Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	286.086	263.590	276.912	-	276.912	290.545	294.807	303.913	309.996	0.000	2,025.849
305: *ATR Research*	-	2.026	2.102	2.142	-	2.142	2.186	2.231	2.276	2.322	0.000	15.285
31B: *Infrared Optics Rsch*	-	4.146	3.742	3.748	-	3.748	3.752	3.753	3.812	3.889	0.000	26.842
52C: *Mapping & Remote Sens*	-	2.028	2.101	2.141	-	2.141	2.185	2.228	2.273	2.318	0.000	15.274
53A: *Battlefield Env & Sig*	-	3.769	3.892	3.971	-	3.971	4.055	4.135	4.218	4.303	0.000	28.343
74A: *Human Engineering*	-	13.022	14.057	15.532	-	15.532	15.852	16.136	16.445	16.774	0.000	107.818
74F: *Pers Perf & Training*	-	5.345	5.485	5.586	-	5.586	5.699	5.812	5.930	6.049	0.000	39.906
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	4.039	4.780	4.866	-	4.866	1.260	1.034	1.048	1.069	0.000	18.096
F20: *Adv Propulsion Rsch*	-	4.164	3.460	3.545	-	3.545	3.637	3.726	3.818	3.894	0.000	26.244
F22: *Rsch In Veh Mobility*	-	0.691	0.735	0.749	-	0.749	0.765	0.778	0.795	0.811	0.000	5.324
H42: *Materials & Mechanics*	-	8.502	9.748	12.211	-	12.211	12.262	12.556	12.868	13.125	0.000	81.272
H43: *Research In Ballistics*	-	8.352	11.319	11.723	-	11.723	12.032	12.304	12.659	12.912	0.000	81.301
H44: *Adv Sensors Research*	-	9.222	8.899	9.915	-	9.915	10.590	10.861	11.099	11.321	0.000	71.907
H45: *Air Mobility*	-	2.273	2.410	2.458	-	2.458	2.506	2.556	2.608	2.660	0.000	17.471
H47: *Applied Physics Rsch*	-	4.197	5.689	5.848	-	5.848	5.434	5.559	5.676	5.790	0.000	38.193
H48: *Battlespace Info & Comm Rsc*	-	27.497	31.394	32.292	-	32.292	36.816	37.397	38.249	39.014	0.000	242.659
H52: *Equip For The Soldier*	-	1.131	1.156	1.178	-	1.178	1.204	1.228	1.252	1.277	0.000	8.426
H57: *Single Investigator Basic Research*	-	91.394	96.081	101.427	-	101.427	104.903	106.378	110.626	112.839	0.000	723.648
H66: *Adv Structures Rsch*	-	2.053	3.108	3.153	-	3.153	3.197	3.240	3.285	3.350	0.000	21.386
H67: *Environmental Research*	-	0.893	1.036	1.065	-	1.065	1.085	1.107	1.130	1.155	0.000	7.471
S13: *Sci BS/Med Rsh Inf Dis*	-	11.118	11.039	11.272	-	11.272	11.509	11.501	12.253	12.498	0.000	81.190
S14: *Sci BS/Cbt Cas Care Rs*	-	5.520	5.296	5.610	-	5.610	7.945	8.578	9.082	9.264	0.000	51.295

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army													Date: February 2018
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*	-	6.600	7.116	6.443	-	6.443	9.654	9.093	8.710	8.884	0.000	56.500
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	40.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	40.000
T22: *Soil & Rock Mech*	-	4.405	4.606	4.695	-	4.695	4.788	4.883	4.982	5.082	0.000	33.441
T23: *Basic Res Mil Const*	-	1.708	1.781	1.815	-	1.815	1.850	1.887	1.929	1.968	0.000	12.938
T24: *Signature Physics And Terrain State Basic Research*	-	1.641	1.685	1.720	-	1.720	1.755	1.792	1.828	1.865	0.000	12.286
T25: *Environmental Science Basic Research*	-	6.853	6.708	6.845	-	6.845	6.990	7.139	7.797	7.953	0.000	50.285
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	8.468	8.847	9.546	-	9.546	11.112	11.281	11.516	11.746	0.000	72.516
T64: *Sci BS/System Biology And Network Science*	-	2.860	3.025	3.079	-	3.079	3.139	3.203	3.268	3.333	0.000	21.907
VR9: *Surface Science Research*	-	2.169	2.293	2.337	-	2.337	2.383	2.431	2.481	2.531	0.000	16.625

Note

There is a realignment of funding from Project H7G under PE 0602105 (which is in Budget Authorization 2) to Project H42.

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.

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army	Date: February 2018
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	253.116	263.590	277.166	-	277.166
Current President's Budget	286.086	263.590	276.912	-	276.912
Total Adjustments	32.970	0.000	-0.254	-	-0.254
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	40.000	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-6.945	-			
• Adjustments to Budget Years	-	-	-0.254	-	-0.254
• FFRDC	-0.085	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Congressional Program Increase*	40.000	-
Congressional Add Subtotals for Project: T14	40.000	-
Congressional Add Totals for all Projects	40.000	-

Change Summary Explanation

Funding increase to support increased investments in robotics, sensors, materials, battlespace information and communication sciences, human-machine teaming, and the extramural single investigator program.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
305: *ATR Research*	-	2.026	2.102	2.142	-	2.142	2.186	2.231	2.276	2.322	0.000	15.285

A. Mission Description and Budget Item Justification

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: ATR Algorithms	2.026	2.102	2.142
Description: Investigate new algorithms to improve aided/unaided target detection and identification.			
FY 2018 Plans: Investigate approaches for image and video analytics and scene understanding at the tactical edge using resource constrained computation platforms for Soldiers and unmanned vehicle/robotic systems; investigate joint text and video approaches for semantic summarization of unconstrained videos; create methods for augmented 3-D scene segmentation and unsupervised			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
labeling of objects viewed at different perspectives in geo-located areas of interest; and create algorithms for producing and fusing photogrammetry-based point clouds and hyperspectral data collected from multiple flying platforms. ***FY 2019 Plans:*** Will investigate approaches for image and video analytics and scene understanding at the tactical edge using resource constrained computation platforms for Soldiers and unmanned vehicle/robotic systems; will investigate joint text and video approaches for semantic summarization of unconstrained videos; will create algorithms for producing and fusing photogrammetry-based point clouds and multimodal image data collected from multiple flying platforms; will investigate light-field based image processing for enhancing situational awareness in degraded visibility environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	2.026	2.102	2.142

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
31B: *Infrared Optics Rsch*	-	4.146	3.742	3.748	-	3.748	3.752	3.753	3.812	3.889	0.000	26.842

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Optoelectronic and Integrated Photonic Materials and Device Research	4.146	1.005	1.000
Description: Conduct research into materials and structures used for infrared (IR) devices, ultraviolet (UV) emitters and detectors, and integrated photonic devices to increase situational awareness in open and complex terrains; improve target detection, identification, and discrimination; and create new device functionality while reducing size, weight, and power requirements.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Perform fundamental studies of carrier transport and vertical light emission in near-UV heterostructures in III-Nitrides to address the challenges associated with device efficiency; demonstrate reduction in surface and side-wall charge accumulation in IR devices through novel passivation using atomic layer deposition; design and develop semiconductor-based integrated photonic devices using new metamaterial or device architectures to obtain new and multiple functionalities such as processing microwave signals in the optical domain. ***FY 2019 Plans:*** Will explore the deposition of cadmium telluride (CdTe) passivation layers by low temperature atomic layer deposition (ALD) to reduce leakage currents in mercury cadmium telluride (MCT) based infrared detectors; will investigate carrier transport studies on semi-polar and non-polar III-Nitride semiconductor heterostructures to improve radiative and injection efficiencies in ultraviolet light emitting structures; and will perform fundamental studies on chip-scale integrated photonic structures with the goal of identifying critical features, such as interaction length for appropriate Stimulated Brillouin Scattering (SBS), then will examine a parametric trade space of photonic structures and materials capable of providing needed response to achieve narrowband filtering over a large RF photonic bandwidth. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Advanced Materials research.			
Title: Advanced Materials	-	2.737	2.748
Description: Investigation of the fundamental physics of energy, charge, and spin materials with an emphasis on understanding the transport along and across novel designed surfaces and active heterogeneous interfaces to achieve new electronic/ optoelectronic device functionalities. Additionally, study beta-photovoltaic and beta-voltaic energy capture. ***FY 2018 Plans:*** Explore surface properties of Indium Arsenide Antimonide (InAsSb) to study the topological state phenomenon on the surfaces of this material; study the external field dependence of topological insulator phase transition of Indium Nitride (InN) structures as a function of gate bias and study the bulk bandgap tunability and its effect on bulk conductivity; study the role of hot electron effects which affect the current and catalytic over-potential in a photoelectrode necessary for water splitting; study the relevant electrical properties of Gallium Nitride Antimonide (GaNSb) for water splitting power generation applications; study diamond surface conduction channels to enable ultra-high frequency and high power-density RF devices; explore complex crystal properties in hybrid one-dimensional (1D) molecular chains and two-dimensional (2D) van der Waals-stacked layered solids to serve as building blocks for high performance and low power electronics; and investigate beta-photovoltaic and beta-voltaic hybrid energy conversion efficiencies. ***FY 2019 Plans:*** Will measure the transport properties, triple-point topological state characteristics, and bulk bandgap tunability and conductivity of indium-containing quantum well structures; will investigate Indium Gallium Nitride (InGaN) electrodes integrated with catalysts to			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
understand and quantify photovoltage boost under photo-electrochemical conditions and study doping characteristics of GaNSb for energy production applications utilizing water splitting; will study transport properties and defect chemistries of intrinsic vacancy materials developed using atomic layer deposition; and will investigate diamond-based semiconductor devices to exceed Gallium Nitride (GaN) performance in frequency and power handling of RF energy. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation			
Accomplishments/Planned Programs Subtotals	4.146	3.742	3.748

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
52C: *Mapping & Remote Sens*	-	2.028	2.101	2.141	-	2.141	2.185	2.228	2.273	2.318	0.000	15.274

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Sensor Phenomenology and Spatial-Temporal Pattern Discovery	2.028	2.101	2.141
Description: Conduct fundamental research to inform the development of applications, techniques, and tools to improve the tactical commander's knowledge of the operating environment.			
FY 2018 Plans: Characterize seismic sources caused by human activity; link biogeochemical measurements and remote sensing signals from permafrost bog systems that are in transition and from stable bogs; and explore the radiometric complexities between illumination and look angles of natural soils.			
FY 2019 Plans: Will statistically analyze collected laboratory data to examine for spectral and angular differences between undisturbed and disturbed soil samples and determine if relationships found in laboratory data apply to collected field data, and will quantitatively discriminate emitted dust particle size distributions by emission mechanism to better quantify and inform dust transport models and impacts on military operations.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	2.028	2.101	2.141

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
53A: *Battlefield Env & Sig*	-	3.769	3.892	3.971	-	3.971	4.055	4.135	4.218	4.303	0.000	28.343

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Predictive Modeling of the Boundary Layer	3.769	3.892	3.971
Description: Increase survivability and improve situational awareness for a variety of sensors, optics, and flying objects (e.g., projectiles, unmanned aircraft systems, etc.) through fundamental research to enhance accuracy of predictive modeling of the atmospheric boundary layer and improve the ability to function effectively in adverse conditions. ***FY 2018 Plans:*** Identify new methods of enhancing electro-optical communication signal transmission through atmospheric ?channels? that are created by ultra-short laser pulses; create an approach to conduct multi-modal wind sensing by merging Doppler wind Light Detection and Ranging (LiDAR) and radar data together to create highly accurate and detailed, remotely-sensed wind observations; investigate a new capability to optically trap atmospheric aerosol particles, allowing very precise measurement			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
and characterization of their composition; research numerical techniques for estimating atmospheric effects on the propagation of acoustic signals; investigate and incorporate a comprehensive atmospheric radiation algorithm into a microscale numerical weather prediction model, enhancing the accuracy of the forecasts by accounting for both dense urban and forest canopy domains; expand datasets and investigate correlations between meteorological conditions/observations and significant threat activities; and explore microscale model initialization and physics refinements based on boundary layer urban and complex terrain discoveries from the Meteorological Sensor Array and other high-resolution atmospheric sensing experiments. ***FY 2019 Plans:*** Will gather and apply Meteorological Sensor Array (MSA) data to: study near-surface processes that impact the flux of sediment, causing wind erosion and dust emission, will investigate fixed-wing and multi-rotor instrumented unmanned aircraft system (UAS) sampling strategies. Will study and enhance the understanding of atmospheric effects on high data rate optical communications between systems. Will expand radiative transfer modeling into environments with forest canopy; will begin coupling radiative transfer model and land surface energy budget in urban domains; will develop initial concepts in constraining machine learning for environmental prediction using physical modeling; will explore new environmental remote sensing techniques of atmospheric parameters, exploiting advances in Stimulated Raman Gain capabilities; will identify new methodologies to accelerate the characterization and analysis of ambient atmospheric aerosol composition. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	3.769	3.892	3.971

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
74A: *Human Engineering*	-	13.022	14.057	15.532	-	15.532	15.852	16.136	16.445	16.774	0.000	107.818

A. Mission Description and Budget Item Justification

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

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Title: Translational Neuroscience ***Description:*** Integrating neuroscience with traditional approaches to understanding Soldier behavior to enable systems designs that maximize Soldier performance. ***FY 2018 Plans:*** Identify novel functional models of visual search using combined measures of gaze position and neural activity in real-word tasks to quantify the effect of cognitive state on task performance; investigate data-driven classification methods to predict emergent behavior in complex tasks with time-evolving brain states; and utilize innovations in community detection analyses to link allegiance and flexibility of functional brain networks to variability in task performance. ***FY 2019 Plans:*** Will identify predictive models of visual search with Army-relevant stimulus luminance properties based on cognitive modeling of brain states and naturalistic eye movements; will investigate the impact of naturalistic sleep fluctuations on functional brain networks and task performance in a variety of cognitive tasks; and will understand the controllability of neural nodes and networks with electrical neurostimulation and functional brain activity to estimate impact on task performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation and to expand research to examine the controllability of neural nodes and networks.	3.553	3.715	3.813
Title: Human System Integration ? Cybernetics ***Description:*** Apply a cybernetic approach (i.e., a theoretical study and comparison of communication and control processes in biological and artificial systems) to human systems integration to achieve tighter control of devices and communications among humans and between machines and humans. Use social, computational, and information approaches to extend the scope of interaction beyond individual systems to the full network context. ***FY 2018 Plans:*** Understand the complexity of conceptual and theoretical closed-loop models of complex, functional, and adaptive behaviors focused on large-scale computational and neuronal models, including exploration of high-performance computing implementations; identify statistical models to improve human performance characterization and prediction, leveraging temporal dependencies inherent to closed-loop systems in human perception and human-system interactions; explore closed-loop (e.g., neuro- and bio-feedback, augmented reality) human-computer interactions for adaptive interfaces that account for individual differences in brain and behavioral dynamics; and apply machine learning and big data approaches to capture higher dimensional features in complex data for implementation in novel cybernetic approaches to human-system communications and interactions. ***FY 2019 Plans:***	5.031	5.205	5.207

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will leverage novel models of complex, functional, and adaptive behaviors to improve understanding of the underlying neural mechanisms involved in human information processing, including perception and sensorimotor control; will examine the role of temporal information integration in the adaptive changes underlying human perception, including how individuals adapt to changes in the relationships among multiple sensory inputs; will investigate how closed-loop (e.g., neuro- and bio-feedback, augmented reality) human-computer interactions can mediate cognitive task performance under varying conditions affecting neural, physiological, and/or cognitive state; and will apply statistical modeling approaches, including machine learning and big data approaches, to account for state-based changes in human behavior and physiology within novel cybernetic approaches to enhance human-system communications and interactions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding increased due to inflation			
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 2018 Plans:*** Identify algorithms to predict changes in task performance in controlled environments on the basis of behavioral, physiological, environmental, and task-based factors; develop algorithms for interpreting state variability in pseudo-controlled environments; collect novel longitudinal, low-resolution, multi-faceted dataset from a large cohort (N > 50) of individuals for several months to characterize state variability in real-world environments ***FY 2019 Plans:*** Will understand prediction of individual task performance over time through analysis of longitudinal, multi-faceted, real-world dataset; will examine behavioral, physiological, environmental, and task-based factors influencing social dynamics; will identify methods to enable modeling of state variability over time using multi-level, systems-based approaches. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to understand prediction of human performance.	3.228	3.873	4.227
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance and behavior. Understand the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to affect performance similar to that in an operational environment. Characterize the appropriate use of different classes of simulated environments to ensure valid results. Develop guidelines for using mobility platforms in simulators to induce physical and cognitive stress representative of the operational environment, implementation of these guidelines will enhance training effectiveness.	1.210	1.264	1.285

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2018 Plans: Explore the impact of state and trait measures in empirically-driven conceptual models that describe and predict the relationships between training environment design elements, individual user differences, and training outcomes. ***FY 2019 Plans:*** Will identify models of the impact of presence and other state/trait measures on relationships between immersion, gamification, other training environment design elements, individual user differences, and training outcomes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Novel Forms of Joint Human-Intelligent Agent Decision Making ***Description:*** This effort will develop novel methods for joint human / intelligent agent learning and decision making so that strengths of individual humans and intelligent agents are accentuated and weaknesses are mitigated for improved, emergent group performance, emphasizing deep learning approaches that function under conditions of limited, mismatched, or dynamic data. ***FY 2019 Plans:*** Will develop a novel human-in-the-loop method of training artificial intelligence that outperforms standard AI training methods after similar amounts of trained time and data. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New start effort to enable pursuit of knowledge for joint human / intelligent agent learning and decision making.	-	-	1.000
Accomplishments/Planned Programs Subtotals	13.022	14.057	15.532

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
74F: *Pers Perf & Training*	-	5.345	5.485	5.586	-	5.586	5.699	5.812	5.930	6.049	0.000	39.906

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.There is also a realignment of funding from Project H7G under PE 0602105 (which is in Budget Authorization 2) to Project H42.

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Personnel Measures (previously Human Behavior)	1.805	1.915	1.914
Description: Basic research to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development. ***FY 2018 Plans:*** Conduct research to advance theoretical knowledge of leadership development during deployment and in garrison. ***FY 2019 Plans:*** Will conduct research to identify job-performance measures that can inform assignment and to examine the validity of using non-traditional data for personnel assessment. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of improved knowledge to support Soldier Lethality for enhanced resilience. Funding decrease will result in a focusing of measures from theoretical understanding to specific job-performance measures.			
Title: Climate, Readiness, and Resilience (previously Human in Complex Organizations)	3.540	3.570	3.672

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: 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 2018 Plans:*** Conduct research to advance theoretical understanding of how best to apply the learning of complex tactical/technical and interpersonal skills (in both formal & informal learning environments) to on-the-job performance to maximize unit readiness. ***FY 2019 Plans:*** Will conduct research to advance theoretical understanding of learning methods and principles to maximize development and transfer of complex cognitive skills; will conduct research to identify methods and computational models to better understand organizational processes and dynamics (e.g., team resilience, trust development, and adaptive flexibility). ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to Soldier Lethality for Soldier readiness and resilience.			
Accomplishments/Planned Programs Subtotals	5.345	5.485	5.586

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	4.039	4.780	4.866	-	4.866	1.260	1.034	1.048	1.069	0.000	18.096

A. Mission Description and Budget Item Justification

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Clinical and Rehabilitative Medicine	4.039	4.780	4.866
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), genitalia (organs of reproduction), and abdomen.			
FY 2018 Plans: Investigate stem-cell released factors to identify promising and innovative therapies to regenerate damaged eye tissue. Characterize cellular mechanisms leading to vision dysfunction. Define and characterize cellular mechanisms that encourage growth of microvasculature (part of the circulatory system made up of the smallest vessels) for multiple tissue types such as hand transplants. Develop innovative biologics (pharmaceutical drug made from biological sources) to encourage improved regeneration of craniofacial tissues. Define biological markers for prognosis (predicting the likely outcome) of wound healing and scarring. Analyze immunomodulatory (modification of the immune response/immune system functioning) technologies that reduce the need for long term immune suppression following transplantation.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will investigate the ability of a magnetic field to pull specialized therapeutic cells with metallic beads into the correct location to optimize the healing of key cellular layers necessary to restore vision. Will further investigate and characterize the pattern of molecules that impact immune response in the eye after injury to understand the timing of clinical impacts. Will further characterize cellular mechanisms leading to vision dysfunction. Will advance studies of cellular mechanisms that encourage growth of microvasculature (part of the circulatory system made up of the smallest vessels) for multiple tissue types muscle or bone. Will continue exploring innovative biologics (potential pharmaceuticals made from biological sources) to encourage improved regeneration of craniofacial tissues. Will define biological markers for prognosis (predicting the likely outcome) of wound healing and scarring. Will continue analysis of immunomodulatory (modification of the immune response/immune system functioning) technologies that reduce the need for long term immune suppression following transplantation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.			
Accomplishments/Planned Programs Subtotals	4.039	4.780	4.866

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
F20: *Adv Propulsion Rsch*	-	4.164	3.460	3.545	-	3.545	3.637	3.726	3.818	3.894	0.000	26.244

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Thermal Materials ***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.	4.164	-	-
Title: Vehicle Propulsion & Power Research ***Description:*** Basic research investigating engine and drivetrain technologies for Army manned-and-unmanned vehicles. Research investigates concepts and theories to provide enhanced tools, methods, and innovative concepts to enable improvements in propulsion power density, energy efficiency, reliability, and lifecycle cost for increased performance and capabilities in future Army systems. ***FY 2018 Plans:*** Investigate engine and drivetrain technologies to enable improved performance and reduced maintenance costs for Army vehicles including: 1) fuel ignition behavior at Army-relevant altitude and low-temperature conditions for fundamental understanding of multi-regime, multi-mode high-pressure turbulent combustion; 2) tailored gradient ceramic coating concepts for high-temperature, low thermal conductivity, sand resistance, and low particulate adherence for Army turboshaft engine hot section component performance and debris tolerance; and 3) advanced lubricant additives and corresponding chemistry interactions to protect highly-	-	3.460	3.545

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
loaded mechanical interfaces, such as gear and bearing surfaces, to meet Army needs for extended operation during loss-of-lubrication events. ***FY 2019 Plans:*** Will investigate propulsion engine and drivetrain technologies that will enable multi-fuel tolerant combustion in extreme environments, with improved debris tolerance, and thermal management/energy recovery of highly-loaded mechanical interfaces. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding increased to account for inflation and expand research into multi-fuel combustion.			
Accomplishments/Planned Programs Subtotals	4.164	3.460	3.545

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
F22: *Rsch In Veh Mobility*	-	0.691	0.735	0.749	-	0.749	0.765	0.778	0.795	0.811	0.000	5.324

A. Mission Description and Budget Item Justification

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency	0.691	0.735	0.749
Description: Research in support of advanced military mobility technologies with emphasis on Terramechanics (vehicle-terrain interaction), and complex vehicle dynamics and simulation. Research is directed at understanding advanced mathematical and computational methodologies using state-of-the-art analytical and empirical procedures. ***FY 2018 Plans:*** Further the development of the framework for the next-generation NATO Reference Mobility Model methodology with the end objective of establishing it as a NATO Standardization Agreement (STANAG document) for use by all NATO nations in development of tools that predict more accurate, operational evaluations for mobility and traversability. The research activity focuses on 6 key thrust areas: Geographic Information System (GIS) Terrain and Mobility Map, Simple Terramechanics, Mobility Standards, Complex Terramechanics, Intelligent Vehicle, Uncertainty treatment, and Verification and Validation. ***FY 2019 Plans:*** Will identify multi-scale computational algorithms that can model a large ground vehicle traversing over fine soil particles to their true size and geometry in one integrated mobility simulation robustly and hyper efficiently; will investigate Deep Learning to supplement high fidelity simulations in generating a Go/No-Go Mobility Map for a large geographic region; will develop human cognitive models to represent behavioral dynamics to work side-by-side with control algorithms in a semi-autonomous robotic system engaged in extreme mobility scenarios, thereby replacing the need for ?real human?-in-the-loop assessments; will assess how ?shared control? and ?control authority? will work, and how to benchmark full algorithmic control against human operators. The mobility performance is affected by the computational challenges faced by the autonomous algorithm; will address the			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
computationally intensive autonomy algorithms and extreme mobility scenarios that demand exceptional performance from the on-board computer such as accurate solutions in real time. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	0.691	0.735	0.749

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
H42: *Materials & Mechanics*	-	8.502	9.748	12.211	-	12.211	12.262	12.556	12.868	13.125	0.000	81.272

Note

There is a realignment of funding from Project H7G under PE 0602105 (which is in Budget Authorization 2) to Project H42.

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).

Funding for this Project is increased due to the need to facilitate discovery and exploitation of biologically-enabled manufacturing of complex nanomaterials with substantial potential to improve material behaviors that could support Army capabilities. The increase results from a realignment of funds from Project H7G under PE 0602105 (which is in Budget Authorization 2).

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Microscopic/Nanostructural Materials	2.314	3.072	3.143
Description: Devise new materials and design capabilities based upon fundamental concepts derived at the microscopic and nanostructural levels for the future force.			
FY 2018 Plans: Complete the development of an advanced computational model that will predict optimal processing parameters and chemistries for alloys and ceramics with improved strength and fracture toughness; and fully characterize a series of model fibers to determine the structure-property relationship as a function of processing.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will synthesize nanostructured alloy systems to validate model predictions of grain size and grain boundary effects on mechanical response; and will investigate if nanostructured metal coatings can provide a 10-fold increase in corrosion protection with other tailorable properties using electrochemical processing from ionic liquids. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation and to expand research into synthesis of nanostructured alloy systems.			
Title: High Deformation Rate Materials ***Description:*** Develop the fundamental understanding necessary to design, process, and characterize materials specifically intended for high loading-rate applications, as in armor and armaments. ***FY 2018 Plans:*** Develop and validate a fully coupled model that predicts the evolution of a failure event based on the dependence of initial microstructure and viscoelastic behavior of an alloy undergoing high-rate and extreme loading. ***FY 2019 Plans:*** Will investigate martensitic transformations in novel strain glass alloys for unique deformation mechanisms and identify a strategy for formulation of novel compositions; will demonstrate novel modeling strategies that link molecular dynamics simulations to continuum models of microfibril structure within single fibers of ultrahigh molecular weight polyethylene (UHMWPE). ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	3.068	3.211	3.260
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 2018 Plans:*** Produce bulk material from optimized metal powders using hot-isostatic-press and fully characterize its microstructure and mechanical properties. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Effort ended due to technology maturation.	1.061	1.110	-
Title: Materiel Research and Processing Using High Energy Fields	2.059	2.355	2.437

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
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 2018 Plans:*** Characterize new ceramic armor material produced using experimental parameters identified by preliminary models and iteratively refine models based on validation results. ***FY 2019 Plans:*** Will validate models using novel experiments to demonstrate enhanced fracture resistance in two-phase ceramic materials under electromagnetic fields; will develop new models to simulate the manipulation of intermolecular interactions with electromagnetic fields. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel materials to underpin future operational capabilities including Next Generation Combat Vehicles, Future Vertical Lift, and Soldier Lethality.			
Title: 1D and 2D Materials and Processing Research ***Description:*** Discover novel building block materials that provide disruptive protection mechanisms. Research includes synthesis, processing, characterization, and modeling to discover new 1-dimensional (1D) and 2-dimensional (2D) building block materials and associated assembly into protective membranes, smart fibers and films, and other molecular composite architectures. ***FY 2019 Plans:*** Will identify synthesis methods for novel 2D polymer molecules assembled with intermolecular hydrogen bonding to create graphene-like materials with enhanced toughness relative to graphene. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New start effort to enable pursuit of knowledge to support novel materials for future operational capabilities.	-	-	1.645
Title: Precision Materials Synthesis and Assembly ***Description:*** Explore new biology-based methods for controlled synthesis and assembly to create materials with precise chemistries, microstructures, properties, and responsive functionalities through controlled molecular placement, spatial architectures, and interfacial structures. This research utilizes biological platforms that can act as micro-environments to control thermodynamics and govern reactions, thereby providing completely new pathways for materials discovery. ***FY 2019 Plans:***	-	-	1.726

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will explore scalable cell-free synthesis of enzymes and subsequent site-specific synthesis of rudimentary polymers that will serve as a foundation for dictating morphology in defense-relevant polymer fibers and membranes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New start effort to enable pursuit of knowledge to support novel materials for future operational capabilities.			
Accomplishments/Planned Programs Subtotals	8.502	9.748	12.211

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H43: *Research In Ballistics*	-	8.352	11.319	11.723	-	11.723	12.032	12.304	12.659	12.912	0.000	81.301

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Energetics Initiative	3.135	3.565	3.567
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 2018 Plans:*** Explore experimental techniques to maximize energy release of chemical formulations for either propulsive or energetic applications; explore methods for larger-scale production: create new computational models which can be used to predict solid-state reaction rates for energetic materials at extreme conditions for upscaling to higher-order models; and develop and validate detailed reaction chemistry representations of plasticizer blends for propulsive applications. ***FY 2019 Plans:*** Ultrafast laser based techniques will be applied to a variety of energetics in order to obtain a more fundamental understanding of detonation event. Will investigate the complexity of deflagration or combustion reactions using ballistic imaging. Will assess experimental characterization methods to measure detonation properties from a minimal amount of material and will validate them with large scale measurements. Will explore novel systems as candidates for disruptive-type energetic/propellant materials to increase the power of explosives and range/velocities of projectiles. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding increased due to inflation.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles	1.978	2.892	2.976

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
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 2018 Plans:*** Derive mathematical frameworks and proofs of convergence for estimation of flight vehicle swarm states in absence of global positioning system; and conduct numerical experiments to demonstrate increased maneuverability of air vehicles using thrust-vector control or enhanced aerodynamic control. ***FY 2019 Plans:*** Will obtain fundamental understanding of flow mechanisms necessary to mitigate undesired vortex interactions or flow separation to ultimately enhance vehicle maneuver control; will establish theory for distributed estimation of multi-agent, high-speed systems with union of heterogeneous sensor signals. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Long Range Precision Fires for projectile launch.			
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 2018 Plans:*** Further advance computational methods that predict and explain simultaneous deformation and failure occurring under various ballistic and blast loading conditions; and perform recently developed experiments to validate multi-scale computations that quantify the cause of high-rate deformation. ***FY 2019 Plans:*** Will create new anisotropic/asymmetric model for flow and localization, and implement into ALE3D. Will perform ballistic model experiments on lightweight metals variants to probe range of flow behaviors exhibited. Will conduct additional experiments at the Dynamic Compression Sector. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	2.505	3.711	3.786
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 2018 Plans:***	0.734	1.151	1.394

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Experimentally evaluate blast effects on tissues; model simulation techniques to produce three-dimensional (3D) shock environments; and experimentally evaluate 3D shock model and use results to refine model. ***FY 2019 Plans:*** Will develop a computational framework to study the effects of mechanical loading on voltage sensitive ion channels of the brain. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Soldier Lethality for enhanced human performance and survivability.			
Accomplishments/Planned Programs Subtotals	8.352	11.319	11.723

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
H44: *Adv Sensors Research*	-	9.222	8.899	9.915	-	9.915	10.590	10.861	11.099	11.321	0.000	71.907

A. Mission Description and Budget Item Justification

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019**
Title: Improving Sensor Research (previously Improving Sensor and Photonics Research (Nano))	2.339	1.547	1.597
Description: Create more survivable and secure sensors and displays, and investigate new magnetic- and electric-field sensor technologies for personnel, activity, and improvised explosive device (IED) detection. Develop novel algorithms and electromagnetic models to investigate radio frequency (RF) propagation and exploitation in complex clutter environments for improved RF and radar sensing.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Investigate notch-filling techniques in the RF spectrum for wideband radar application; investigate micro-Doppler effects and algorithms for threat unmanned air system (UAS) modeling and detection research; apply infrasound propagation theory and develop new algorithms to enhance localization accuracy and classification in complex wind and flow environments and propagation channels; develop modeling and simulation techniques and algorithms for electrical- and magnetic-field sensing of targets, terrain, power lines, sensors and sensor platforms influenced by complex field interaction; explore distributed change detection by fusion of sensor and open source text; and research adaptive distributed multiple target tracking over bandwidth constrained networks. ***FY 2019 Plans:*** Will investigate the development of new methods to efficiently solve extremely complex quasi-static electric/magnetic-field boundary-element problems on DoD supercomputers for wide-area power lines; will research joint estimation and fusion of human generated measurements for crowd sourcing applications; will research distributed deep learning fusion with low cost, low energy electro-optic sensors for robust target classification; will research decentralized quickest change detection algorithms and performance metrics; and will develop fundamental electro-magnetic models and signal processing algorithms to support airborne sensing of ground-based concealed targets using networked based distributed sensing concepts. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation			
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 2018 Plans:*** Create numerical methods and algorithms to enable new high-fidelity multi-scale computer simulations of materials capable of taking full advantage of emerging large-scale heterogeneous computing environments; and develop computational methodologies to advance the state-of-the-art of at-scale computer models of materials, from the electronic scale through atomistic- and meso-scale to continuum, to take full advantage of emerging large-scale heterogeneous computing environments. ***FY 2019 Plans:***	2.776	2.899	2.936

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will explore uncertainty of model predictions; will explore approaches to employing state-of-the-art computing architectures, which enable large-scale numerical processing; and will advance the bridging of at-scale models, across the electronic- to atomic- to meso- to macro-scales. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Biological and Bio-inspired Materials and Devices Research ***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 2018 Plans:*** Explore improved large-scale models of microbial consortia in concert with improved experimental protocols monitoring consortium evolution for future applications such as waste-to-energy; identify second generation bioinformatic and modeling tools that integrate experimentally monitored dynamics of the diversity of synthetic peptide library development for inorganic and multifunctional materials; establish synthetic biology methods to engineer cell systems for improved and programmable control of interactions of biological/abiological heterogeneous interfaces; develop protocols for systems-level analysis of multi-organism communities; extend metabolic and transcriptional network reconstruction to additional organisms; and research available systems biology tools for use in microbial consortia members. ***FY 2019 Plans:*** Will investigate computational and experimental routes to functional, stable microbial interactions for biologically enabled devices and processes; and will explore mechanistic and evolutionary responses of engineered bacteria to environmental factors for improved bio-hybrid materials, sensors, and electronic devices. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Living Materials research.	4.107	4.453	2.075
Title: Living Materials ***Description:*** Research the concept of responsive materials imparting living functions for operation in Army relevant environments thus enabling disruptive capabilities, such as self-healing, adaptation, protection, and situational awareness. Perform research to enable design and synthesis of materials both enabled by and including biological entities to provide these living functions. ***FY 2019 Plans:*** Will perform innovative synthetic biology research in novel hosts to move technology into Army relevant environments; and will investigate pioneering tools for dynamic control of biological / abiological hybrid assemblies. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	-	-	3.307

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
New start effort to enable pursuit of knowledge to support Next Generation Combat Vehicles, Soldier Lethality, and Future Vertical Lift.			
Accomplishments/Planned Programs Subtotals	9.222	8.899	9.915

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
H45: *Air Mobility*	-	2.273	2.410	2.458	-	2.458	2.506	2.556	2.608	2.660	0.000	17.471

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Rotary Wing Aerodynamics	2.273	2.410	2.458
Description: Create robust experimental and computational approaches for understanding, modeling, and predicting the complex fluid flow and aerodynamics of next generation rotorcraft concepts. This research includes innovative numerical methods for capturing the details of steady state and non-steady state aerodynamics and acoustics occurring with multi-rotor, rotor-propeller, and rotor hub configurations; and associated experimental techniques needed to verify modeling results.			
FY 2018 Plans: Conduct experimental investigations to better understand the flow field surrounding a rotor hub to enable drag reduction using active and passive flow control technology; continue computational aero-science investigations on both high-fidelity and mid/low fidelity numerical methods including work on validation and developmental testing of the physical assumptions forming the building blocks of the underlying theory.			
FY 2019 Plans: Will conduct experimental research in acoustics and interactional aerodynamics of multi-rotor and rotor-propeller configurations; will explore the possibility of active flow control for adverse force reduction on rotorcraft empennage structure; will conduct computational sciences research on higher-order accuracy in time for improved flow computations of maneuvering rotorcraft; will leverage high performance computing tools for fundamental studies of unsteady aerodynamics and rotor flow fields in hover and forward flight.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	2.273	2.410	2.458

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H47: *Applied Physics Rsch*	-	4.197	5.689	5.848	-	5.848	5.434	5.559	5.676	5.790	0.000	38.193

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Nanoelectronic Devices and Sensors	1.799	1.490	1.552
Description: Conduct research on advanced battery materials; fuel cells and reformers for Soldier and vehicle power; electronic materials structures and defects in high-temperature, wide-bandgap semiconductors for high-power electronic and photonic applications; materials for advanced nano- and micro-devices; and integration of nano-energetics and Micro-Electro-Mechanical Systems (MEMS) for fusing and micro-robotic applications.			
FY 2018 Plans: Investigate underlying reliability limitations of ultra-wide band gap materials and devices; research and compare electron mobilities in state-of-the-art dielectrics on gallium nitride (GaN) for gate dielectric and passivation in 600-Voltage class devices; develop computational transport models for bipolar ionic conducting membranes for use in high energy density fuel cells using liquid fuels; analyze techniques for improving piezoelectric material properties and integration strategies to enable tunable, adaptable radio frequency (RF) MEMS devices and inertial sensors; study radiative efficiency in microcavities for high power, single aperture near-			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
ultraviolet (UV) lasers; and study indium gallium nitride on gallium nitride substrates (InGaN on GaN) devices for improved gain in near-UV lasers. ***FY 2019 Plans:*** Will initiate improvements in charge trapping dielectrics models to cover a broader range of wide band gap materials; will evaluate characterization results of the gallium nitride (GaN) power devices and develop improved understanding of the dielectric/semiconductor interaction under high field, high temperature condition; will develop an approach to couple variational thermodynamic theory with stochastic models; will apply this approach to heterogeneous materials systems with distributed structure & properties; will develop modeling approaches for simulations of concentrated aqueous electrolytes for energy storage applications; will apply developed approaches and quantum chemistry methods to guide development of safe lithium-ion and zinc-based batteries; will develop, verify, and validate modeling and simulation methodologies to enable research of advanced energy harvesting and (photo)electrochemical energy storage/conversion technologies; will explore theory to directly bridge scales (e.g., molecular to continuum); will analyze 2-D and three-dimensional (3-D) fabrication techniques for achieving both piezoelectric materials properties and integration strategies to enable tunable, adaptable RF MEMS devices, inertial sensors, and position/ navigation aiding sensors; and will investigate processes and structures for improving the near ultraviolet and deep ultraviolet quantum efficiency of silicon carbide (SiC) detectors to enable low-cost and compact chemical and biological agent detection and identification. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of knowledge to support Next Generation Combat Vehicles, Future Vertical Lift and Tactical Unit Power Independence.			
Title: Fundamentals for Energy Efficient Electronic Components (previously Advanced Energy Efficient Science Research) ***Description:*** This program addresses the power draw of radio frequency (RF) front ends for communication and the digital back-end from electronic materials. This work explores new materials with inherently higher energy efficiencies, while improving upon the current state-of-the-art. These materials will be used in conjunction with advances in circuits and systems to provide improvements in power efficiencies, linearity and noise at the subsystem level which are unique needs of the military. Conduct materials, components, and multi-scale modeling research that will lead to advances in energy storage, harvesting, conversion, and efficiency for a wide range of Army applications such as Soldier and vehicle power, microgrids, communications, radar and electronic warfare. ***FY 2018 Plans:*** Explore chip level integration of active devices made using 2D and surface conduction electron transport for high conductivity channels that enable more efficient RF performance; develop underlying principles for vertical gallium nitride (GaN) device/ material issues (more efficient vs lateral); investigate high-electron-mobility transistor (HEMT) devices in multiple geometries. ***FY 2019 Plans:***	2.398	1.880	1.909

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will integrate front-side optical filter and backside scattering reflector into a photovoltaic (PV) cell to fully match the emission spectrum of the microburner/selective emitter; will experimentally investigate the dramatic power density improvement at reduced temperatures via near-field coupling between the emitter and PV cells having separations less than the peak blackbody wavelength; will investigate non-linear energy conversion in metal oxide conformal thin-film coatings to boost areal power density; will investigate new ferroelectric materials and composites and evaluate properties for greatly enhanced pyroelectric energy conversion; will explore micro-compression effects on the dislocation density motion in gallium nitride (GaN) materials; will develop phase change and surface enhanced semiconductor-based RF switches with superior power handling, lifetime, and insertion loss; and will investigate magneto-dielectric material research for ultra-thin (<1mm) multiband antennas. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Fundamentals for Precision Measurement for Contested Environments ***Description:*** Develop new materials, novel device architectures, and unique processing techniques to successfully maintain communication and information sharing protocols in global positioning system (GPS)-denied, actively jammed, or austere environments. ***FY 2018 Plans:*** Explore new materials and novel device architectures to reduce the phase noise and environmental sensitivity of microwave-photonic oscillators in order to improve the performance of the Army's radar and position, navigation, and timing (PNT) systems; investigate a compensation locking concept to interlock oscillator cavities with different characteristics to increase long-term timing stability of the overall system. ***FY 2019 Plans:*** Will explore new materials and novel device architectures to realize compact field-capable oscillators that are environmentally insensitive; and will identify issues associated with propagation of the timing pulses. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Networks/C3I for enhanced communications.	-	0.539	0.591
Title: Fundamentals for Alternative Energy ***Description:*** Explore novel concepts in energy generation and capture, and in technologies for efficient conversion of ambient energy to electrical energy for use and storage. Design novel structures to include microscale power devices for multimodal harvesting and efficient distributed power conversion. Focus areas include: energy storage and release from atomic nuclei, new materials for topological insulators for energy conversion, and new designs for solar cells. ***FY 2018 Plans:***	-	1.780	1.796

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Investigate atomic-nuclear effect by isomer depletion, and study the nuclear structure for enhanced energy release; explore semiconductor structures by substrate and epitaxial growth conditions; investigate new materials to optimize plasmonically augmented performance; investigate the mechanism of plasmonic enhancement found in the structures built previously; develop 3-D plasmonic arrays and examine alternative field effects to enhance plasmonic reactions and decouple the electron transfer process to further elucidate the mechanism; and investigate electrochemical oxidation of high energy density liquid fuels with carbon-carbon bonds at low temperatures. ***FY 2019 Plans:*** Will demonstrate a 1-microwatt per square centimeter 3D etched nuclear-to-electric direct energy converter using a tritium-loaded carrier as the energy source; will determine the efficiency limits for 3D nano-pillared gallium nitride direct energy conversion using promethium-147 isotope; will design a 1-microwatt, 10 cubic centimeter, 10 gram isomer power source using indirect energy conversion; will explore ion solvation, ion-ion interaction and new liquid structure in the new aqueous electrolytes; will establish relation between electrochemical properties and the liquid structure at super-concentrations; will explore light-matter interactions at plasmonically-enhanced electrocatalytic interfaces tailored for carbon-carbon oxidation; will initiate development of light initiated surface chemical reactions and measure scattering and/or absorption spectra of select photo-electrodes to evaluate efficiency; will explore chip level integration of active devices made using 2D and surface conduction electron transport for high conductivity channels that enable more efficient radio frequency (RF) performance; will develop underlying principles for vertical gallium nitride (GaN) device/material issues (more efficient vs lateral); will test high electron mobility transistor devices in multiple geometries; will model and demonstrate acoustic (ultrasonic) power transfer and design enhanced acoustic coupled with inductive transfer of approximately 1W; will develop the technology to co-fabricate piezo-transformers with matching networks at -40 dBm of power; and will quantify cell performance improvements resulting from a new ?greenhouse? solar cell design which captures recombination luminescence that is lost in traditional cells. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	4.197	5.689	5.848

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
H48: *Battlespace Info & Comm Rsc*	-	27.497	31.394	32.292	-	32.292	36.816	37.397	38.249	39.014	0.000	242.659

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Communications in Complex Dynamic Networks	1.910	1.110	1.098
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 2018 Plans:*** Create theories, algorithms, and models to enable cognitive hybrid networks that utilize radio frequencies (RF) (e.g. Very High Frequency (VHF) and ultra-high frequency (UHF)), as well as higher frequencies ranges in non-RF bands; research novel energy efficient methods for controlling autonomous communications infrastructures to maintain network operations in disruptive environments; develop adaptive point-and-track algorithms and techniques for the modeling and design of multiplexed			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
systems for networking both RF and non-RF physical layer technologies; and develop formal theories, models and algorithms for decentralized and distributed software-defined networking control plane architectures across heterogeneous mobile networks. ***FY 2019 Plans:*** Will investigate and create adaptive networking and algorithms that extends previous research in joint physical, media access control (MAC) and network layer optimization to consider higher layer performance requirements. Will develop directional networking algorithms that consider radio frequency (RF) & non-RF channels. Will extend energy efficient methods to operate more effectively in an adversarial (contested) and congested operating environments, will extend software defined networking control plane algorithms to work across contested hybrid channels. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Machine Learning for Intelligent Agent and Human Decision Making research.			
Title: Data-to-Knowledge to Support Decision-Making ***Description:*** Design and implement a laboratory-scale common information processing infrastructure, inclusive of cloud computing, for networking processes that aids the transformation of data into actionable intelligence to support decision-making under uncertainty. Perform research to utilize real-time, tactical, soldier-centric information for improved decision-making and situational awareness. Perform research in support of rapidly enhancing long-duration, complex, dynamic decision-making capabilities of individual Warfighters and units through the integration of cognitive augmentation and course of action recommender technologies. ***FY 2018 Plans:*** Explore techniques for utilizing active and passive feedback from information consumers to enhance and customize multi-media information processing, knowledge presentation and querying for improved decision-making, situational awareness and computational reasoning; research text and video analytic approaches to associate information from text with information derived from video sources to improve the collection, processing and exploitation of tactical battlefield data. ***FY 2019 Plans:*** Will investigate methods for incorporating online and continuous learning of decision-relevant feedback and preferences stemming from interactions with multi-sourced, multi-media information and knowledge representations; Will investigate methods for developing belief-state models of intelligence, surveillance, and reconnaissance tasks which teams of agents can use to autonomously select actions such as observations, motions, and interactions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	4.381	5.055	5.107
Title: Information Protection for Mobile Dynamic Networks	5.829	4.704	3.923

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
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. . ***FY 2018 Plans:*** Investigate distributed, energy efficient techniques to enhance network survivability in the presence adversarial attacks at both the physical and network layers; develop quantitative models of information semantics trust and quality; create models, theories and algorithms for secure, content-based software-defined networking in dynamic coalition environments; investigate and create secure techniques for distributed composition, positioning, and adapting of information services based on user context and state, device processing capabilities, and security policies; explore and quantify cyber risk accurately in real-time to provide security and mission assurance; explore dynamically risk, exploit likelihood, and impact of vulnerability exploitation, as cyber sensor observations are received for a system with known vulnerabilities; investigate, detect, analyze, and assess temporal and spatial causality of cyber events representing attacker activities, attack provenance, exploits, and vulnerabilities, and investigate methods to attribute the authorship of source code and binary samples using machine learning techniques. ***FY 2019 Plans:*** Will enhance distributed energy efficient techniques that minimize the radio frequency (RF) signatures and are resilient to coordinated attacks on both the physical layer and network layer; will identify techniques for the distributed composition, positioning, and adapting of information services based on user context and state & device processing capabilities that is resilient in the presence of adversary disruption of portions of the information layer; will develop provably secure networking techniques that enable authenticated, private & reliable networks. Will explore and develop metrics for characterizing risk, and cyber-attack effects on mission performance; will investigate techniques for cyber-physical systems security; will research generation-after-next cyber tools for intrusion detection and active defense of Army systems; will investigate behaviors of attackers and defenders for possible attribution and anomaly detection. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Machine Learning for Intelligent Agent and Human Decision Making research.			
Title: Naturalistic Behavior for Shared Understanding and Explanation with Intelligent Systems ***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of- the-art techniques in machine translation and natural language processing. ***FY 2018 Plans:***	1.105	1.158	1.178

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Investigate machine learning techniques that support rapid, high quality text analysis in sparse data environments; and investigate knowledge representation techniques for automated dialect identification, linguistic analysis, and summarization for low-resource languages and social media data. ***FY 2019 Plans:*** Will research semantic meaning, object recognition, and information extraction; will understand natural language approaches to support tactical communication in human-intelligent agent interaction. Will develop algorithmic approaches to derive tactical meaning from heterogeneous data sources. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Advanced Computing Architectures and Algorithms ***Description:*** Investigate advanced computing and high performance computing (HPC) networking architectures, memory/storage architectures, algorithms and visualization techniques to support advanced battle command applications for command, control, communications, computers, and intelligence (C4I) systems. ***FY 2018 Plans:*** Identify gaps in the next generation computing hardware systems in relation to power, performance, portability, and programmability; create interdisciplinary mathematical algorithms and models for execution on advanced and high performance computing systems; investigate the use of traditional high-level to low-level compiler transformations and approaches to reduce the time for algorithm deployment on advanced systems; perform fundamental research into novel applications that will benefit from the deployment of tactical high performance computers for increased Soldier effectiveness and algorithms devoted to scalable and temporal data analytics for machine learning, real-time detection, and predictive analytics. ***FY 2019 Plans:*** Will pioneer compiler techniques for re-using non-parallel software and porting / compiling for new low-power high-core density architectures; will perform fundamental research on memory and processor architecture to simulate and estimate performance characteristics of next-gen computer systems; will investigate expanding usability for neuromorphic processors thru use of innovative programming techniques beyond machine learning; will create interdisciplinary mathematical algorithms and models devoted to scalable and temporal data analytics for machine learning, real-time detection, increased, and predictive analytics to increase Soldier effectiveness, situational awareness, and decision-making. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	4.004	4.186	4.240
Title: Quantum Information Sciences	5.203	5.402	5.461

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: Perform research to enable quantum networks, which necessitates research in efficient light / matter interfaces and long-lived, robust quantum memories. Additionally, the study of quantum techniques for sensing and ultra-precise navigation, timing, and communications will be undertaken. Conventional techniques for sensing magnetic fields, gravity, and timing have reached a plateau in their performance, and will be severely impacted in future contested-battlefield environments. This research brings new insights regarding the use of quantum science to enhance Warfighter effectiveness. ***FY 2018 Plans:*** Investigate optical nanofibers with strong evanescent fields embedded in cold atom systems; investigate cold-atom ensembles in optical cavities; investigate nanophotonic integration with solid-state defects; investigate solid-state stoichiometric crystals in cryogenic environments; investigate qubit (a unit of quantum information) manipulation in ion trap systems and solid-state defects; use an advanced control system for qubit manipulation for benchmark standardization; examine methods for coupling these different platforms via wavelength conversion; theoretically analyze experimental systems; and study theoretically and computationally the enhancements to sensing using distributed, entangled sensors; and investigate protocols and algorithms for quantum networks to increase the quantum channel capacity using exotic spatial modes of light. ***FY 2019 Plans:*** Will investigate experimentally and theoretically nanophotonic interactions with quantum systems and cold atoms in exotic electronic states strongly coupled to laser beams; will investigate experimentally and theoretically highly-efficient light-matter interactions in four physical platforms for quantum memories and coherent manipulations, including rare-earth materials, ion traps, and solid-state defects; will investigate experimental and theoretical methods for coupling different quantum systems using frequency conversion and multiplexed interactions using higher-order light modes; and will investigate advantages and limitations of distributed quantum systems through theoretical modeling. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Experimental Methods in Network Science ***Description:*** Supports in-house Network Science studies in conjunction with the Network Sciences Collaborative Technology Alliance and Distributed Analytics and Information Science for United States / United Kingdom (U.S. / U.K.) Coalition Operations Information (PE 0601104A). ***FY 2018 Plans:*** Investigate methods for network design that consider tradeoffs between current optimality and long-term behavior as well as adversarial dynamics; explore the impact of quality-of-information and semantics knowledge on distributed decision-making in physical and virtual agents as network size increases; develop optimal methods to configure multi-genre networks in the presence of highly dynamic operational environment based on the information quality requirements derived from semantic understanding	5.065	4.443	2.237

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
of the mission; develop novel techniques to model and influence the evolution of complex adaptive groups and networks, and the diffusion of opinions in dynamic multi-genre networks; and develop formal theories, techniques and frameworks to enable multi-level integrated fusion of disparate information sources in context of decision support objectives in coalition operations. ***FY 2019 Plans:*** Will investigate models, techniques and fundamental limits for dynamically adapting analytics processing (code and data) in a tactical coalition environment as missions and coalitions change to support distributed analytics in coalitions; will develop models, theories and algorithms for dynamically adapting information and network configurations in multi-genre networks to support mission based information quality requirements and enable improved distributed decision-making; will identify methods and techniques for simulating and emulating large scale software defined wireless networks; will develop techniques, algorithms for discovering hidden network processes in multilayer time-evolving networks under incomplete information; will investigate deep learning based algorithms for pattern discovery, classification and prediction in multi-genre networks. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Machine Learning for Intelligent Agent and Human Decision Making research.			
Title: Assured Operations in the Physical, Social and Cyber Domain	-	4.283	4.730
Description: Conduct research that will enhance the survivability of information by radically dispersing and continuously moving data across a multitude of inter-networked devices. This effort seeks to address the growing demands on information assurance, reliability and transmission in resource constrained environments. Theories and methods will be developed for securing information across heterogeneous devices/sources and networks, detecting and creating information obfuscation and deception techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. ***FY 2018 Plans:*** Identify and extend models that characterize the complex trade-offs inherent in radical dispersion of information among mobile tactical edge devices, such as communications, energy consumption, and security; investigate approaches to minimize impact of dispersion on timely, secure, and efficient re-gathering of information, especially semantic-based techniques, that support situational awareness that is timely and mission relevant; formulate requirements for formal models, theories and methods to execute and manage successful obfuscation of information within an environment of highly dispersed information; explore algorithms for adversarial-context-adaptive aggregation and presentation of information from distributed sources. ***FY 2019 Plans:*** Will investigate the impact of computational reasoning over machine learning outputs inherent in notions of quality and value of information; formulate characteristics for integrating formal models to prevent/detect information tampering while enabling deception detection and adaptive hardening against adversarial machine learning techniques; will develop formal models, theories and methods for information obfuscation and deception across the network of tactical edge devices that adapt to			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
adversarial activity in the network; will develop models and theories for characterizing the impact of information dispersal on trust & information quality; will investigate machine learning based approaches for information dispersion that optimizes the tradeoff between security and timely re-gathering of mission relevant information; will identify context aware algorithms for the timely aggregation and presentation of radically dispersed information. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable improved knowledge to support Networks/C3I for enhanced communications.			
Title: Mobile Network Modeling ***Description:*** This research focuses on techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldiers' information needs, modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber-attacks. Also to be considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information. ***FY 2018 Plans:*** Develop scalable, high fidelity models for high capacity aerial networks in contested and benign environments; develop high performance computing (HPC) enabled finite difference time domain (FDTD) based approach to directly solve Maxwell?s equations in the time domain in order to provide high fidelity propagation loss models in complex environments, e.g., through large buildings, urban canyons, indoor/outdoor, tree canopy and tunnels; develop heterogeneous network models that encapsulate the diverse characteristics and configurations of nodes supporting multimodal (RF and non?RF) waveforms based on actual multi-user channel measurements; develop appropriate metrics and analytical tools to characterize node- and network-level performance metrics such as data throughput, security, priority, and latency. ***FY 2019 Plans:*** Will demonstrate high fidelity simulations for communications in unconventional frequency bands with specific focus on high frequency (HF) and very high frequency (VHF) bands; will develop key enablers for multi-wavelength uninterrupted communications and networking capability in infrastructure-poor austere environments with novel localization techniques; will demonstrate concepts for low power systems for autonomous networking and control. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	-	1.053	1.070
Title: Machine Learning for Intelligent Agent and Human Decision Making ***Description:*** This effort will research methodologies and algorithms for machine learning with incomplete, unstructured, potentially deceptive and heterogeneous information, enabling joint decision making for Intelligent Agent-Human teams which	-	-	3.248

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
adapt to unknown environments and missions. Research will include methods for learning and decision making that occur under short time frames and constrained resources (computation, power, spectrum and networks). ***FY 2019 Plans:*** Will develop novel methods for joint human / intelligent agent learning and decision making to capitalize on individual strengths of humans and intelligent agents to improve emergent group performance; will identify approaches for rapid, cooperative decision making and learning utilizing machine learning approaches; will investigate the training of deep networks from sparsely labeled data under time constraints; will investigate learning approaches with statistically mismatched data. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New start effort to enable pursuit of knowledge to support Next Generation Combat Vehicles and Future Vertical Lift.			
Accomplishments/Planned Programs Subtotals	27.497	31.394	32.292

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H52: *Equip For The Soldier*	-	1.131	1.156	1.178	-	1.178	1.204	1.228	1.252	1.277	0.000	8.426

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Equipment for the Soldier	1.131	1.156	1.178
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 2018 Plans: Examine the potential use of single-layer graphene as a universal substrate for flexible, conformable sensors with future application to textiles, wearable materials, food safety, and Soldier performance sensing platforms; create materials with orthogonal functionalities using nanoparticles and thin films to understand the molecular and surface structural phenomena which define compatibility; continue to explore the effects of silver nanowire in hydrogel substrates on conductive and thermal properties with a focus on 3D architecture arrangements.			
FY 2019 Plans: Will begin to understand the role of surface patterning, structure and surface area on functional performance of seemingly incompatible functionalities (e.g. water repellency and catalysis) with a long term goal of developing orthogonal multifunctional systems for Soldier protection. Will explore fundamental phenomena that influence diffusion and surface segregation of metal oxide nanoparticles within polymer matrices. Will create a 3D dynamic knee OpenSim model informed by biomechanics load			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
carriage and magnetic resonance imaging data to enable prediction of the effects of equipment load and augmentation on Soldier performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	1.131	1.156	1.178

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H57: *Single Investigator Basic Research*	-	91.394	96.081	101.427	-	101.427	104.903	106.378	110.626	112.839	0.000	723.648

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Basic Research in Life Sciences	8.583	5.605	6.068
Description: Pursues fundamental discoveries in life sciences with the ultimate goal of facilitating the development of novel biomaterials to greatly enhance Soldier protection and performance. More specifically, i) molecular genetics research pursues fundamental studies in molecular and systems biology, and genetics, ii) neurosciences research investigating the physiology underlying perception, neuro-motor output, and potential methods of monitoring cognitive states during activity, iii) biochemistry research focuses on studies in structural and cell biology, metabolic processes, and biophysics, iv) research in microbiology pursues studies in microbial physiology, ecology, and evolution, v) social science research aims to elucidate the social, cultural, and other influences to human actions, and vi) auditory and signal processing research to map the cognitive implications of multisensory information integration.			
FY 2018 Plans: Develop a yeast-based system using a non-canonical amino acid incorporation technique to impart chemical modifications into putative adhesive proteins for the generation and selection of novel adhesive properties that, if successful, may enable new adhesive proteins for future uses ranging from next-generation therapeutics or transdermal drug delivery patches on or near the battlefield; investigate and validate new candidate brain circuits, predicted to be involved in sleep and wake cycles, by identifying the distribution and dynamics of transcription-factor binding (as a proxy to assess gene expression), that if successful may reveal physiological functions of sleep-regulatory regions in a manner that has never been done before and, in the long term, may enable non-invasive methods for reducing sleep deficit and sleep need for Soldiers who operate in conditions not conducive to restful			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
sleep; investigate the potential of the insect-specific cysteine in acetylcholinesterase as a unique, unexplored, and viable target to develop insecticides with reduced insecticide resistance and minimal toxicity to mammals for the control of disease vectors, that if successful this should lead to new and more effective methods to control the spread of diseases such as malaria and Zika virus; identify the proteins and pathways in the bacterium A. baumanii, responsible for maintaining cell viability under conditions of desiccation to review new methods for the engineering of bacterial cells capable of surviving harsh environmental conditions, that if successful may enable the development of sustainable in-field bio manufacturing processes. ***FY 2019 Plans:*** Will use digital polymerase chain reaction to quantify copy numbers of barcoding markers and single-copy nuclear genes in pollen samples of known counts, thereby allowing estimates of both isolation and copy number biases, ultimately enabling the genetic mapping and identification of various pollen species, that if successful, will enable new forensic capabilities for personnel and materiel; will genetically integrate a protein switch isolated from cephalopod reflectin protein that can reversibly switch between assembled and disassembled states into a related protein that is naturally unable to disassemble once assembled, that if successful, may enable a wide range of future electro-optical applications relevant to the Army and DoD, including systems that are more energy-efficient, lightweight, or exhibit adaptive concealment capabilities; will understand a multiple-target visual search experimental system and test results versus traditional laboratory assessments to evaluate and validate the effectiveness of laboratory-based searches as compared to real-world searches, that if successful, will lead to new designs and validation methods for new standard operating procedures to improve accuracy in visual search tasks (e.g., to ID contraband) known to be susceptible to dangerously high miss rates; within a biofilm of the bacterium P. aeruginosa, which produces redox-active electron shuttles called phenazines, will explore how biofilm of the bacterium P. aeruginosa is affected by the presence of non-phenazine producing species, that if successful, in the long term may lead to the creation of precisely balanced microbial communities for the control of energy generation within electrode-laden biofilms in microbial fuel cells. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel bio-derived materials through extramural basic research.			
Title: Basic Research in Environmental Sciences	1.503	0.578	0.309
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 2018 Plans:*** Design and utilize chamber experiments to determine partition coefficients for volatile organic compounds (VOCs) between soil, air, and airborne particles under various temperatures, and relative humidity settings that mimic real world conditions, that if successful, will provide data that may ultimately enable new tools for protecting the Soldier and other first-responders from			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
exposure to toxic chemicals, or to sequester and remove VOCs; design and synthesize simulated soil using synthetic colloids, demonstrate tunable inter-particle attraction to then examine the mechanical properties and flow of earth surface materials such as soils in dynamic environments that if successful may ultimately lead to future methods for safer infrastructure development, economical erosion control, efficient route planning. ***FY 2019 Plans:*** Will investigate the fundamental surface photo-reactivity of organic compounds during reaction with gaseous and bulk aqueous phases of environmental relevance, that if successful, will provide new methods for protecting the Soldier and other first-responders from exposure to toxic chemicals; will develop a city-scale model of how heat is stored by urban typical urban surfaces, transferred by runoff and dissipated by evaporation following a rainfall event, allowing better prediction of how UAVs will be affected by updrafts caused by spatial variations in ground temperature and how environmental conditions affect sensor performance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Chemical Sciences, Life Sciences, Network Sciences, and Social Sciences research.			
Title: Basic Research in Chemical Sciences	12.529	13.761	14.040
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 2018 Plans:*** Devise a new approach to fabricate precise conjugated polymers with controlled monomer sequences that in the long term, if successful, may lead to new semi-conducting materials with applications in sensing and detection; establish the relationship between the 3D interphase structure, the interface impedance, and the electrochemical behavior of all-garnet solid-state systems, to enable the characterization of different sources of interfacial resistance and advance the current understanding of the solid-solid electrode/electrolyte interface that, if successful, could lead to new solid-state high-performance batteries with increased safety and reduced weight; devise new methods to fabricate multifunctional nanostructures with features that can be dynamically regulated in space and time that in the long term, if successful, may ultimately lead to novel materials with applications in protection such as dynamic camouflage; prepare a population of molecular hydrogen and determine the quantum state of the ensemble using multiphoton ionization-mass spectrometry that, if successful, may provide results ultimately leading to new methods in quantum computation for ultra-secure communication. ***FY 2019 Plans:***			

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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 2017	FY 2018	FY 2019
Will develop mechanistic descriptions of catalysis by metal nanostructures when excited with photons, electrons and ions, that if successful, will provide an improved understanding of photoelectrocatalysis that is essential to reducing soldier-borne weight associated with power storage and generation; will use new high-resolution methods to image dissociation of designated compounds to directly observe and characterize roaming mechanisms for the first time, that if successful may enable improved control and development of next-generation propellants and explosives; will design and synthesize polymer-protein hybrid materials and ascertain the design rules necessary for achieving hybrid materials with optimal protein stabilization in non-natural environments, that if successful, may lead to methods for sensing, energy conversion. optical nonlinearity; will devise a versatile method to immobilize enzymes to abiological substrates while preserving biological structure and function, that if successful will provide new methods for detecting and neutralizing harmful chemicals. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of unique Chemical Sciences knowledge through extramural basic research.			
Title: Basic Research in Physics	17.102	17.861	19.293
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 2018 Plans:*** Investigate a new class of photonic structures called photonic topological metamaterials that, if successful, will provide for better control of light in materials and in the long term will enable the design and creation of metamaterials to bend light in ways previously impossible and with lower loss, potentially providing new tools for microscopy, sensing, and power harvesting; induce and demonstrate superconductivity in a material in which electrons behave in a way not achievable in traditional semiconductors, that in the long term may enable new electronics with dramatically-reduced power consumption; use ultra-cold atoms in highly-excited states, called Rydberg atoms, to achieve quantum simulation of the Ising model of optical lattices (gaseous-phase atoms in a specialized ordered state) whereby certain atoms are in competition for spin state, that if successful may provide a method for predicting and measuring defects in materials, enabling the rapid development of new materials with desired properties; demonstrate entanglement between neutral atoms and microwave photons in a superconducting cavity that, if successful, may enable the development hybrid quantum systems for use in ultra-secure communication devices. ***FY 2019 Plans:*** Will modify graphene to induce an optical nonlinearity (e.g., emitting light at a different frequency than was introduced) that in the long term may enable the creation of new materials with greatly enhanced functionalities; will create theoretical models of the quantum phases and dynamics of periodically driven ultra-cold atomic gases that, if successfully validated, may provide a method for predicting and measuring defects in materials and enable the rapid development of new materials with desired			

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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 2017	FY 2018	FY 2019
properties; will explore the quantum limits of spectroscopy and control of single molecular ions using atomic ions as qubit probes, that if successful may enable capabilities beyond those possible with classical systems in the application areas of resource optimization, efficient C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) and maximal logistical support; will utilize optical laser beams to discover energy-release channels for several nuclear isomers, that if successful may reveal new methods for long-lived energy source sources, such as batteries. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of unique physics knowledge through extramural basic research.			
Title: Basic Research in Electronics and Photonics	10.895	8.634	7.340
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 2018 Plans:*** Investigate photocurrent generation in new nanohybrid, carbon-based systems for ultraviolet (UV) and infrared (IR) detection; create aluminium gallium nitride (AlGaN) nanowire arrays for deep UV electrically controlled lasers; identify complementary metal-oxide-semiconductor (CMOS) nano-electrode arrays that interface with mammalian neuronal networks for potential restoration of neural functions; create new capabilities for beam steering, beam forming, and waveform control in the terahertz range, by use of electrically switchable metasurfaces. ***FY 2019 Plans:*** Will exploit exotic electromagnetic phenomena in solid-state structures which require theoretical formulations beyond Maxwell?s equations (such as axion electrodynamics, chiral anomaly and spontaneous symmetry breaking) and interfacial proximity effects in quantum heterostructures; will establish the nano-specific functionality of electrical currents and fields unique to the interior of a single cell for stimulation, sensing, and manipulation of the critical functions within and surrounding individual biological cell structures; will incorporate materials, microcavity, and metamaterial design advances to exceed the mobility and resistive loss limitations of electron transport for enhanced computational processing and data communications; will elucidate the transition between notably different forms of energy (such as magnetic, phononic, as well as hybrid physical regimes involving magnons, polarons, and surface plasmon polaritons) to develop novel devices manifesting these phenomena. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased to enable support of Chemical Sciences, Life Sciences, Network Sciences, and Social Sciences research.			
Title: Basic Research in Materials Sciences	7.996	7.882	8.744

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
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 2018 Plans:*** Establish the design and directed assembly of nano-building blocks into complex, hierarchical 3D architectures capable of long-range control over multifunctional behavior and smart/dynamic responses using an additive 3D material assembly approach (for applications in manufacturing, novel electronics and communications); create new systems exhibiting the physics of anyons (a type of quasiparticle that only occurs in two-dimensional systems) and topologically protected states (for unique communication, sensing and logic applications); and develop a novel theory-experiment feedback loop to accelerate discovery of optimized novel polymer nanocomposites (PNCs) (for structural, durability, and light-weighting applications). ***FY 2019 Plans:*** Will design and synthesize selective quantum grade quality novel host materials with desired color centers exhibiting unique quantum properties and elucidate the physical mechanisms responsible for the observed novel quantum properties (e.g. spin coherence) and governing composition- processing- defect- property relationships; will employ theory and integrated modeling/ simulations to guide experimental efforts and explore new quantum science opportunities such as collective states; will develop spectroscopic and other applicable characterization methods for direct observation of plasma/material interactions and the dynamics of the consolidation process; will refine or modify plasma and materials processing tools to achieve bulk manipulation and scalable consolidation of first-of-their-kind 3D macrostructures. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel materials through extramural basic research.			
Title: Basic Research in Computing Sciences ***Description:*** Provides the backbone for performing complex, multi-system analysis, modeling and simulation for understanding information systems. Advancements in computer sciences have a direct impact on enhancing the Warfighters' decision-making, situation awareness, command and control, as well as on the overall performance of weapon, intelligence, transportation and logistics systems. ***FY 2018 Plans:*** Create a new set of algorithms and software environments to perform scientific and geometric computations on heterogeneous processors to address issues related to load balancing between central processing unit (CPU) and graphics processing unit (GPU) cores, programmability, and power management that can be applied to enhance data processing capabilities for Army big data challenges; establish new methodologies for modeling multimodal neural activity to design closed-loop adaptive algorithms	8.281	6.761	6.952

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
for optimized brain-computer communication; and develop novel cyber system adaptation techniques that will make Department of Defense (DoD) cyber systems more resilient and robust against potential cyber attacks. ***FY 2019 Plans:*** Will create computational methods to ensure that critical timing constraints are met for real-time mixed-criticality workloads on multicore platforms augmented with graphics processing units (GPUs) for acceleration; will establish a framework for robust, decentralized processing of sensing data that leads to enhanced performance under dynamic and constrained environments to support processing algorithms that exploit geographically distributed and contaminated big data for near optimal inference and decision making; will explore new cyber deception approaches that rely on both obfuscation and decoy techniques that can confuse adversaries and divert cyber attacks to the wrong targets. The particular workloads of interest are emerging safety-critical embedded Army systems where autonomous functionality is required such as in unmanned airplanes and helicopters, battlefield robots, unmanned ground vehicles, and various autonomous weapon systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel approaches for decentralized processing of sensing data.			
Title: Basic Research In Network Sciences ***Description:*** Focuses on gaining an understanding of the fundamental aspects of how networks develop, function, and adapt to the environment and the rate of information flow in man-made and naturally occurring networks. This understanding will have a direct impact on net-centric force operations, such as better communication system design and operations, and more efficient logistics or communications support. ***FY 2018 Plans:*** Compare the performance of a reservoir computer, a novel neuromorphic self-timed computer architecture to state-of-the-art time series analysis and prediction methods using nonlinear Gaussian process regression to understand dynamics of systems with multiple time scales, multivariate data, and whether a hybrid reservoir Gaussian regression architecture surpasses the performance of either algorithm alone; develop new algorithms and tools to design/re-design teams for improved performance over time, and discover the underlying mechanisms behind cyber flash mob behaviors as a manifestation of interconnected networks; investigate the use of the software defined networking paradigm to adapt to rapidly changing network conditions without operator intervention to enable delay intolerant communications (voice, real-time video, and facilitate robotic control), and improve overall throughput to maximize situational awareness; and discover game theory principles in the world of biochemistry as it relates to strategies for leading tumor cells to degrade to a benign state. ***FY 2019 Plans:*** Will develop state-of-the-art modeling for opinion dynamics over multiple, coupled networks focused on the role of human interactions for shaping people's opinions, beliefs, and actions; research the adaptation of information theoretical free energy minimization principles in brain theory into the formation of natural and man-made networks; will investigate algorithms,	10.235	11.574	12.769

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
routing methodologies, and software defined network derivatives resulting from free energy related approaches for maximizing information delivered in networks; will investigate applications of network analysis and control to study the organization and functional principles of the human brain. Existing analytical methods based on graph theory and statistics fail to take system dynamics into account. Research will focus on investigating new theories of network evolution describing interactions in population dynamics, especially using Lotka-Volterra dynamical system models to elucidate high-level properties of community structure. The impact of network structure on Mean Field Games will be investigated, as well as hybrid games that combine discrete and continuous games with application to opinion dynamics. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel networking protocols, components, and theoretical networking understanding through extramural basic research.			
Title: Basic Research in Mechanical Sciences	6.752	6.556	6.848
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 2018 Plans:*** Investigate an electrokinetic instability mechanism as an explanation for observed banding of microparticles which may lead to a novel process for microscale self-assembly of particles based on surface charge characteristics rather than bulk properties for novel material characteristics; develop a detailed liquid-phase decomposition mechanism of RDX (a white solid explosive) which includes only elementary reactions which in turn will be used to predict the burn-rate and flame structure of RDX and the burn-rate modifier for future design of enhanced energetic materials; derive a hierarchy of tractable analytical models of actuated elastica to enable distributed estimation and control of the intrinsic curvature and contact deformation/adhesion properties of continuous media which will lead to enhanced robotic mobility; investigate mechanics of dynamically growing crack interacting with an interface and associated stress wave attenuation in transparent layered material for potential development of blast resistant transparent material systems for future soldier system protection. ***FY 2019 Plans:*** Will investigate underlying fluid-structure interaction mechanisms governing vortex-induced galloping of rectangular prisms, which may lead to controlled stability for suspension lines in precision airdrop systems; will develop and demonstrate the fundamentals of a predictive, computational method for modeling damage due to propagating localized bands of plastic deformation in metals, in particular shear bands, under both high temperature and room temperature conditions which will lead to enhanced structures; will develop and validate a new theoretical foundation for describing multi-modal combustion under autoignition conditions achieving a new general, computationally efficient combustion model for Large Eddy Simulation (LES) models that can account			

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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 2017	FY 2018	FY 2019
for all three modes of combustion (premixed, non-premixed and autoignition) involved in turbulent lifted flame stabilization which will lead to broad fuel flexibility for vehicles; will develop a predictive framework for minimum energy legged locomotion pathways in heterogeneous and cluttered terrain using methods from nonequilibrium statistical mechanics and scattering to enable fast, efficient, and robust autonomous vehicle maneuverability in environments complicated by complex topographies, dense vegetation, or significant debris. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of mechanical scientific knowledge underpinnings through extramural basic research.			
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 2018 Plans:*** Initiate and conduct basic research efforts to develop the stochastic mathematics that underlie and enable the analysis of mean field games, and develop interdisciplinary approaches to reduce the order of the huge systems of equations generated for modeling the control of open quantum systems. Development of these new mathematical areas is expected to provide new mathematical tools to social scientists for modeling strategic decisions in reasoning about cultural norms and emergence of non-state adversarial groups among large populations and enable the design of more efficient quantum computation algorithms. ***FY 2019 Plans:*** Will initiate and conduct basic research efforts to develop the stochastic mathematics that underlie and enable the analysis of mean field games, and will continue to investigate interdisciplinary approaches to reduce the order of the huge systems of equations generated for modeling the control of open quantum systems. Development of these new mathematical areas is expected to provide new mathematical tools to social scientists for modeling strategic decisions in reasoning about cultural norms and emergence of non-state adversarial groups among large populations and enable the design of more efficient quantum computation algorithms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of stochastic mathematics underpinnings through extramural basic research.	5.517	5.750	5.891
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,	2.001	2.032	2.131

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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 2017	FY 2018	FY 2019
structural, functional, and computational aspects of the brain during learning, simulation, and training. It will be necessary to determine how neural circuits develop and are arranged physiologically in individuals to produce cognitive computations during simulation and training. This research will also include extensive studies to discover and map the neural circuitry that enables cognitive adaptation, and the dynamic mechanisms of neural network modification need to be established. ***FY 2018 Plans:*** Perform data fusion of electroencephalogram and functional magnetic resonance imaging data to yield spatial and temporal resolution of brain activity during search tasks, to test candidate mechanism developed in prior year in which data suggested area of brain was previously thought not to be involved in visual search may have role in camouflage-breaking, that in the long term, if validated, may provide new simulation methods for camouflaging personnel and materiel, and new training methods to help observers detect hidden objects; develop and validate new models of risks of error in human interaction in complex systems to determine risk points at which human behavior undermines system performance that in the long term, if successful, may lead to new automated methods to detect and mitigate human error in complex systems that could otherwise lead to catastrophic failures. ***FY 2019 Plans:*** Will identify numerous candidate genes found to have increased expression in key sleep-promoting nuclei that if successful, may reveal new methods to reduce sleep deficit and requirements for Soldiers who operate in conditions that are not conducive to restful sleep, that in term would have a positive impact on the maintenance of operational tempo and cognitive resilience; will identify points of divergence between human behavior, task model behavior, and technological systems requirements through the development of computational models that scale to large-scale complex systems that integrate a number of different discrete technologies, that if successful, may enable more effective design methods for user interfaces in Army equipment, training paradigms, and methods to mitigate operator error. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of improved knowledge of brain structure and neuronal connectivity for enhanced human performance through extramural basic research.			
Title: Expeditionary Materials Processing Science ***Description:*** Basic research coupling materials, innovative design, and manufacturing science to enable conversion of resources for meeting an expeditionary Army?s requirements. This research will enable predictive material-to-materiel models for high-confidence, certifiable article production, high-fidelity expeditionary and versatile material-to-materiel processing capabilities, and a new generation of materials responsive to applied field for shape shifting and phase transformation. ***FY 2018 Plans:*** Demonstrate proof-of-concept through design, synthesis, and validation of adaptive compounds that elicit activated remodeling via mechanochemistry to create synthetic materials with stress-responsive behavior analogous to that observed in biological systems.	-	5.117	5.391

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
If successful, this approach may provide a method for creating materials that enhance protection for the Soldier by strengthening or changing shape in response to external stresses. ***FY 2019 Plans:*** Will establish the fundamental relations between morphology and composition of single-function nanostructures that can be seamlessly integrated into hierarchical multifunctional systems and incorporate dynamic components capable of inducing actuation of the material across a wide range of length scales; will create materials that incorporate sensory elements, propagate waves of information through coupled reaction-diffusion and mechanical processes, and integrate feedback loops and energy transduction mechanisms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel materials processing approaches for point-of-need manufacturing through extramural basic research.			
Title: Basic Research in Social Sciences	-	3.970	5.651
Description: Social science research focuses on generating fundamental understanding of how social dynamics unfold, taking into account individual-level biophysiological factors contributing to social interaction (e.g., genetics, health, cognition, perception), group processes (e.g., interpersonal forces that determine influence, power, conformity), and the impacts of social institutions (e.g., economic processes, legal/governance structures, religious/belief systems, kin networks), with attention to the interconnections among these levels of analyses, and to the physical and natural environments in which human social dynamics are situated. This scientific understanding will improve situational awareness for Warfighters and analysts, improving efficacy of decision-making to achieve mission objectives. ***FY 2018 Plans:*** Research to improve measurement and modeling of social dynamics by tying biometric measurement (e.g., facial thermography, neural imaging, nervous system monitoring, voice acoustic sensing) to interpersonal dynamics and perception networks in small and large groups in localized and dispersed environments; develop new analytic approaches to capture interdependence of actions and precursors of action as well as spatial and temporal dependencies across levels of analyses (i.e., individual-to-group-to-society) to improve predictive accuracy of models of social interaction; advance ecological modeling approaches developed to capture organizational and group dynamics to better understand human social dynamics at population levels; assess impact of media and information technology on cross-cultural diffusion of information, opinion, and influence. ***FY 2019 Plans:*** Will establish methods to validate and measure social dynamics by demonstrating the relationship between vocal patterns in the nonverbal acoustic band and status, dominance, and prestige dynamics and will develop models capturing these relationships,			

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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 2017	FY 2018	FY 2019
that in the long term may enable the rapid detection of the most influential members in a social network, to measure the degree of group cohesiveness, and therefore could provide new capabilities in detecting and improving group performance in Army units. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of novel social scientific understanding, including genetics, group processes, and impacts of social institutions, through extramural basic research.			
Accomplishments/Planned Programs Subtotals	91.394	96.081	101.427

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H66: *Adv Structures Rsch*	-	2.053	3.108	3.153	-	3.153	3.197	3.240	3.285	3.350	0.000	21.386

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Structural Analysis and Vibration Methods	2.053	-	-
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.			
Title: Air Vehicle Structures & Dynamics Research	-	2.104	2.153

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H66 / *Adv Structures Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Conduct basic research in advanced analytical methodologies and techniques for understanding and predicting the health and performance of rotorcraft structures. Develop and experimentally validate technologies, models, and approaches to increase the reliability, useful life, or performance of components in vertical takeoff and landing systems. ***FY 2018 Plans:*** Investigate rotor blade morphing technology by comparing and improving analytical predictions with data collected from low speed wind tunnel tests as an approach to reduce vibration and potentially enable swashplateless flight. Investigate structure fatigue models to correlate damage indicators and more accurately predict the remaining useful life of structural components and improve theoretical computational algorithms to more accurately predict structural durability and damage tolerance. ***FY 2019 Plans:*** Novel methods will be developed using concepts such as material self-awareness for the detection and identification of precursors to damage under different types of loading conditions. Will investigate the capability to manufacture mission-specific multifunctional and tailored materials/components. Will explore complex systems, which will enable the prediction of complex dynamics behavior in real-life conditions and increase rotor performance through better understanding of rotor system aeromechanics processes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to understand materials with self-aware mechanisms suitable for use as damage precursors.			
Title: Reconfigurable Platform Mechanics & Propulsion ***Description:*** Conduct basic research in reconfigurable platform mechanics and propulsion science technologies to enable high-speed Vertical Take-off and Landing (VTOL). Investigate reconfigurable technologies for improved performance, stability and handling qualities across different flight regimes in all operational environments. ***FY 2018 Plans:*** Investigate aeromechanics characteristics of morphing structures and reconfigurable propulsion concepts such as engine cycles and propulsor drive system configurations. ***FY 2019 Plans:*** Will investigate wide-operability propulsion for future vehicles, including multi-fuel-responsive combustion, tailoring of magnetic properties of materials for aviation electric motors, and extended temperature range smart materials. Propulsion theories associated with achieving the dynamic response of flight stability and maneuverability will also be explored, in addition to fundamental research on the effect of interfacial interaction on mechanical response which would enable reconfigurable platform sub-systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	-	1.004	1.000

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H66 / *Adv Structures Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Funding levels decreased to enable support of Air Vehicle Structures & Dynamics research.			
Accomplishments/Planned Programs Subtotals	2.053	3.108	3.153

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H67: *Environmental Research*	-	0.893	1.036	1.065	-	1.065	1.085	1.107	1.130	1.155	0.000	7.471

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).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Industrial Pollution Prevention	0.893	1.036	1.065
Description: This effort conducts research on innovative environmentally-friendly technologies that support the warfighter (focusing on pollution prevention technologies).			
FY 2018 Plans: Investigate and perform basic research on the development of novel energetics for the reduction of hazardous materials in the processing of energetics. Additional research includes the investigation of airborne lead reduction for Army weapon systems as well as investigating new advanced surface coating products to minimize human health, environmental and long-term sustainable risks.			
FY 2019 Plans: Will investigate and perform basic research to formulate new environmentally friendly propellants, pyrotechnics, and explosives, which reduce the generation of hazardous materials during processing. The focus areas will be the replacement of high explosives including RDX, TNT, and hazardous binders and plasticizers. Will investigate novel materials to minimize human health, environmental, and long-term sustainable risks from Army weapon systems.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	0.893	1.036	1.065

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
S13: *Sci BS/Med Rsh Inf Dis*	-	11.118	11.039	11.272	-	11.272	11.509	11.501	12.253	12.498	0.000	81.190

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's 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 military-relevant infectious diseases in the following four areas:

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

Work is managed by the Medical Research and Materiel Command (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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Basic Research on drugs and vaccines against parasitic diseases	6.467	6.188	6.351
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			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
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 were merged into one task area titled Parasitic Diseases ? Drugs and Vaccines. ***FY 2018 Plans:*** Assess new lead candidates from the Triazine class of compounds. Identify and assess new lead candidates from the pyrimidinylguanidine class of compounds (a newly discovered family of similar chemical compounds that are active against malaria parasites in experimental animals) and a new primaquine-like compound used to prevent or treat malaria. Continue to monitor for emergence of drug resistant malaria in Asia, Africa and South America. Fabricate newly discovered malaria proteins (artificially produced via genetic engineering) to characterize their ability to prevent malaria in experimental animals. Continue to identify new formulations or delivery methods of malaria proteins for inclusion into malaria vaccines. ***FY 2019 Plans:*** Will formulate and analyze triazine class compounds intended for oral administration in humans. Will develop analysis methods for projected pyrimidinylguanidine class of compounds (a newly discovered family of similar chemical compounds that are active against malaria parasites in animal models) and primaquine-like compounds used to prevent or treat malaria. Methods will be developed for projected clinical trials and to assess drug distribution and efficacy in experimental animals and humans. Will continue to identify and assess new lead candidates from additional chemical classes for treatment and prevention of malaria. Will continue to monitor for emergence of drug resistant malaria in Asia, Africa and South America. Will fabricate newly discovered malaria proteins (artificially produced via genetic engineering) to characterize their ability to prevent malaria in experimental animals. Will continue to identify new formulations or delivery methods of malaria proteins for inclusion into malaria vaccines. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
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 2018 Plans:*** Characterize the newly-identified antigens (substances derived from the agent which stimulate immune systems to produce antibodies) from Campylobacter, Shigella, and ETEC which together are responsible for most of the cases of diarrhea in deployed	1.505	1.582	1.604

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Warfighters. Review epidemiology data from deployed populations to determine which pathogens should be included in future vaccines. Continue to discover/identify indicators of vaccine effectiveness (correlates of protection) identified in animal models of bacterial diarrhea for protection from disease. ***FY 2019 Plans:*** Will characterize previously identified antigens (substances derived from the agent which stimulate immune systems to produce antibodies) from Campylobacter, Shigella, and enterotoxigenic E. coli. (ETEC) which together are responsible for most of the cases of diarrhea in deployed Warfighters. Will continue to characterize various types of Shigella, ETEC and Campylobacter to inform vaccine development efforts. Will further investigate previously identified indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea for protection from disease. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.			
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 2018 Plans:*** Continue to characterize the role of human cells and antibodies recovered from patients vaccinated during dengue vaccine trials in Asia and Latin America and dengue human infection model studies conducted in the United States to identify new methods of vaccine formulations. Continue assessment of host immune responses against dengue virus proteins from patient populations enrolled in expanded Food and Drug Administration (FDA) safety/efficacy/dosing vaccine studies and dengue virus challenge studies in humans to understand protection mechanisms. Use molecular approaches (recombinant Deoxyribonucleic Acid (DNA) based techniques) to determine structures of protective antibodies against dengue. Identify vaccine technologies to produce antibody products that might be used to prevent or treat disease by lethal viruses such as Hantavirus, South American and African Hemorrhagic viruses. ***FY 2019 Plans:*** Will continue to formulate new attenuated (weakened) dengue viruses for use in dengue human challenge trials as part of vaccine testing and studying virus induced host damage and immune cell mediated protection. Will characterize immune cells and antibodies in samples from humans in novel inactivated virus/ live attenuated virus vaccinations against dengue. Will continue	1.624	1.688	1.712

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
computer based assessments of human immune responses to dengue vaccination and dengue infection. Will continue to identify and characterize vaccine technologies to produce antibody products that might be used to prevent or treat disease by lethal viruses such as Hantavirus, South American and African Hemorrhagic viruses. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.			
Title: Vector Identification and Control ***Description:*** This effort conducts research to investigate the biology of biting arthropods (i.e. mosquitoes and sand flies) and other vectors (organisms that transmit disease) and their control. This effort also expands identification of infectious disease pathogens in vectors and disease surveillance capabilities in the field. This research will help to direct new interventions into preventing disease transmission. ***FY 2018 Plans:*** Identify unique biological markers (e.g., proteins, genes) that can be used to produce improved detection tools that can identify multiple pathogens in a vector population. Identify technology in vector-borne disease risk assessment tools to manage data and support decision making for vector control operations. Explore integrated vector control strategies to include new insecticides or unique formulations, application equipment, and non-chemical control methods. ***FY 2019 Plans:*** Will continue to develop knowledge keys to identify and characterize new species of vectors. Will continue to explore integrated vector control strategies to include new insecticides or unique formulations, application equipment, and non-chemical control methods. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.	1.522	1.581	1.605
Accomplishments/Planned Programs Subtotals	11.118	11.039	11.272

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 2019 Army											Date: February 2018	
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 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
S14: *Sci BS/Cbt Cas Care Rs*	-	5.520	5.296	5.610	-	5.610	7.945	8.578	9.082	9.264	0.000	51.295

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 being 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; studies to control severe bleeding; and studies on traumatic brain injury (TBI). Such efforts will minimize lost duty time and provide military medical capabilities for far- forward medical/surgical care of injuries.
Research conducted in this project focuses on combat casualty care in the following four areas:

(1) Damage Control Resuscitation
(2) Combat Trauma Therapies
(3) Combat Critical Care Engineering
(4) TBI

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Damage Control Resuscitation	1.581	1.669	1.652
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.			
FY 2018 Plans: Use cell culture (cells grown under controlled conditions) techniques to understand the potential blood-clotting and anti-inflammatory effects of stem cells. Use cell culture methods to screen small-volume cytoprotectant (protect blood-deprived cells from further damage and restore normal function) drugs. Characterize response of tissue capillary (smallest of the body?s blood vessels) function to traumatic bleeding.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Will study effects of hypotensive (lower than normal blood pressure) resuscitation on human physiology. Will identify candidate key additives for improving platelet storage. Will study changes in the blood clotting system that occur after traumatic injury. Will study biomechanical aspects of blood vessels relevant to bleeding control. As a following on to the FY18 effort, will use cell culture techniques to better understand stem cell safety and effects of stem cells on blood-clotting and inflammation. Will continue use of cell culture methods to screen candidate small-volume drugs for ability to protect blood- and oxygen-deprived cells from further damage and restore normal function. Will continue characterization of response of tissue capillaries to traumatic bleeding. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding decrease to support prolonged field care.			
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 2018 Plans:*** Build upon work from FY17 to perform genetic analyses of wound bacteria to aid in identifying improved products to prevent or treat infected facial, mouth, and extremity wounds. Continue to identify wound healing agents (including re-purposed drugs and combination products) that mitigate wound infection. Begin work to identify ways to reduce injury progression and mitigate eschar (dead necrotic tissue formed on the surface of the skin after burn injury)-induced inflammation, and/or resolve dysregulated (impairment of a physiological regulatory mechanism) inflammation in burn wounds when early debridement (surgical removal of dead tissue) is not possible. ***FY 2019 Plans:*** Will perform studies to determine factors associated with composite bone-muscle injury that lead to impaired healing. Will characterize cell /tissue scaffolds and stem cells as potential candidates for skin substitute. Will continue work to identify wound healing agents and means to reduce injury progression and mitigate eschar (dead skin tissue formed as result of burn injury)-induced inflammation when early debridement (surgical removal of dead tissue) is not possible. Will study burn wound fluid to identify potential biomarkers that signal adequacy of wound healing. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	1.817	1.432	1.483
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.	0.824	0.868	0.894

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2018 Plans: Progress FY17 efforts to identify new methods to improve prehospital airway management and detection of tension pneumothorax (a life threatening condition caused by a collapsed lung). Advance work from FY17 to develop animal models in which to study impact of pain and pain drugs on resuscitation and stabilization outcomes following traumatic injury. Perform research to identify lung stem cells that may be used to treat lung injuries. ***FY 2019 Plans:*** Will characterize new coating materials for Extracorporeal Life Support circuits that will prevent blood clotting within the system. Will study stem cells to identify potential therapeutic capabilities. Will study biology of airway stem cells. Will conduct studies to characterize effects of partial aortic occlusion on vital organs. Will determine the correlation between blood pressure and renal oxygenation/function, the threshold of hypotension (low blood pressure) for ischemia (lack of blood flow) or reperfusion (resumed blood flow)-induced kidney injury, and correlated ischemia tolerance time of the kidneys. Will assess feasibility of new approaches to enable combat medics to provide basic critical care in austere, out-of-hospital settings. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase is due to inflation adjustment.			
Title: Traumatic Brain Injury ***Description:*** This effort conducts basic research in poly-trauma (multiple injuries)/TBI model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI. ***FY 2018 Plans:*** Apply systems biology methods to identify new proteins that appear in blood as a result of TBI. 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. ***FY 2019 Plans:*** Will identify proteins in blood that may be of benefit in diagnosing TBI. Will explore the basic biology underlying how and why the brain continues to degenerate in the weeks and months following severe TBI. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase is due to inflation adjustment.	1.298	1.327	1.366
Title: Prolonged Field Care ***Description:*** This effort performs basic research to study the physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties.	-	-	0.215

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2019 Plans: Will study physiological effects of reintroducing circulation to a limb after long-term administration of oxygen-carrying blood substitutes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New effort starting in FY19 examining physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties.			
Accomplishments/Planned Programs Subtotals	5.520	5.296	5.610

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
S15: *Sci BS/Army Op Med Rsh*	-	6.600	7.116	6.443	-	6.443	9.654	9.093	8.710	8.884	0.000	56.500

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 military operational medicine in the following four areas:

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Injury Prevention and Reduction	1.287	1.229	2.227
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 2018 Plans: Use computational analysis and modeling to define the inflammatory and regenerative response to tissue injury. Formulate blast injury scaling laws for the eyes across species, completing studies on larger animals (rabbits, pigs), with the ultimate goal of developing a surrogate human ocular injury model. Identify biochemical, physiological, and genetic markers of pro- and anti-			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
inflammatory events in skeletal muscle and bone using cell, animal, and human models for eventual transition to clinical trials. Identify molecular, pharmacological, and (or) nutritional interventions to reduce musculoskeletal injury and promote repair. ***FY 2019 Plans:*** Will continue to identify risk factors for musculoskeletal injury in DoD personnel and identify leading candidates of biomarkers that can diagnose injury from overuse. Will continue to determine injury mechanisms and scaling laws from repeated blast in animal models to refine pre-clinical models of low level blast induced mild Traumatic Brain Injury (mTBI). ***FY 2018 to FY 2019 Increase/Decrease Statement:*** In FY19, increased funding for Injury Prevention and Reduction is due to: 1) high priority of the program and 2) normal and planned progression of the effort.			
Title: Physiological Health ***Description:*** This effort conducts research on the physiological mechanisms of sleep, fatigue, and nutrition on Soldier performance, readiness and well-being. Also, efforts will contribute to human health and performance optimization and enhancement. ***FY 2018 Plans:*** Characterize role of sleep in resilience to, and recovery from, mild Traumatic Brain Injury (mTBI) events. Characterize the impact of blast and/or impact-acceleration on the gut microbiome. Investigate the impact of nutritionally optimized products on indicators of immune function in laboratory studies. ***FY 2019 Plans:*** Will characterize the impact of sleep on operational performance by designing field-based methodologies to assess sleep, fatigue and performance. Will investigate nutritional support for metabolic recovery and immune function. Will define inflammatory regulation of nutrient absorption and metabolism. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding reduced to support higher priority Injury Prevention and Reduction.	3.420	3.611	2.031
Title: Environmental Health and Protection ***Description:*** This effort involves the understanding of 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 2018 Plans:*** Use animal models to identify novel circulating biomarkers of organ damage following exertional heat injury (EHI) and exertional heat stroke (EHS) for the diagnosis and assessment of severity of heat injury. Discover biomarkers that are specific to the	0.810	1.053	1.126

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
type and extent of organ damage during EHI/EHS exposure and recovery. Determine the predictive power of various clinical biomarkers for the type and extent of organ damage that is observed at 7 days of recovery. Target biomarkers for EHI/ EHS assessment to characterize sensitivity and specificity in military working dogs. ***FY 2019 Plans:*** Will establish criteria to down-select biomarkers of multi-organ injury to improve diagnosis of exertional heat injury severity in male and female rats at 1, 2, 3 and 7 days of recovery as a model for human health effects. Will investigate dose response modeling for identifying latent hepatic, renal, and cardiac injury after toxic metal and/or toxic industrial chemical exposure during training and operations, including emerging megacities and other multi-domain battle scenarios. Will identify novel circulating biomarkers of organ damage in military working dogs following heat injury for improved medical readiness and recovery assessment. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
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 2018 Plans:*** Screen for additional compounds for the treatment of PTSD in an animal model, including investigating the ability of the compounds to inhibit adverse memory formation and related disorders. Identify additional vulnerable factors and diagnostic indicators of PTSD and co-existing mental health problems that overlap or complicate PTSD. Use an established rat model of mTBI with or without the addition of stress to identify nutritional and other targets for improved resolution or resilience to the trauma. Identify at least two novel compounds that are active at the nociceptin/orphanin peptide (NOP) receptor (a receptor involved in the regulation of numerous brain activities, particularly instinctive and emotional behaviors) for their ability to mitigate the adverse behavioral effects of traumatic stress and for their impact on PTSD-related symptoms in an animal model. ***FY 2019 Plans:*** Will screen for additional compounds for the treatment of PTSD in an animal model, including investigating the ability of the compounds to inhibit adverse memory formation and related disorders. Will complete specific refinements to animal model behavioral test procedures and expand capacity for bench pharmacological assays for PTSD. Will use an established animal model of mild Traumatic Brain Injury (mTBI) with or without the addition of stress to identify dietary supplements for improved resolution or resilience to brain trauma. Will characterize markers and time course of nervous and endocrine systems response and recovery following trauma exposure in rats. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	1.083	1.223	1.059

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding reduced to support higher priority efforts.			
Accomplishments/Planned Programs Subtotals	6.600	7.116	6.443

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	40.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	40.000

Note

Congressional Interest Item funding provided for Defense Research Sciences.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Defense Research Sciences.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018
Congressional Add: Congressional Program Increase	40.000	-
FY 2017 Accomplishments: N/A		
Congressional Adds Subtotals	40.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T22: *Soil & Rock Mech*	-	4.405	4.606	4.695	-	4.695	4.788	4.883	4.982	5.082	0.000	33.441

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Military Engineering Basic Research	2.114	2.212	2.260
Description: Conduct fundamental research to determine how physical and chemical characteristics of materials affect their interactions with environment. ***FY 2018 Plans:*** Construct a mechanistic process synthesis model for graphene-carbon nanotube metal nano-composites; investigate new mass and energy transfer models across land-atmosphere boundaries; evaluate novel wave breaking shape prediction models with in-situ experiments; and conduct surf zone transit experiments using an experimental vessel. ***FY 2019 Plans:*** Will reduce non-physical oscillations from high-order nonlinear finite element models of environmental flows by devising entropy viscosity numerical methods for hydrodynamics and numerical methods for a new class of continuum formulations that will be the foundation for new models for mass and energy transfer across land-atmosphere boundary, and will devise a capability for the creation, synthesis, and evaluation of lattice dislocations and surface functionalization for graphene, Carbon Nanotube-metal composites with significantly improved dynamic strength and durability. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Materials Modeling for Force Protection	2.291	2.394	2.435

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Description: Conduct fundamental research on material interactions at the micro- and nano-scales to determine how they affect macroscale properties ***FY 2018 Plans:*** Investigate and validate fuzzy logic tools to improve understanding of data fusion frameworks for predictive models; characterize in-vivo and in-vitro microtubule morphologies to investigate relationships between microscale structure and macroscale material performance; create synthetic analogues of alkali-silica reaction gels; and determine silica fume effects on hydration, rheology, and hardened properties in cementitious materials. ***FY 2019 Plans:*** Will create scalable fuzzy logic tools combined with Geographic Information System multi-criteria decision analysis for geospatial data fusion that will enhance knowledge of environmental parameters with reduced uncertainty in limited knowledge conditions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	4.405	4.606	4.695

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T23: *Basic Res Mil Const*	-	1.708	1.781	1.815	-	1.815	1.850	1.887	1.929	1.968	0.000	12.938

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Facilities Research	1.708	1.781	1.815
Description: Conduct fundamental research on innovative infrastructure technologies to optimize facility mission performance, through enhanced security and reduction in resource requirements, design errors and omissions, and environmental burdens. ***FY 2018 Plans:*** Fabricate nanopillar arrays on silicon substrates using nanosphere lithography and functionalize nanopillars with organic and inorganic compounds to investigate bactericidal properties; create controlled oxide growth method and investigate thickness effect on adhesion; and tune bacteriophage and crystalized nanofibers to understand how energy scavenging operates. ***FY 2019 Plans:*** Will determine the aspects of geopolymer chemistry that affect metal bonding and adhesion, and will examine martensite formation in dual phase stainless steels and the impact of this formation on material durability in corrosive environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	1.708	1.781	1.815

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T23 / *Basic Res Mil Const*

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T24: *Signature Physics And Terrain State Basic Research*	-	1.641	1.685	1.720	-	1.720	1.755	1.792	1.828	1.865	0.000	12.286

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Analysis for Signal and Signature Phenomenology (Previously titled - Terrain State and Signature Physics)	1.641	1.685	1.720
Description: Conduct fundamental research to examine the effects of environmental parameters on electromagnetic, acoustic, and seismic signatures as well as energy propagation with regard to terrain state and near surface atmosphere. ***FY 2018 Plans:*** Investigate seismic and acoustic wave transmission and reflection at the land-water boundary to characterize lake or river boundary effects on wave propagation; derive empirical expressions of the boundary effects by wave type, wave shape, polarization, and amplitude; and determine if the liquid water contents of frozen soils can be detected remotely (e.g., with airborne sensors) by exploiting polarization phenomena. ***FY 2019 Plans:*** Will conduct full-scale field measurements of multimodal wave transmission across a land/water boundary to identify the waves reflected, transmitted, and converted to different types at a land-water interface; and will advance the understanding of military relevant urban radiofrequency (RF) propagation by investigating urban structures both as materially heterogeneous and geometrically rough, considering both the surface and interior characteristics of urban structures, and explicitly considering			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
multipath effects (fading) by performing wideband channel sounding measurements inside and outside buildings, alleys, and narrow streets. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable full-scale field measurements of multi-modal wave transmission across land/water boundaries.			
Accomplishments/Planned Programs Subtotals	1.641	1.685	1.720

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T25: *Environmental Science Basic Research*	-	6.853	6.708	6.845	-	6.845	6.990	7.139	7.797	7.953	0.000	50.285

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Environmental and Ecological Fate of Explosives, Energetics, and Other Contaminants	3.659	3.446	3.518
Description: Conduct fundamental research to examine the effects of Army relevant compounds on the environment			
FY 2018 Plans: Correlate munition constituent environmental fate processes with soil horizon types and compare models to results from intact soil columns; understand fundamentals of photo-degradation pathways and kinetics of insensitive munitions formulations and individual components through a combination of computational chemistry methods, controlled lab experiments, and outdoor sample analysis; and construct and test an estrogen responsive promoter memory circuit and create and test an arsenic responsive yeast memory circuit.			
FY 2019 Plans: Will determine if sub-lethal exposures to an environmental toxicant can negatively impact an animal?s ability to thrive in the ecosystem, will assess interactive feedbacks on individual stamina and cognition after exposure to sublethal concentrations, and will evaluate spatial scaling effects on individual level cognition after exposure to sublethal concentrations.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Title: Fundamental Understanding of Explosives, Energetics and UXO in the Environment ***Description:*** Conduct fundamental research to increase the understanding of the physical and chemical characteristics of insensitive munitions ***FY 2018 Plans:*** Determine chemical kinetic parameters for each insensitive munitions compound on different natural soils; functionalize and characterize cellulose and chitin using electron donating molecules; determine role of electrode surface area in electrode charging; and determine mechanisms of zone dispersion and their limits. ***FY 2019 Plans:*** Will identify biogeochemical parameters that stimulate horizontal gene transfer that will increase the understanding of degradation processes, will identify the sources and mechanisms of photo-activated insensitive munitions toxicity, and will determine the environmental relevance of photo-activated insensitive munitions toxicity. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	1.020	1.066	1.089
Title: Training Land Natural Resources ***Description:*** Conduct fundamental research on the molecular interactions of plants and animals with environmental stimuli. ***FY 2018 Plans:*** Understand anuran olfactory receptor-odorant interaction at the molecular level; define and assess the composition and stability of the lizard microbiome; and determine effects of contaminants on microbiome composition. ***FY 2019 Plans:*** Will explore the interrelationships between surface affinity and photocatalytic degradation, including orientation, kinetics, selectivity, and mechanistic pathway; and will determine the feasibility, mechanisms, photonic efficiency and fundamental processes of a novel, indirect excitation of photocatalyst using evanescent waves. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.	1.284	1.249	1.276
Title: Network Science ***Description:*** Conduct fundamental research to examine the behavior of environmental networks to inform data models and algorithms	0.890	0.947	0.962

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
FY 2018 Plans: Understand information propagation through imperfect biological networks and how biology adapts to overcome obstacles; and determine the relationship between path length, information flow, and perturbation parameters in full-scale networks. ***FY 2019 Plans:*** Will compare nectar defense in generalist and specialist plants that are in pollination networks, and will model crowd confusion and evacuation in complex networks. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	6.853	6.708	6.845

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	8.468	8.847	9.546	-	9.546	11.112	11.281	11.516	11.746	0.000	72.516

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Robotics Autonomy and Human Robotic Interface Research	1.945	1.899	1.930

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
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 2018 Plans:*** Explore techniques for recognizing novel behaviors and circumstances that support generalized learning and long-term adaptability. Continue efforts towards creating machine understanding of the purpose or intent for objects and behaviors. Explore the bridging of a cognitive architecture and control technology for disparate robotic systems. ***FY 2019 Plans:*** Will research methods to improve the ability of robots to have a deeper understanding of the world, increasing their capability to learn from limited, dirty, dynamic, and complex data. This includes the development of a shared-world model with a single probabilistic framework and a unified probabilistic knowledge base for robotic data. Cognitive approaches to perceptions will also be explored. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased due to inflation.			
Title: Intelligent Systems ***Description:*** Pursue in-house research that supports and unburdens Soldiers in a flexible, robust, survivable and comprehensive manner. This work will address the cognitive requirements of humans and (non-human) agents, both hardware and software based, operating individually or in collaboration, on the battlefield. Emphasis will be placed on perception, reasoning, and collaboration techniques that can apply to and transfer between a broad range of systems (such as: adaptive communication and data collection networks; cyber defense, crowd-sourcing and information retrieval software agents; and predictive and explanatory decision support systems). ***FY 2018 Plans:*** Develop novel techniques to simplify the semantic labeling methodology and increase its scalability using an on-line learning framework; and develop intelligent system algorithms for prioritizing decisions based on the context of mission objectives. ***FY 2019 Plans:*** Will investigate methods to enable the teaming of intelligent systems with Soldiers by developing techniques for online semantic learning from sparse datasets and for intelligent exploration of complex environments. Will explore using sparse representations	4.976	5.346	6.016

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
to map high-dimensional physical problems into low-dimensional ones that can be solved using existing techniques. Will investigate perceptual and intelligence methods to enable an autonomous system to participate in squad level missions. Will explore semantic vector spaces to bridge symbolic and metric representations to develop common representations between humans and intelligent agents. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels increased to enable pursuit of knowledge to support Next Generation Combat Vehicles and Future Vertical Lift for Manned-Unmanned Teaming.			
Title: Unmanned Air Vehicle Research ***Description:*** Conduct basic research focused on topics that contribute to the body of knowledge required to create future intelligent s 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 2018 Plans:*** Explore application of a cognitive architecture to manned-unmanned teaming of aircraft systems by initially using virtual environments. ***FY 2019 Plans:*** Will develop and explore methods and architectures that enable unmanned air vehicles to interact with the environment while airborne, including perception models for manipulation and flight control methods for robust performance in extreme environments and kinetic/kinematic simulations of unmanned air system (UAS) swarm behavior to enable human-agent teaming. Algorithms for real-time control system adaptation due to conditions such as platform reconfiguration will be developed, where probabilistic methods to access material state awareness will be explored to enable risk-informed maneuver. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding levels decreased due to decreased emphasis on application of cognitive architectures while maintaining research on fundamental underpinnings of cognitive architectures.	1.547	1.602	1.600
Accomplishments/Planned Programs Subtotals	8.468	8.847	9.546

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
T64: *Sci BS/System Biology And Network Science*	-	2.860	3.025	3.079	-	3.079	3.139	3.203	3.268	3.333	0.000	21.907

A. Mission Description and Budget Item Justification

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Network Sciences Initiative	2.860	3.025	3.079
Description: This basic research effort involves the use of mathematical models and algorithms to extract medical information from large-scale datasets (generated from the study of cellular genetic makeup, protein structures and function, and whole organism responses) to improve understanding, prevention, diagnostics, and treatments of post-traumatic stress disorder (PTSD), uncontrolled bleeding, infectious diseases, hard-to-diagnose pulmonary disease, and exposure to environmental stressors and hazards.			
FY 2018 Plans: Design algorithms to identify the impact of load-carriage and activity intensity in stress-related bone fracture in Warfighters during basic combat training. Formulate computational algorithms to investigate the association of genetic factors with neurological disorders, e.g., PTSD. Develop models to (a) predict drug targets for enhancing antibiotic sensitivity in wound pathogens that tend to be more antibiotic-resistant because they form biofilms (a group of microorganisms that stick to each other and adhere to a surface), (b) understand how antibody responses may lead to neutralization or enhancement of viral infection, and (c) identify molecular biomarkers of viral infection. Develop algorithms to model blood clotting processes under coagulopathic (inability for blood to clot) conditions and assess the ability of pharmacological (drug) interventions to mitigate trauma-induced coagulopathy (blood?s ability to form clot is impaired).			
FY 2019 Plans: Will design algorithms to identify the impact of bone size, structure and function on the risk of stress-related bone fracture in Warfighters during basic combat training; will improve and refine computational algorithms to investigate the association of			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
genetic factors with psychiatric disorders such as PTSD; will refine models to understand how antibody responses may lead to neutralization or enhancement of viral infection; will improve algorithms to predict biomarkers indicative of toxic chemical exposure and organ damage; will extend capabilities to understand blood clotting processes under coagulopathic conditions and assess the effects of shape changes in blood vessels, biochemical pathways, and pharmacological (drug) interventions on trauma-induced coagulopathy (blood?s ability to form clot is impaired); will develop mathematical models of upper respiratory airflow patterns for the non-invasive diagnosis of pulmonary (lung) diseases. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation adjustment.			
Accomplishments/Planned Programs Subtotals	2.860	3.025	3.079

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 2019 Army			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
VR9: *Surface Science Research*	-	2.169	2.293	2.337	-	2.337	2.383	2.431	2.481	2.531	0.000	16.625

A. Mission Description and Budget Item Justification

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Surface Science Research	2.169	2.293	2.337
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 2018 Plans: Conduct fundamental research on chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces; the effects of binding energy, reactions, transport and deposition; study the interactions between chemical reactions and transport processes on surfaces; theory and modeling of processes at complex surfaces; and experimental work focused on the systematic understanding of surface structure, morphology and surface group properties.			
FY 2019 Plans: Will further fundamental research on chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces; will probe the connection between low frequency vibrational modes and macroscopic behavior of metal organic frameworks; will investigate the effects of binding energy, reactions, transport and deposition, theory and modeling of processes at complex surfaces, and experimental work focused on the systematic understanding of surface structure, morphology and surface group properties.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
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 2017	FY 2018	FY 2019
Funding levels increased due to inflation.			
Accomplishments/Planned Programs Subtotals	2.169	2.293	2.337

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A