transport processes in confined media to reveal an improved understanding of ion transport (will provide new long-term applications such as fuel cell membranes with higher ionic conductivity to provide the Soldier with more effective portable power systems). ***FY 2016 Plans:*** Investigate and characterize 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; elucidate the basic mechanisms by 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); synthesize 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 identify and characterize 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).			
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. ***FY 2015 Accomplishments:*** Explored the infrared and optical responses of electrostatically-induced effects in correlated oxides, such as metal-to-insulator transitions (may lead to advanced electronic technologies for sensing and computational hardware); investigated new synthetic	14.091	16.262	18.678

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
physics in cold quantum gases (will contribute to the development of cold-atom interferometers for ultra-accurate navigation and quantum computing applications for secure communication); detected single molecular ion spectra using laser-cooled atomic ions by exploiting previous research on trapped ions for quantum information science (may lead to capabilities beyond what is possible with classical systems, such as resource optimization, optimal wargaming, efficient and secure command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) that will greatly benefit the Department of Defense (DoD), airline, financial, and telecommunications industries); and demonstrated and characterize microjoule-level laser pulse energies for 150 attosecond pulses in the 30-70 eV photon energy range (>1,000 times higher than the current world record) (may enable future applications in standoff explosives detection and sensing through obscurants). ***FY 2016 Plans:*** Develop 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); investigate 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); develop 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 characterize 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).			
Title: Basic Research in Electronics and Photonics	10.541	11.094	11.260
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 2015 Accomplishments:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Showed independent tuning of the temperature coefficient of resistance and noise in bolometers to improve signal to noise ratio of room temperature infrared detectors; showed electrically injected, high-speed 1.55 μm nanoscale lasers on a silicon platform for potential gains in energy efficiency of computational and sensor systems; demonstrated that plasmonic antennas can mitigate efficiency degradation of conventional antennas at terahertz and optical frequencies to investigate the potential of free-space interconnects for efficient data communications and energy harvesting; and created and investigated a novel sensor based on optical dark modes in nanorods for use in biomolecule, chemical sensing, and near-field imaging. ***FY 2016 Plans:*** Establish infrared and optical response in a carbon nanotube-oxide-metal rectenna for room temperature infrared detection; show coaxial nanolasers scalable to deep-subwavelength dimensions suitable for on-chip interconnects; initiate metasurface control of THz radiation emission (direction and beam width) without external antenna, using variable surface wave propagation for chemical and biological agent sensing; and create 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.			
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 2015 Accomplishments:*** Elucidated the molecular mechanisms by which living cells regulate intracellular biochemical activity with mechanical force and designed novel materials with force-activated control; provided novel functional materials with unprecedented physical properties through strongly linked multi-scale models developed specific to the materials systems; and completed a vigorous investigation of two-dimensional non-graphitic atomic layers and heterostructures and identified advanced material properties and capabilities. ***FY 2016 Plans:*** nable 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	6.868	7.227	7.334

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
and extraordinary energy production and storage; create stable free-standing single monomer thick novel two-dimensional (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 develop 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).			
Title: Basic Research in Computing Sciences	7.543	7.938	8.558
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 2015 Accomplishments:*** Established new knowledge in acquiring, computing, and analyzing big data in a trusted fashion, and investigate novel techniques for processing multi-modal data that may be in the form of text, photo, video, and audio so that actionable intelligence and timely information can be extracted and derived for better situation awareness and better decision making; investigated new concepts such as value of information, and invest in new research opportunity areas such as social informatics; and pursued efforts on information assurance with a special focus on hardware based resilient techniques. ***FY 2016 Plans:*** Establish novel representations, non-commutative information theory, and dimensionality reduction of multimodal data that enable effective large scale multimodal data analyses, particularly image/video data analytics to extract actionable intelligence to support C4ISR; create 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; investigate metrics for determining information trustworthiness and for detecting deception in social data; and establish new analytical models that quantify the resiliency of computing systems. ***FY 2017 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
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.			
Title: Basic Research In Network Sciences	8.123	8.549	10.578
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 2015 Accomplishments:*** Studied interconnected networks and how failure in a network spreads to other networks; investigated rigorous mathematical theories that bring together statistical mechanics, operations research, game theory and reliability theory to predict how failures propagate and when/how failures could be controlled; explored new game theory inspired models for how economic and social factors lead to large societal changes, such as Arab spring style revolutions; and studied tensor decomposition of spectral graphs that arise from big data in social networks with a view towards automatically learning the structure of networks and their properties. ***FY 2016 Plans:*** Research design mechanisms for deriving consensus, for use in crowd-sourcing based solutions for resource allocation problems; study how to design teams to optimize performance and diversify capabilities by building mathematical models that explain and predict how teams organize, exchange information, build knowledge, influence, adapt, learn, and build consensus, resulting in actionable findings that create effective teams; study how information from social networks can be used to design and build adaptive, predictive solutions for managing load, mobility, and connectivity of communication networks; develop new control theory to facilitate task allocation and efficient exploration by autonomous teams; and develop spectral methods to determine important properties of random graphs and different classes of dynamics on networks related to flows/advection and consensus processes to enable 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			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
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.			
Title: Basic Research in Mechanical Sciences	6.578	6.913	6.977
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 2015 Accomplishments:*** Gained an understanding of oxidizer behavior in energetic materials via determination of how the morphology and phase behavior evolved during the heating and reaction process; demonstrated new capabilities to actively control entropy production and free energy exchange in arrays of molecular motors; developed a reduced-order methodology suitable for the study of the large parameter design space associated with "dynamic stall"; and developed a numerical modeling approach capable of quantifying the formation of shear bands and dynamic crack propagation of structural materials under high strain rate loading. ***FY 2016 Plans:*** Gain understanding of dynamic responses of reactive metallic alloys (RMA) -- how they deform, fracture and combust to enable novel energetic material behaviors; develop 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; determine effectiveness of near-Kolmogorov & Kolmogorov scale forcing of shear layers for re-distributing energy from large scale turbulent structures to small scales dominated by viscous dissipation for improved understanding of flow separation and control; and determine 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			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
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.			
Title: Basic Research in Mathematical Sciences ***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 2015 Accomplishments:*** Conducted innovative basic research in statistical analysis, infinite-dimensional stochastics and control, multiscale procedures that transfer information among multiple sets of scales, identification and quantification of fundamental principles of biological dynamics often through multiscale modeling, representation of three-dimensional (3D) terrain and new metrics for small-group social and sociolinguistic phenomena. This mathematical science research led to improved conventional and quantum information networks and information processing, soldier health and performance, decision making, training, simulation and mission planning. ***FY 2016 Plans:*** Initiate basic research efforts to develop a theory of information at the quantum level, to develop advanced geometric models of social processes as an alternative to network models, and to develop mathematical models that can achieve a two-way flow of information in the computational modeling of materials. These new mathematical areas will bring new modeling capabilities in secure communications, the prediction of collective behavior, and enable designer materials. ***FY 2017 Plans:*** 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.	5.804	6.106	5.700
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	1.837	2.036	2.066

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
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 2015 Accomplishments:*** Conducted basic research efforts related to the design of mathematical models and experimental methods to map the cognitive implications of multisensory information integration, including neurobiology studies to elucidate the mechanisms of synaptic signaling that underlies perception, network science studies to characterize the functional connectivity and information processing, and computer science studies to design models to accurately represent these systems. ***FY 2016 Plans:*** Further 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 determine 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).			
Accomplishments/Planned Programs Subtotals	78.575	87.001	94.519

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H66: *Adv Structures Rsch*	-	2.000	2.033	2.061	-	2.061	2.095	2.133	2.174	2.217	-	-

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 joint Army/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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Structural Analysis and Vibration Methods	2.000	2.033	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 2015 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Investigated strategies for improving the durability of vehicle platforms through the introduction of novel composite materials; developed and demonstrated a probabilistic tool for the development of novel composite materials to address specific structural performance requirements; developed the capability to capture and quantify precursors to damage in structural components that will enhance the operation and sustainability of future vehicle systems; and demonstrated three-dimensional (3D) printing of multifunctional structural components for air and ground vehicle applications. ***FY 2016 Plans:*** Investigate (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 research 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.			
Accomplishments/Planned Programs Subtotals	2.000	2.033	2.061

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
H67: *Environmental Research*	-	0.901	0.913	0.928	-	0.928	0.943	0.961	0.979	0.999	-	-

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 2015	FY 2016	FY 2017
Title: Industrial Pollution Prevention	0.901	0.913	0.928
Description: This effort conducts research on innovative environmentally-friendly technologies that support the warfighter (focusing on pollution prevention technologies).			
FY 2015 Accomplishments: Researched green technologies for new energetics/propellants, airborne lead reduction in Army weapon systems, and environmentally friendly technologies to support Army soldier systems; selected projects to support the Army Environmental Requirements and Technology Assessments (AERTA).			
FY 2016 Plans: Perform research involving hazardous materials and wastes generated from production of energetic materials, additive manufacturing, and weapon systems; investigate efforts to enhance technologies to support Soldier systems; and investigate selected projects to comply with the Office of the Secretary of the Army's environmental initiatives.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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 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.			
Accomplishments/Planned Programs Subtotals	0.901	0.913	0.928

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
S13: *Sci BS/Med Rsh Inf Dis*	-	10.924	11.181	11.318	-	11.318	11.503	11.722	11.952	12.191	-	-

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 2015	FY 2016	FY 2017
Title: Prevention/Treatment of Parasitic (organism living in or on another organism) Diseases	3.871	3.997	-

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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 2015 Accomplishments:*** Continued to identify new lead candidate drugs and combinations to stay ahead of emerging drug resistance in malaria parasite; and identified new technologies to deliver drugs into the human body by using novel formulations. ***FY 2016 Plans:*** Optimize 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 2015 Accomplishments:*** Identified and characterized mechanism of protective immunity; continued to assess immunogenicity of new vaccine candidates in small-animal models to determine suitability in formulations of multiple antigen vaccines and identified and characterized new technologies to deliver candidate vaccine into the human body by using novel formulations. ***FY 2016 Plans:*** Continue to identify and characterize 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.	2.482	2.530	-
Title: Basic Research on drugs and vaccines against parasitic diseases	-	-	6.583

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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 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.			
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 2015 Accomplishments:*** Explored common adjuvants and routes of delivery for a combination vaccine against the major diarrheal causing bacterial impacting Warfighters: Campylobacter (leading bacterial cause of food borne disease in many developed countries), Shigella (bacteria that causes diarrhea, similar to salmonella), and enterotoxigenic E. coli (leading bacterial cause of diarrhea). Identified epidemiologic (study of the causes, distribution, and control of disease) importance of enteric (gastrointestinal) pathogens to develop strategies for preventing diarrhea in deployed Warfighters. Identified correlates of protection (indicator of effectiveness) in animal models; identified new techniques and tools for improved infection control and wound healing; and identified and evaluated novel methods for prevention of trauma-associated infection by highly antibiotic-resistant bacteria. ***FY 2016 Plans:***	1.527	1.517	1.532

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Continue to identify 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:*** 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.			
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 2015 Accomplishments:*** Identified and evaluated the role of human cells and antibodies in developing medical countermeasures to prevent and/or treat hantavirus and dengue virus infections; identified host and viral determinants (risk factors) of dengue disease severity; explored innovative vaccine designs, adjuvant (agent that enhances the immune response, usually used with a vaccine antigen) systems, and delivery methods for dengue virus vaccine; and continued world-wide epidemiological studies to determine the prevalence and incidence of dengue fever and dengue hemorrhagic fever. ***FY 2016 Plans:***	1.588	1.619	1.653

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Continue to assess 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 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.			
Title: Vector Identification and Control	1.456	1.518	1.550
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 2015 Accomplishments:*** Explored innovative technologies (traps, attractants, and devices) for vector surveillance in military operations; continued development of user friendly, web-based tools for identification of medically relevant arthropods and insects; identified novel pesticide (chemicals used for the control of insects and allied organisms) matrices/application strategies for vector control; and explored passive arthropod repellent systems/strategies (do not require pesticide applications). ***FY 2016 Plans:*** Leverage 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:***			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
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.			
Accomplishments/Planned Programs Subtotals	10.924	11.181	11.318

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
S14: *Sci BS/Cbt Cas Care Rs*	-	10.183	9.758	5.699	-	5.699	5.540	5.636	5.743	5.857	-	-

Note

In Fiscal Year (FY) 2015 and 2016 the funding for Clinical and Rehabilitative Medicine is 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. Funding for Clinical and Rehabilitative Medicine basic research moved to project ET6 starting in FY17.

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 2015	FY 2016	FY 2017
Title: Damage Control Resuscitation	2.606	2.268	1.644
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: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
FY 2015 Accomplishments: Conducted studies of cell and tissue protective drugs as potential new candidate alternatives to blood products and fluids when these are not available. ***FY 2016 Plans:*** As a follow on to the FY15 work, perform 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.			
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 2015 Accomplishments:*** Conducted studies to determine the optimal thicknesses of skin grafts for more rapid closure and improved functional outcomes of face wounds. ***FY 2016 Plans:*** Start development of models to identify 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.	0.772	0.824	1.889
Title: Combat Critical Care Engineering ***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.	0.775	0.774	0.857

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
FY 2015 Accomplishments: Continued research on decision support algorithms using non-traditional vital signs(for example, individual physical components of arterial pressure waveforms and light-based measurement of muscle oxygen content) to assess patient status and optimize fluid resuscitation; and conducted studies to identify new physiological (characteristic of or appropriate to an organism's healthy or normal functioning) information that distinguish individuals with high and low tolerances to blood loss. ***FY 2016 Plans:*** Validate 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.			
Title: Traumatic Brain Injury	1.447	1.294	1.309
Description: This effort conducts basic research in poly-trauma (multiple injuries)/Traumatic Brain Injury (TBI) model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI. ***FY 2015 Accomplishments:*** Continued studies applying Systems Biology (field of study that focuses on complex interactions within biological systems, using a holistic approach) to refine models of mild and severe TBI to aid in discovery of novel proteins in the blood that appear as a result of traumatic injury, which may aid in diagnosis of TBI; continued basic research to study the brain and nervous system during the sub-acute (weeks) and chronic (months) periods after head injury to identify predictors of long-term consequences of TBI; continued research to understand cell death and neuroprotection (protection of the brain) mechanisms and determined critical thresholds for secondary injuries (polytrauma) complicating TBI; and conducted studies to determine the time course of neuroplasticity (capacity of the nervous system for adaptation or regeneration after trauma) markers during the post-injury recovery periods. ***FY 2016 Plans:*** Utilize the application of systems biology methods to aid in discovery of novel proteins that appear in blood as result of TBI; study the multiple stages of TBI recovery to identify predictors of long-term consequences of TBI; and characterize cell death and			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
potential mechanisms (a process, technique, or system for achieving a result) to protect brain cells from subsequent inflammation and secondary injuries. ***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.			
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 2015 Accomplishments:*** Explored the cellular mechanisms and functional challenges of eye trauma injuries and advanced promising therapies for eye trauma wounds into the applied research phase; correlated the epidemiology of eye trauma with clinical outcomes. Explored innovative strategies to regenerate and reconstruct 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, craniomaxillofacial, genitalia, and abdominal regions. ***FY 2016 Plans:*** Analyze 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.	4.583	4.598	-
Accomplishments/Planned Programs Subtotals	10.183	9.758	5.699

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
S15: *Sci BS/Army Op Med Rsh*	-	6.721	6.599	6.688	-	6.688	6.801	6.924	7.060	7.201	-	-

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 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 2015	FY 2016	FY 2017
Title: Injury Prevention and Reduction	0.986	1.429	1.304
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 2015 Accomplishments: Explored inflammatory processes in muscle and surrounding tissues following physical injury and during cellular repair, using cell and animal models. Examined and documented the presence or absence of visible retinal alterations following blast exposure to			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
rodents and laser exposures to eyes in a non-human primate model by using retinal imaging (photographic procedure that details the optic nerve, retinal blood vessels and the light sensing tissues in the back of the eye). ***FY 2016 Plans:*** Identify 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 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.			
Title: Physiological Health ***Description:*** This effort conducts research on the physiological mechanisms of sleep, fatigue, and nutrition on Warfighter performance and well-being. ***FY 2015 Accomplishments:*** Investigated the metabolic mechanisms underlying injury recovery and explored the capability of macronutrients and micronutrients to promote metabolic recovery using cell and animal models; and determined the neurophysiological basis (how the nervous system functions on a molecular and tissue level) of recuperation during sleep and explored the use of pharmaceuticals and non-pharmacological approaches for improving the recuperation processes during sleep. ***FY 2016 Plans:*** Identify 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:***	2.481	2.084	3.466

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
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 2015 Accomplishments:*** Used animal models to identify sensitive biomarkers (indicator of a process, event, condition or change within the body) of organ damage and delineated the molecular pathways of heat injury. This data can be used to identify targets for therapeutic interventions to accelerate recovery from heat injury. ***FY 2016 Plans:*** Use 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.	0.789	0.809	0.821
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 2015 Accomplishments:*** Utilized an animal model to explore traumatic exposure, traumatic stress symptoms (i.e., anxiety, avoidance, hyper vigilance), and trauma recovery to preliminarily screen of pharmaceuticals that may impact mental health status. The results of these studies aided in creating a methodology for systematic testing of novel pharmaceuticals leading ultimately to clinical trials for the treatment	2.465	2.277	1.097

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
of PTSD. Identified the association of exposure to blast and/or blunt impact on the likelihood of a brain concussion in a rodent model. ***FY 2016 Plans:*** Identify 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:*** 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.			
Accomplishments/Planned Programs Subtotals	6.721	6.599	6.688

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	18.250	40.000	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 2015	FY 2016	FY 2017
Title: Reprogramming - Congressional Add for Single Investigator	8.000	-	-
Description: Congressional Add for Single Investigator ***FY 2015 Accomplishments:*** Reprogramming of funding from PE 0601103, Project D58 for Single Investigator for proper execution.			
Accomplishments/Planned Programs Subtotals	8.000	-	-

	FY 2015	FY 2016
Congressional Add: Program Increase ***FY 2015 Accomplishments:*** Program increase for Defense Research Sciences ***FY 2016 Plans:*** Program increase for Defense Research Sciences	8.000	40.000
Congressional Add: Science, Technology, Engineering, and Math (STEM) Pilot Program ***FY 2015 Accomplishments:*** Congressional increase for STEM pilot program focused on underserved populations.	2.250	-
Congressional Adds Subtotals	10.250	40.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army										Date: February 2016		
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
T22: *Soil & Rock Mech*	-	5.537	4.456	4.520	-	4.520	4.597	4.681	4.773	4.868	-	-

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 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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Military Engineering Basic Research	2.331	2.137	2.169
Description: Funding is provided for the following efforts.			
FY 2015 Accomplishments: Devised an improved understanding of interaction between gel chemistry and concrete to reduce explosive spalling under ultra-high temperatures; investigated multi-temporal radar physics to identify frequency dependencies of roughness scale and grain size of dielectrically similar soils and snow; directed tunable bacteriophage morphology to assemble high-ordered nanoscale structures.			
FY 2016 Plans: Determine the physical and chemical mechanisms that allow geopolymers to bond strongly to glass, ceramics, and metallic alloys with specific surface compositions; characterize the chemical structures that are involved in gels and thermal effects on gels; and provide fundamental theory for moisture effects on wave propagation in heterogeneous unsaturated soils.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
Title: Materials Modeling for Force Protection ***Description:*** The long-term goal of this task is to develop a structural ceramic composite that could replace steel and aluminum for most applications at one third the weight. To accomplish this goal, a technical ceramic such as silicon carbide will have to be improved five-fold in tensile strength and fracture toughness. ***FY 2015 Accomplishments:*** Identified and introduced energy dissipation mechanisms in novel multi-layered, heterogeneous structural systems to achieve significant weight reduction; and investigated fundamental nanoscale parameters of biological protective materials on the macroscale damage variables of a multi-layered protective material, where the macroscale variables were incorporated into simulations of multi-layered nano-composite materials. ***FY 2016 Plans:*** Investigate how the material interface prevents delamination for composites during impact and penetration loading; investigate the fundamental mechanisms of concrete composition that inhibit damage initiation and spread; determine calcium carbonate bonding strength in homogeneous mortar; and provide 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.	3.206	2.319	2.351
Accomplishments/Planned Programs Subtotals	5.537	4.456	4.520

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T22 / *Soil & Rock Mech*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T23: *Basic Res Mil Const*	-	2.045	1.722	1.747	-	1.747	1.777	1.809	1.844	1.881	-	-

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 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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Facilities Research	2.045	1.722	1.747
Description: Funding is provided for the following efforts.			
FY 2015 Accomplishments: Determined fundamental processes in microbial interactions with surfaces that lead to bio-fouling and corrosion; re-created plant photosynthesis processes in an artificial cell matrix.			
FY 2016 Plans: Identify microbial and chemical distribution in a biofilm correlated to points of corrosion; assess transport kinetics of self-assembling vesicles for photocatalytic hydrogen evolution in aqueous solutions; and interpret the vortical structure thermal field with shape memory alloy materials used for inducing vortices to enhance solid-fluid and thermal interactions.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
Accomplishments/Planned Programs Subtotals	2.045	1.722	1.747

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T24: *Signature Physics And Terrain State Basic Research*	-	1.981	1.627	1.649	-	1.649	1.675	1.706	1.740	1.775	-	-

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 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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Analysis for Signal and Signature Phenomenology (Previously titled - Terrain State and Signature Physics)	1.981	1.627	1.649
Description: Funding is provided for the following effort. ***FY 2015 Accomplishments:*** Investigated radio frequency propagation signal loss in mountainous terrain shadow zones to determine causes of attenuation variance to model predictions and determine the utility of a low frequency simulation with reduced computational demand to emulate actual high frequency behavior; enabled realistic modeling of high bandwidth impulsive waveforms to improve space/time localization of high resolution acoustic and electromagnetic receivers by extending wave propagation theory in random media to include decorrelations of signals over separations in space and time resulting from dynamic variability of the atmosphere. ***FY 2016 Plans:*** Determine controls on the broadband complex relative permitivities (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			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
scientific basis for subsurface geophysical technique for detection; establish 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 investigate 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 through adjusting to changes in environmental conditions. ***FY 2017 Plans:*** 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.			
Accomplishments/Planned Programs Subtotals	1.981	1.627	1.649

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T25: *Environmental Science Basic Research*	-	7.061	6.980	7.081	-	7.081	7.202	7.336	7.480	7.630	-	-

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 in water, soil, and sediments resulting from military activities; 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 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 and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2015	FY 2016	FY 2017
Title: Environmental and Ecological Fate of Explosives, Energetics, and Other Contaminants	2.797	3.719	3.781
Description: Funding is provided for the following efforts. ***FY 2015 Accomplishments:*** Determined the fundamental biological mechanisms that predict interactions of new insensitive munitions with environmental constituents; increased understanding of chemical-environmental interactions and ecosystem functions for advanced sensing; and provided underlying mechanisms of biological networks to utilize in man-made systems. ***FY 2016 Plans:*** Experimentally determine the fundamental environmental cues required to develop a workable multi-modular agent-based model decision network; determine the rate controlling physiological mechanisms in order to formulate a systems biology model which			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
will improve ability to rapidly assess and predict the effects of individual chemicals and mixtures of chemicals; and describe 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 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.			
Title: Fundamental Understanding of Explosives, Energetics and UXO in the Environment ***Description:*** Previously titled:Remediation of Explosives, Energetics, and UXO ***FY 2015 Accomplishments:*** Determined the potential for use of aquatic biological systems as a basis for trace chemical sensors in water; determined how understanding of chemical impact on biological systems can be translated across different species through similarities in molecular systems; and identified the mode of toxic interactions of multiple chemical mixtures in IMX. ***FY 2016 Plans:*** Assess the basics of physiological response to and toxicity of the IMX-101 mixture constituents and provide 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.	2.296	1.039	1.054
Title: Training Land Natural Resources ***Description:*** Funding is provided for the following efforts. ***FY 2015 Accomplishments:*** Investigated how invasive species impact the affected ecosystem at the molecular level; and determined the potential of novel mechanisms to assess ecosystem components utilizing specialized monitoring of unique sounds. ***FY 2016 Plans:***	1.097	1.306	1.327

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Investigate 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.			
Title: Network Science ***Description:*** Funding is provided for the following efforts. ***FY 2015 Accomplishments:*** Investigated how molecular design impacts biological function and how this can be translated to man-made systems like robotics; and investigated biological cell assembly mechanisms for man-made systems and programming. ***FY 2016 Plans:*** Evaluate 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.	0.871	0.916	0.919
Accomplishments/Planned Programs Subtotals	7.061	6.980	7.081

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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	6.730	7.233	8.764	-	8.764	8.988	9.680	11.242	11.407	-	-

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 and the Army Modernization Strategy.

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

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
Title: Robotics Autonomy and Human Robotic Interface Research	1.996	1.983	2.012
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 2015 Accomplishments:*** Conducted experimental studies related to fundamental flow behavior of very small scale air vehicles; explored algorithms for semantic labeling and relationship determination between objects in the environment to permit robots to interact with soldiers using more intuitive and natural means and to enable the robot to infer the purpose of objects and human activity; and examined novel locomotion concepts to enable greater efficiency and application in complex and confined environments. ***FY 2016 Plans:*** Explore the use of neuromorphic (software systems that implement models of neural systems) control employing analog elements to enable robust low-level control of microsystems; examine hybrid mobility concepts to enable robust maneuver in three dimensional environments, including biomimetic utilization of appendages, to achieve both functionality and efficiency; and explore 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.			
Title: Intelligent Systems	4.734	5.250	5.152
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 2015 Accomplishments:*** Explored and characterized architectures and algorithms for intelligent explanation, facilitating human interpretation of machine outputs; investigated techniques for limited supervised learning to enhance machine recognition of threats and objectives and			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
assessed their impact on baseline planning algorithms; and addressed socially-inspired concepts for collective intelligence in the context of dynamic situation assessment, re-organization and collaboration. ***FY 2016 Plans:*** Research 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, commanders intent, friendly and enemy forces disposition, and non-combatant participants) environment; explore the use of semantic understanding and learning to enhance robotic behavior and perceptual capabilities; and explore the use of 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).			
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.	-	-	1.600
Accomplishments/Planned Programs Subtotals	6.730	7.233	8.764

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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: PB 2017 Army			Date: February 2016
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
T64: *Sci BS/System Biology And Network Science*	-	2.306	2.930	2.974	-	2.974	3.025	3.080	3.141	3.204	-	-

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 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 2015	FY 2016	FY 2017
Title: Network Sciences Initiative	2.306	2.930	2.974
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 2015 Accomplishments: Used algorithms to investigate the discrimination between biomarkers of mild, moderate, and severe TBI; tested and extended computational biology algorithms to identify drug targets and therapies for conditions such as infectious diseases; developed mathematical models of upper respiratory airflow patterns for the non-invasive diagnosis of pulmonary (lung) diseases; computationally predicted potential drug targets that could induce re-sensitization to current antibiotics in biofilm (a group of microorganisms that stick to each other, on a surface) forming bacteria (tend to be more antibiotic-resistant than individual bacteria); and mathematically modeled standard vital-sign data to enable the non-invasive prediction of heat stress injury and allow for timely counteractive measures.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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 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.			
Accomplishments/Planned Programs Subtotals	2.306	2.930	2.974

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: PB 2017 Army										Date: February 2016		
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 2015**	**FY 2016**	**FY 2017 Base**	**FY 2017 OCO**	**FY 2017 Total**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**Cost To Complete**	**Total Cost**
VR9: *Surface Science Research*	-	2.403	2.222	2.256	-	2.256	2.294	2.337	2.384	2.432	-	-

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 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 2015**	**FY 2016**	**FY 2017**
Title: Surface Science Research	2.403	2.222	2.256
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 2015 Accomplishments: Investigated chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces, to include the effects of binding energy, reactions, transport and deposition; 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 (the study of form and structure), and surface group properties.			
FY 2016 Plans: Conduct 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:			

Exhibit R-2A, RDT&E Project Justification: PB 2017 Army		Date: February 2016
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 2015	FY 2016	FY 2017
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.			
Accomplishments/Planned Programs Subtotals	2.403	2.222	2.256

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

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