Exhibit R-2, RDT&E Budget Item Justification: PB 2025 Army											Date: March 2024	
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 2023**	**FY 2024**	**FY 2025 Base**	**FY 2025 OCO**	**FY 2025 Total**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**Cost To Complete**	**Total Cost**
Total Program Element	-	386.594	296.670	310.191	-	310.191	321.007	341.789	352.177	360.411	0.000	2,368.839
AA1: *ILIR - AMC*	-	11.305	11.758	12.094	-	12.094	12.108	12.116	12.248	12.370	0.000	83.999
AA2: *ILIR - SMDC*	-	1.015	1.068	1.098	-	1.098	1.075	1.076	1.088	1.099	0.000	7.519
AA3: *Single Investigator Basic Research*	-	94.959	108.599	108.011	-	108.011	113.024	123.931	127.768	133.646	0.000	809.938
AA4: *Training and Human Science Research*	-	21.677	21.024	19.865	-	19.865	19.517	21.654	22.132	22.493	0.000	148.362
AA5: *Biotechnology and Systems Biology*	-	6.366	6.547	8.999	-	8.999	9.007	9.941	9.904	9.999	0.000	60.763
AA6: *Robotics and Mobile Energy*	-	21.458	25.268	27.522	-	27.522	27.565	27.592	27.865	28.144	0.000	185.414
AA7: *Mechanics and Ballistics*	-	34.586	35.014	34.685	-	34.685	34.726	37.595	38.343	38.729	0.000	253.678
AA8: *Sensing and Electromagnetics*	-	13.402	16.383	25.634	-	25.634	31.208	29.397	33.471	33.806	0.000	183.301
AA9: *Information and Networking*	-	42.581	43.075	43.808	-	43.808	44.155	49.240	49.796	50.268	0.000	322.923
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	4.294	4.508	4.672	-	4.672	4.649	4.652	4.704	4.751	0.000	32.230
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	18.739	19.564	19.900	-	19.900	20.065	20.684	20.904	21.113	0.000	140.969
CH9: *Advancing Concepts and Technology Forecasting*	-	3.712	3.862	3.903	-	3.903	3.908	3.911	3.954	3.993	0.000	27.243
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	112.500	-	-	-	-	-	-	-	-	0.000	112.500

A. Mission Description and Budget Item Justification

This Program Element (PE) builds fundamental scientific knowledge contributing to the sustainment of United States (US) 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 are no commercial investments due to limited markets (e.g., vaccines for

Exhibit R-2, RDT&E Budget Item Justification: PB 2025 Army	Date: March 2024
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*

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 phenomenology). 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. This PE also supports basic research at the Army laboratories through the In-House Laboratory Independent Research (ILIR) program. The ILIR program serves as a catalyst for major technology breakthroughs by providing laboratory directors flexibility in implementing novel research ideas and by nurturing promising young scientists and engineers and is used to attract and retain top doctoral degreed scientists and engineers. The ILIR program also provides a source of competitive funds for peer reviewed efforts at Army laboratories to stimulate high quality, innovative research with significant opportunity for payoff to Army warfighting capability. This PE also identifies emerging and disruptive basic scientific research outcomes in order to translate, integrate, and ingrain research outcomes with Army Warfighting Concepts which describe how the Army will fight in the far-term future.

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

B. Program Change Summary ($ in Millions)	FY 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total
Previous President's Budget	391.642	296.670	309.571	-	309.571
Current President's Budget	386.594	296.670	310.191	-	310.191
Total Adjustments	-5.048	0.000	0.620	-	0.620
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.001	-			
• SBIR/STTR Transfer	-5.049	-			
• Adjustments to Budget Years	-	-	0.620	-	0.620

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2023	FY 2024
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Program increase - EXPLOSIVES AND OPIOIDS DUAL-USE UV DETECTION*	10.000	-
Congressional Add: *Program Increase - DIGITAL THREAD FOR ADVANCED MANUFACTURING*	9.500	-
Congressional Add: *Program Increase - JOINT RESEARCH LABRATORIES*	18.000	-
Congressional Add: *Program Increase - ARTIFICIAL INTELLIGENCE (AI) FUSION*	2.500	-
Congressional Add: *Program Increase - BASIC RESEARCH*	25.000	-
Congressional Add: *Program Increase - CENTER FOR UAS PROPULSION*	5.000	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2025 Army	Date: March 2024
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2023	FY 2024
Congressional Add: *Program Increase - COUNTER UAS TECHNOLOGY RESEARCH*	5.000	-
Congressional Add: *Program Increase - HIGH ENTROPY METALLIC ALLOYS*	5.000	-
Congressional Add: *Program Increase - RENEWABLE ENERGY TECHNOLOGIES*	15.000	-
Congressional Add: *Program Increase - SUSTAINABLE AVIATION FUEL PROPULSION*	7.500	-
Congressional Add: *Program Increase - UNMANNED AERIAL SYSTEMS HYBRID PROPULSION*	10.000	-
Congressional Add Subtotals for Project: T14	112.500	-
Congressional Add Totals for all Projects	112.500	-

Change Summary Explanation

Minor increase in FY25 funding from the previous PB to the current PB due to economic assumptions.

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army											Date: March 2024	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA1 / *ILIR - AMC*			
COST ($ in Millions)	**Prior Years**	**FY 2023**	**FY 2024**	**FY 2025 Base**	**FY 2025 OCO**	**FY 2025 Total**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**Cost To Complete**	**Total Cost**
AA1: *ILIR - AMC*	-	11.305	11.758	12.094	-	12.094	12.108	12.116	12.248	12.370	0.000	83.999

A. Mission Description and Budget Item Justification

Work in this Project supports basic research at the Army Futures Command through the In-House Laboratory Independent Research (ILIR) program. Basic research lays the foundation for future developmental efforts by identifying fundamental principles governing various phenomena and appropriate pathways to exploit this knowledge. The ILIR program serves as a catalyst for major technology breakthroughs by providing laboratory directors flexibility in implementing novel research ideas and by nurturing promising young scientists and engineers and is used to attract and retain top doctoral degreed scientists and engineers. The ILIR program also provides a source of competitive funds for peer reviewed efforts at Army laboratories to stimulate high quality, innovative research with significant opportunity for payoff to Army warfighting capability.

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

Work in this Project is performed by the Armaments Center (AC), Aviation and Missile Center (AvMC), Chemical Biological Center (CBC), Command, Control, Communication, Computers, Cyber, Intelligence, Surveillance and Reconnaissance Center (C5ISR), Ground Vehicle Systems Center (GVSC), and Soldier Center (SC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Edgewood Chemical Biological Center (ECBC) ***Description:*** Basic research in chemistry, biology, biotechnology, toxicology, material science, and aerosols for creating the science base needed for countering improvised explosive devices (IEDs), explosives forensics, obscurants, sensing, advanced materials, and defeating targets.	1.064	-	-
Title: Armaments Research, Development and Engineering Center (ARDEC) ***Description:*** Funds basic research in weapons component physics, explosives synthesis/detection, and the fundamental science base of area denial.	1.539	-	-
Title: Tank Automotive Research, Development and Engineering Center (TARDEC) ***Description:*** This effort funds basic research in ground vehicle technologies that include power, mobility, autonomous systems, materials and manufacturing.	1.294	-	-
Title: Natick Soldier Research, Development and Engineering Center (NSRDEC) ***Description:*** This effort funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection.	1.214	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts (AMRDEC-MI) ***Description:*** This effort funds the underlying fundamental science of Lethality and Protection Superiority for guided missile and rocket systems, directed energy weapons, unmanned vehicles, and related components.	2.460	-	-
Title: Aviation and Missile Research, Development and Engineering Center: Aviation Efforts (AMRDEC-AV) ***Description:*** This effort funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science.	1.436	-	-
Title: Communications Electronics Research and Engineering Directorate (CERDEC) ***Description:*** Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors.	2.298	-	-
Title: Chemical Materials - ILIR ***Description:*** Conduct advanced, high-risk, basic research that explores new phenomenology at the boundaries of chemistry, biology, mathematics, and physics. Specifically, conduct fundamental research in novel materials, synthetic biology, novel sensing, molecular toxicology, obscuration, explosives forensics, aerosol sciences, and machine learning. ***FY 2024 Plans:*** Will conduct competitively selected basic research on chemical and biological phenomenology to expand the body of knowledge and serve as the foundation for characterizing, assessing, and protecting against emerging threats; study basic principles of biological systems to broaden our understanding of detection and our ability to exploit these principles to aid in detection; expand the employment of artificial intelligence, machine learning, and predictive modeling to include computation tools that analyze novel biological and chemical synthetic pathways in the identification of novel precursors, materials, or threats. ***FY 2025 Plans:*** Will conduct first principal research in the areas of chemistry, biology, material science, and engineering that address technical performance and knowledge gaps relevant to Warfighter requirements that align to Army Modernization Priorities. Topics for research include biomanufacturing, metamaterials, reactive coatings/surfaces, material structure and processing, sensing, and analytical characterization. Research will be aided by employing artificial intelligence, machine learning, and predictive modeling and analytics as applicable. ***FY 2024 to FY 2025 Increase/Decrease Statement:***	-	1.081	1.236

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Funding increase in FY2025 supports additional research in the areas of biology and biological systems, material science and physical properties of novel obscurants, as well as increased use of machine learning to aid in explosive hazards and their precursor materials.			
Title: Structural Materials - ILIR ***Description:*** Funds basic research in weapons component physics, explosives synthesis/detection, and the fundamental science base of area denial. ***FY 2024 Plans:*** Will research chemical sciences, computational sciences, life sciences, and material sciences for structural materials related to armament systems; study intermolecular interactions and kinetics related to energetic and organic solids; explore optical computing methods, distributed deep fusion, and algorithms for object detection, target recognition, and component collaboration. ***FY 2025 Plans:*** Will conduct research in chemical, computational sciences, material, and life sciences with a potential for future applications in weapons, fire control, pyrotechnics, explosives, projectile and munition technologies; investigate burn rate augmentation methodologies for energetic materials to provide precise and consistent ignition processes; research energetic material design workflow algorithms and methodologies for novel approaches to new energetic molecules; explore biology-based sensors for real-time detection of hexavalent chromium below current detection thresholds. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.	-	1.590	1.600
Title: Advanced Mobility - ILIR ***Description:*** This effort funds basic research in ground vehicle technologies, including power, mobility, and unmanned systems. ***FY 2024 Plans:*** Will competitively select in-house basic research topic areas and use them to advance fundamental scientific understanding in support of ground vehicle systems, including: control systems for vehicles, autonomous systems control and characterization, lightweight and composite materials, additive manufacturing, multi-physics energy conversion modeling, hydrodynamic modeling, and internal combustion heat transfer modeling. ***FY 2025 Plans:*** Will competitively select in-house basic research topic areas and use them to advance fundamental scientific understanding in support of ground vehicle systems, including: autonomous systems control and characterization, lightweight and composite	-	1.328	1.370

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
materials, additive manufacturing, multi-physics energy conversion modeling, solid oxide fuel cell studies, and internal combustion heat transfer modeling. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of the effort.			
Title: Functional Materials - ILIR ***Description:*** This effort funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection. ***FY 2024 Plans:*** Will explore nonlinear optical properties of bio-inspired small-molecule materials towards advancement of responsive material systems for sensing and energy harvesting; use machine learning to establish a high-dimensional mathematical model of 3-D fluid-structure interaction dynamics of braided cords. Resulting models will inform strategies to reduce guided parachute drag and innovative methods for controlling, or even harvesting the energy from, cable vibrations to improve airdrop accuracy. ***FY 2025 Plans:*** Will investigate and document results of research on responsive color of bio-inspired small molecule materials; explore controlled organic phase change materials for novel polymer and metal organic frameworks; study fundamental knowledge of processing and perception of body control under stress impacting cognitive resilience; conduct research and experiments on nonlinear dynamics of cognitive and motor behavior under dynamic conditions. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.	-	1.240	1.248
Title: Optical Electronics - ILIR ***Description:*** This effort funds the underlying fundamental science of Lethality and Protection Superiority for guided missile and rocket systems, unmanned vehicles, and related components. ***FY 2024 Plans:*** Will investigate the use of emerging information theoretic quantities and statistical approaches to understand their potential utility for advanced sensing techniques; continue basic research into the effects of the free electron layer on light-matter interactions at metal-vacuum boundaries to inform its use in next generation metamaterial design for sensors and devices for signal detection, sensor protection, and masking; study the fundamental characteristics of radio frequency signals containing entangled photons to provide a basis for an assessment of their potential for advanced sensing applications; explore and model key chemical functional groups enhancing molecular interactions between the Nitrocellulose polymer and plastic fillers (e.g., ionic liquid plasticizers, ionic solids, and novel nano materials) to inform the design of next generation multifunctional energetic materials; explore the nature of	-	2.630	2.664

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
noise propagation through continuous time digital signal processing techniques to provide a foundational understanding that could enable a more comprehensive comparison of these techniques against traditional digital signal processing techniques. ***FY 2025 Plans:*** Will model the fundamental characteristics of entangled radio frequency photons to provide a basis for their assessment for advanced sensing and electronic warfare applications; investigate the role of the free electron layer on light-matter interactions at metal-vacuum and dielectric-vacuum boundaries to inform its use in next generation metamaterial design for sensors and devices for signal detection and sensor protection; develop an understanding of key chemical functional group molecular interactions between the Nitrocellulose polymer and plastic fillers to inform the design of next generation multifunctional energetic materials; validate models of noise propagation through continuous time digital signal processing techniques to provide a more comprehensive comparison of these techniques against traditional digital signal processing techniques; perform state-of-the-art quantum calculations to study the basic principles of atomic collisions on the resonance profiles of atoms; explore bright quantum states for their potential to enhance target detection. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Sol Struct Mech - ILIR ***Description:*** This effort funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science. ***FY 2024 Plans:*** Will combine visualization and high fidelity flow measurements of secondary vortex structures present in rotor wakes to develop a fundamental understanding of their formation, evolution, and associated instabilities; explore new mathematical formulations and algorithms for higher-order near-body solvers as a building block for a truly higher-order overset computational fluid dynamics solution framework. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding re-aligned to task "Aeromechanics - ILIR" within this same PE 0601102A (Defense Research Sciences) / PROJECT AA1 (ILIR - AMC)	-	1.480	-
Title: Comms Cyber IR RF-ILIR ***Description:*** Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors. ***FY 2024 Plans:***	-	2.409	2.485

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will conduct research on tunable dielectric materials that will be created by deposition by Pulsed Laser Deposition (PLD) and Magnetron Sputtering and Molecular Beam Epitaxy (MBE); investigate Jet Propellent 8 (JP8) reforming catalyst and processes to augment the decomposition of contaminants, while minimizing the use of noble metals to broaden potential fuel sources for fuel cells; conduct research on the band structure engineering of low cost perovskite materials and their potential applications in ultra-high power conversion efficiency multi-junction photovoltaic devices; conduct research to modify and characterize the interface between plasma enhanced atomic deposition layer and III-V infrared detector material layer to optimal surface preparations for strained layer superlattices infrared detector test devices. ***FY 2025 Plans:*** Will conduct research on radar design characterization and image processing / machine learning algorithms for target recognition; research signal processing to enhance physical layer secrecy and covertness in multiantenna systems; conduct research to determine the fundamental electrical impact of misfit dislocation defects on Vertical HgCdTe n-p diodes to improve performance of MBE Vertical HgCdTe Focal Plane Arrays; conduct research on cathodic synthesis and battery electrolytes for high-power density batteries; research novel tilt-, rotation- and neutralization-dependent X-ray photoelectron spectroscopy (XPS) technique to directly measure the surface composition and chemistry of as-fabricated infrared focal plane arrays (IRFPAs) to gain a fundamental understanding of how surface composition resulting from specific processing steps impacts IRFPA performance and yield. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Aeromechanics - ILIR ***Description:*** This effort funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science. ***FY 2025 Plans:*** Will investigate use of additive manufacturing (AM) for rotor blades for small UAS to better understand the effect of AM processes on blade structural and aerodynamic properties and rotor performance; develop parallelized three-dimensional structural dynamics solver to complement the fidelity of computational fluid dynamics solvers and apply to modern tip designs including taper, anhedral, and dihedral. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding re-aligned from task "Sol Struct Mech - ILIR" in this same PE 0601102A (Defense Research Sciences) / PROJECT AA1 (ILIR - AMC).	-	-	1.491
Accomplishments/Planned Programs Subtotals	11.305	11.758	12.094

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army											Date: March 2024	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA2 / *ILIR - SMDC*			
COST ($ in Millions)	**Prior Years**	**FY 2023**	**FY 2024**	**FY 2025 Base**	**FY 2025 OCO**	**FY 2025 Total**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**Cost To Complete**	**Total Cost**
AA2: *ILIR - SMDC*	-	1.015	1.068	1.098	-	1.098	1.075	1.076	1.088	1.099	0.000	7.519

A. Mission Description and Budget Item Justification

Work in this Project supports basic research at the United States Army Space and Missile Defense Command - Technical Center (USASMDC-TC) through the In-House Laboratory Independent Research (ILIR) program. Basic research lays the foundation for future developmental efforts by identifying fundamental principles governing various phenomena and appropriate pathways to exploit this knowledge. The ILIR program serves as a catalyst for major technology breakthroughs by providing laboratory directors flexibility in implementing novel research ideas and by nurturing promising young scientists and engineers and is used to attract and retain top doctoral level scientists and engineers. The ILIR program also provides a source of competitive funds for peer reviewed efforts at Army laboratories to stimulate high quality, innovative research with significant opportunity for payoff to Army warfighting capability.

Work in the Project provides a foundation for applied research initiatives at the Army laboratories and research, development, and engineering centers.

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

Research in this Project complements other Army Directed Energy efforts conducted under (PE) 0602150A (Air and Missile Defense Technology)/Project DC1 (Next Generation Directed Energy Concept Development and Analysis).

Research is performed by the United States Army Space and Missile Defense Command - Technical Center (USASMDC-TC) in coordination with Rapid Capabilities and Critical Technologies Office (RCCTO).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2023**	**FY 2024**	**FY 2025**
Title: SMDC In-house Laboratory Independent Research (ILIR)	1.015	1.068	1.098
Description: This effort provides ILIR at USASMDC-TC. This basic research on lasers and directed energy lays the foundation for future developmental efforts on high energy lasers and directed energy systems by identifying the fundamental principles governing various scientific phenomena with the goal of developing technologies that will significantly revolutionize laser weapon systems of the future.			
FY 2024 Plans: Continue Basic Research of DE Technologies. Will compare vertical path optical turbulence boundary layer data to advanced models with a high fidelity of accuracy in location, terrain, and meteorological data as inputs. Update Numerical theory as data is fitted to current models. Will evaluate data collected with the Ultra Short Pulsed Lasers (USPL) to better understand the interaction with the atmosphere and other materials to better understand the applicability of weaponization.			
FY 2025 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA2 / *ILIR - SMDC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will conclude research effort on vertical path optical turbulence and transition to a 6.2 effort. Will investigate beam control techniques to enable use of a supercontinuum laser in a HEL weapon. Will examine propagation phenomena of pulsed lasers with varying parameters such as wavelength, pulsed width, repetition frequency, and energy. Complete studies on the interaction of pulsed lasers with various materials. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Fiscal Year 25 increase aligns the program with Army modernization priorities in support of the National Defense Strategy.			
Accomplishments/Planned Programs Subtotals	1.015	1.068	1.098

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army											Date: March 2024	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA3 / *Single Investigator Basic Research*			
COST ($ in Millions)	**Prior Years**	**FY 2023**	**FY 2024**	**FY 2025 Base**	**FY 2025 OCO**	**FY 2025 Total**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**Cost To Complete**	**Total Cost**
AA3: *Single Investigator Basic Research*	-	94.959	108.599	108.011	-	108.011	113.024	123.931	127.768	133.646	0.000	809.938

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 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 competency areas of Biological and Biotechnology Sciences; Electromagnetic Spectrum Sciences; Energy Sciences; Humans in Complex Systems; Mechanical Sciences; Military Information Systems; Network, Cyber, and Computational Sciences; Photonics, Electronics, and Quantum Sciences; Sciences of Extreme Materials; Terminal Effects; and Weapons Sciences. The breadth of this basic research program covers approximately 800 active, ongoing research grants and contracts with leading academic researchers and approximately 2,500 graduate students and 1,100 post-doctoral fellows yearly, supporting research at nearly 210 institutions in 50 states.

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

Project is performed by the Army Research Laboratory (ARL).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2023**	**FY 2024**	**FY 2025**
Title: Basic Research in Life Sciences	10.975	11.721	11.686
Description: This effort fosters 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 that pursues fundamental studies in molecular and systems biology, and genetics, ii) neurosciences research to investigate the physiology underlying perception, neuro-motor output, and potential methods of monitoring cognitive states during activity, iii) biochemistry research focused on studies in structural and cell biology, metabolic processes, and biophysics, iv) research in microbiology that pursues studies in microbial physiology, ecology, and evolution, v) social science research that aims to elucidate the social, cultural, and other influences to human actions, and vi) auditory and signal processing research that maps the cognitive implications of multisensory information integration.			
FY 2024 Plans: Will determine how interspecies electron transfer influences the architecture of a microbial community on an electrode, that if successful may enable the development and control of novel biofilms for improved microbial fuel cells and bioelectrical sensors; investigate the neurophysiological mechanisms that enable human and non-human primates to monitor and recognize other's emotions and exploit this information to regulate one's own behavior during social interactions in close-to-natural contexts that if successful, will inform models of human-human teaming and training; determine the genetic and external factors that influence			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
mitochondrial cellular thymidylate synthesis that lead to changes in mitochondrial genome integrity and mitochondrial function, which if successful will enable non-invasive strategies that reduce mitochondrial damage in order to be able to meet the energy demands of brain and muscle tissues to enable optimization of soldier cognitive and physical performance capabilities; determine the role of hydrophobic-hydrophilic balance in guiding shape-change of silk-elastin copolymers in response to specific stimuli, and to modulate the kinetics of these changes, that if successful may provide the foundation for tailored biomaterial properties for future sensors, functional coatings, and on-demand material manufacturing. ***FY 2025 Plans:*** Will examine control of cellular envelope and deoxyribonucleic acid supercoiling by cellular magnesium in pathogenic species to determine mechanisms by which cellular growth can be manipulated and controlled; investigate the directed evolution of thiamine-dependent proteins into artificial metalloenzymes to enable new-to-nature chemical transformations, which may yield to novel catalytic routes for synthesis of Army-relevant energetic materials, material precursors, polymers, and composites; study the impact of gut microbial metabolites, particularly short chain fatty acids, on key cognitive and behavioral core functions (e.g., working memory, cognitive flexibility, and response and cognitive inhibition) under acute stress conditions; identify the genes and genetic networks involved in microbial polyurethane degradation and construct optimized synthetic communities of microbes that can efficiently degrade polyurethane, that if successful will enable novel bio-based methods for extending the material lifetime. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.			
Title: Basic Research in Chemical Sciences ***Description:*** This effort fosters 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 2024 Plans:*** Will elucidate the organization and dynamics of confined fluids in nanoporous environments at freezing conditions to probe the mechanisms underlying the immobilization of contaminants such as aqueous hydrocarbons and gasses such as carbon dioxide and methane, that if successful will enable improved storage for hydrocarbon fuels in cold climates; uncover the molecular-level mechanism of reconfiguration in self-healing and reconfigurable materials from both single layer materials and multi-layer self-healing structures that if successful, will enable the design of future materials for use in sensors and chem-bio defense applications; synthesize high entropy perovskite oxide nanosheets that are large area, high quality, and ultrathin and assess candidate 2D oxide nanosheets for their potential as electrocatalysts, that if successful will enable increased performance and	10.361	10.587	10.670

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
functionality in future electrochemical energy conversion devices including batteries, fuel cells, electrolyzers, and chemical sensors. ***FY 2025 Plans:*** Will investigate the adsorption of biomolecules and their reaction and transformation pathways on different mineral surfaces (i.e., oxides, clays, and carbonates) to better understand how surface-biomolecular interactions impact biomolecule transformations; design and synthesize novel two-dimensional (2D) high entropy materials capable of catalyzing both oxidation and reduction reactions for electrochemical energy conversion and storage; develop new supramolecular approaches and scaffolds that enable the ability to predictably activate chemical reactivity in response to specified external cues; design and synthesize a new class of mechanically robust adaptive polymeric materials, that if successful will enable novel materials with advanced tailorable functionalities (i.e., ability to heal and reprocess, mechanical adaptability, and mechanical defect sensing). ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Basic Research in Physics ***Description:*** This effort fosters 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 2024 Plans:*** Will systematically study the potential of a novel quantum-optical neuromorphic optimization implementation which employs a unique multimode cavity to couple atoms via intracavity photons to act as an associative memory that, if successful, may serve as a fundamental neural network suitable for use in optimization problems, such as Army logistics, distribution, and routing on the battlefield; assess a new class of matter-wave interferometer in which ultracold lithium atoms are continuously trapped in a modulated lattice with a sculpted band structure to enable the attainment of new regimes of precision and control that if successful, will enable new methods for precision inertial navigation; determine the rules and guidelines for developing volumetric meta-optics and investigate both the opportunities and challenges provided by the 3D optical design space that if successful, will enable new sensing methods in the future battlefield. ***FY 2025 Plans:*** Will investigate meso-scale magnonic topological insulator materials and explore their utility to enable the first-ever assessment of topological magnon edge states and topological magnon devices; study the interplay between complex light fields and metamaterials and explore the physical properties of 3-Dimensional (3D) structured light, which if successful, may enable new paradigms in optical devices and communication systems; examine measurement-induced phase transition as a means of discovering and characterizing entanglement dynamics in quantum many-body systems; investigate magnet-less ring-resonator-	12.488	13.220	13.194

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
based isolators and circulators for superconducting quantum devices to enable ultralow insertion loss and minimal shielding, that if successful will provide a novel approach to addressing current scaling challenges in quantum information systems. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.			
Title: Basic Research in Electronics and Photonics ***Description:*** This effort fosters 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 2024 Plans:*** Will explore the ability to stack-engineer the interaction between vibrational motion and electronic states in van der Waals thin layers that if successful could enable new quantum sensors; study the electrical impedance of biological cells over a broad range of frequencies under mechanical stimulation that if successful could lead to new ways of manipulating cell behavior; examine the use of balanced coherent detection to enhance photonic analog tensor accelerators that if successful could improve the accuracy and speed of artificial neural networks; study the relationship between the circular photogalvanic effect in topologically non-trivial materials and the heterostructure configuration that if successful could enable new smaller polarization sensitive photodetectors; investigate comprehensive mapping of bioelectric fields and engineer consciousness down to a single cell level, via precisely understood and controlled bioelectric fields in a community of cells. ***FY 2025 Plans:*** Will investigate the design, arrangement, and structural/optical properties of Aluminum Gallium Nitride (AlGaN) quantum dot epitaxial nanoridge waveguide laser structures, and assessment lasing operation in the mid and deep ultraviolet (UV) spectrum; investigate and design a bioelectronic synaptic system capable of neuromorphic computing capabilities to examine dynamic physiological profiles in stress response, that if successful will enable a novel mechanism for stress classification and human performance monitoring; study the underlying mechanisms of shift current generation in real-world materials to enable shift-current based ultrafast photodetectors capable of operating at room temperature in the infrared (IR) spectral range; examine novel physical mechanisms permitted by the coupling of functionalities in paraelectric, ferroelectric, and magnetic two-dimensional (2D) semiconductors; explore bioelectric signaling mechanisms across different taxa to determine how these non-verbal signals facilitate communication. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.	9.324	9.312	9.276
Title: Basic Research in Materials Sciences	13.314	14.089	14.073

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
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 2024 Plans:*** Will investigate the use of self-assembly techniques to create colloidal crystals with "diamond lattice" symmetry to fabricate photonic crystals with a full 3D photonic band gap at infrared and optical frequencies that if successful, could enable new classes of materials for applications in directed energy, control over thermal and optical emission, and 3D integrated photonic circuits; determine if and how responsive peptide crystals can exhibit induced fit binding and reactivity as enzyme-inspired catalytic materials to support condensation reactions, which if successful, will provide new molecular sensing modalities and reconfigurable systems and materials; investigate the physics of rigid granular flow through mechanical experiments on 3D systems of complex-shaped grains and through discrete element modeling that if successful, could enable damage adaptive Soldier and vehicle protection systems or reconfigurable robotic platforms; employ atomistic theoretical modeling approaches and realistic simulations to understand light-matter interactions in advanced materials such as functional dipolar systems that if successful, will enable novel opto-ferroic devices, especially ultrafast, nonvolatile ferroelectric memories; conduct vibration experiments to create ordered arrangements of spherical particles as templates for polymer and metallic lattice structures designed to provide high mechanical strength at extremely low mass that if successful, will establish a new processing method for the fabrication of extremely lightweight macroscale structural concepts that previously have only been fabricated at the microscale. ***FY 2025 Plans:*** Will explore a new class of amorphous coordination polymers with tunable and programmable electronic and magnetic properties; design and synthesize liquid crystal elastomer materials with embedded photonic crystals and local head control, and study the ability of these materials to dynamically change color and/or surface texture; study the influence of electromagnetic fields on the crystallization process during ceramic material formation to better understand how crystal nucleation influences the final ceramic properties; investigate neuromorphic metasurfaces capable of performing computations using both elastic and inelastic mechanical loads, that if successful will enable materials capable of performing and adapting in extreme or remote environments where conventional electronics and associated equipment may be prohibitive or impossible to utilize; study the impact of municipal development and atmospheric phenomena on mass, energy, and momentum exchange processes in urban environments, that if successful will help predict urban climate variability. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.			
Title: Basic Research in Mechanical Sciences	9.124	11.248	11.023

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Description: This effort 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 2024 Plans:*** Will study the flow physics of force generation and aeroacoustic noise of small rotors that if successful could enable new modeling and analysis tools for improving small rotorcraft; investigate principles of dual energy and information processing in far-from-equilibrium systems such a robot swarms that if successful could enable robotic materials with computational abilities; construct a novel physics-based crystal plasticity model of precipitation-strengthened metals which if successful could enable new lightweight materials for protection; study how high-frequency seismic waves are produced in sheared granular flow which could enable better understanding and sensing of the seismic signature of ground vehicles; develop new mathematically robust computational tools and the corresponding validative experiments to predict complex material phenomena and behaviors in extreme environments. ***FY 2025 Plans:*** Will develop a new random probability distribution modeling framework that enables the systematic description and integration of model uncertainties in molecular dynamics simulations, that if successful will provide simulation-based predictive capabilities for robust material design and multiscale mechanistic studies; investigate the principles of dissipative self-assembly and space-time synchronization in collections of self-spinning motors that may enable new concepts in topological active matter; develop network theoretic methodologies and models to better understand the fundamental and dominant pathways of energy transfer and the inter-connectedness of energy transfer interactions in complex vortex-dominated flows; investigate the interaction of low-frequency shockwaves and laminar separation bubbles for a range of Mach numbers to determine the physical mechanisms of bubble bursting and compressibility effects; examine the role of nonlinear solid mechanics and irreversible deformations in phase separation that if successful could permit autonomous patterning of synthetic structural materials. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.			
Title: Basic Research in Computing Sciences ***Description:*** This effort 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 and situation awareness. ***FY 2024 Plans:*** Will explore extending causal modeling to describe a much larger class of phenomena and show how causality can be applied to a variety of domains, including security and fairness that if successful, could discover meaningful relationships from data,	7.358	7.335	7.389

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
assessing system failures, determining fairness, and building robust and secure autonomous software agents; develop a framework that will feature an expert-in-the-loop capability to address the challenges related to building causal models that if successful, could disentangle cause-effect relations from observational data to both predict and explain affective polarization; develop a geometric terrain model for natural terrain that extracts, learns, and compresses topological features and supports scalability and fast information retrieval that if successful, could produce novel approaches to modeling the terrain for use in the autonomous vehicles and modern intelligence gathering; develop a comprehensive theoretical and algorithmic framework for learning fine-grained instructions from uncurated long procedural videos with minimal to no supervision that if successful, could enable more robust human-agent teaming by increasing the throughput for training new skills of the machine. ***FY 2025 Plans:*** Will develop machine learning algorithms capable of accurately processing highly uncertain data and mathematically guaranteeing well-calibrated predictions under practical conditions; create robust machine learning models that can analyze and learn relationships across data input components and develop methods for enforcing consistencies when making inferences relating to security, that if successful will significantly harden data models for better cyber resiliency; develop new estimation methodologies and algorithms for learning a model of dynamic decisions with hidden states, that if successful could improve predictions of the state of the environment and the human decision makers, allowing intelligent agents to devise more effective strategies to assist human teammates; develop a unified framework for cooperative lifelong learning theory and practice that if successful will permit adaptable, computation-efficient multimodal information fusion systems. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Basic Research In Network Sciences ***Description:*** This effort 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 2024 Plans:*** Will leverage advances in dynamic analysis, machine learning, cognitive models, and adaptive planning and control to synthesize, plan, assess, and adapt deception mechanisms with minimal human intervention to manipulate and mislead adversarial decision making that if successful, could lead to degrading adversarial decision making or situational awareness; develop novel computational methods to facilitate maximum likelihood estimation when more than half of the network data is missing that if successful, could enable more accurate situational awareness of a given social network from less intelligence data; develop an information theory of multidimensional spatial networks, extending into two- and three-dimensions, particularly spatial network entropy that if successful, could be applied to problems such as wireless communications network topology compression to	11.470	12.017	13.132

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
increase robustness of those networks; develop concepts and methods to model and control networked oscillatory systems with potential applications in computing, power systems, and biology that if successful, could enable novel methods in decision and control theory; investigate methods and techniques that will enable spectrum space radio frequency (RF) signal interrogation and the subversion of the sensing and computational components of systems that if successful, could prevent the identification and tracking (surveillance) of mission personnel; research the interaction between adversarial statistical signal processing and inverse reinforcement learning in cognitive sensing that if successful, could lead to a reconfigurable sensor that dynamically adapts its sensing mechanism by using stochastic control to optimize its sensing resources; investigate co-design of communications and radar signals so they to coexist that if successful, could reduce radar and communication interference while maintaining each having its own individual signal. ***FY 2025 Plans:*** Will develop new models, based on algorithmic game theory and machine learning, capable of strategic decision making in adversarial environments marked by uncertainty and information asymmetry; identify metrics, tools, and methods to enhance network resilience that accounts for scenarios with different amounts of knowledge and leverages variable actuation and network topologies, that if successful will provide insights into mechanisms for hardening and securing communication networks; design both supervised and unsupervised advanced machine learning algorithms to solve the optimal allocation problem in fragmented mobile networks; examine the combination of fundamental insights and models of team behavior from the social sciences with machine learn and dynamical systems methods to develop a theory of human-artificial intelligence (AI) team coordination in complex cognitive tasks; investigate the integration of deep neural networks with relational, symbolic representations from classical AI to leverage positive attributes of both that if successful will enable more flexible, robust, and adaptive AI; explore deep learning as a tool for the design of novel communication algorithms capable of extended range, increased reliability, and adaptation; investigate a non-Markovian model-based reinforcement learning framework that if successful will permit enhanced safety and reliable control of autonomous systems and cyber-physical systems. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase supports additional research in the area of network resilience.			
Title: Basic Research in Mathematical Sciences ***Description:*** This effort fosters 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 2024 Plans:*** Will investigate some of the fundamental questions involved in multimodal optimization, with the goal of enabling global optimization in the presence of separated local optima and non-smooth objective functions that if successful, could enable	7.868	8.173	8.229

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
more optimized models and algorithms in machine learning for areas such as mean time between failure and component wear; determine the fundamental law(s) of biology which create a well-defined relationship between motor/actuator mass and motor force over 25 orders of magnitude in mass and which hold for diverse species, individual biomolecular motors, and even extend to man-made motors that if successful, could improve the performance of macroscale motors of all types in biological systems; create a homotopical certification of algorithms used in complex data analysis that if successful, could improve the analysis of data generated by quantum information systems; investigate the design and interaction of radar signals and communications that if successful, could lead to a better understanding of category theory, in the context of algorithms, error correction, and complexity, such as are present in quantum information; develop personalized optimal regulation strategies for circadian rhythms and the related processes that if successful, could detect and mitigate the impacts of mild traumatic brain injury; develop a framework to mathematically summarize prior information that is easily combined with information in a current data set that if successful, could provide the statistical analysis techniques needed to analyze imagery to determine whether an object, such as a vehicle is present or not present, thus increasing robustness of situational awareness. ***FY 2025 Plans:*** Will develop mathematical models to study the information processing capability of coupled guanosine triphosphate hydrolase enzyme (GTPase) switches which will enable critical insights into the biochemical and/or mechanochemical events that enable precision in cellular decision-making; explore the integration of statistical mechanics with physics-informed machine learning to enable learned coarse-grained non-equilibrium macroscale models with enhanced accuracy and extrapolative power; employ ideas and techniques from noncommutative geometry to advance the understanding of quantum transforms, explore new avenues of constructing new periodic and non-periodic systems, and investigate the mathematical structures that underly exotic states of matter which may have important implications for the discovery of new materials; examine origami structures to derive a general theoretical design framework that if successful will inform engineering design capable of scaling across multiple orders of magnitude; investigate complex turbulent systems with pre-determined physics to develop robust nonlinear stochastic forecast and data assimilation models. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: HBCU/MI Single Investigator	2.677	5.105	3.225
Description: This effort supports extramural basic research to create and exploit new scientific discoveries from Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) that will improve the Army's transformational capabilities. Areas of interest include chemical sciences, computing sciences, electronics and photonics, life sciences, material sciences, mathematical sciences, mechanical sciences, network sciences, and physics. ***FY 2024 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will identify and support competitively-selected extramural research conducted at HBCU/MI institutions to provide increased knowledge and understanding in fields related to long-term future force needs; support faculty immersion program where HBCU/MI faculty are aligned with R-1 universities and Army research laboratories in order to grow organic research capabilities at the HBCU/MI institutions and contribute to the long-term Army modernization priority needs; increase infrastructure and research support to establish true partnerships and expand capacity at HBCU/MI institutions. ***FY 2025 Plans:*** Will expand the research base of partner institutions particularly among R2 and HBCU performers, targeting principal investigators new to the Army to provide increased knowledge and understanding in fields related to long-term future force needs; continue supporting faculty immersion program where HBCU/MI faculty are aligned with R1 universities and Army research laboratories in order to grow organic research capabilities at the HBCU/MI institutions and contribute to the long-term Army modernization priority needs; continue to increase infrastructure and research support to establish true partnerships and expand capacity at HBCU/MI institutions. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease in FY 2025 reflects reduction in infrastructure support as infrastructure changes were accomplished in the previous fiscal year.			
Title: Energy Sciences ***Description:*** This effort supports studies to enable the design of novel materials for energy storage and generation through development of isomers where manipulations to half-life enables the molecules' energy to be harvested, the creation of multi-fuel tolerant electrodes for fuel cells and batteries to avoid contaminant poisoning while preventing electrode degradation, and the emergence of multivalent electrode chemistries and their electrolytes to achieve a higher capacity battery without issues related to dendrite formation, electrode degradation, and long life as a recharge asset. ***FY 2024 Plans:*** Will dynamically control isomer atomic state population through external means by manipulating the interplay between atomic and nuclear degrees of freedom, beginning with the use of nuclear excitation by electron capture to switch isomers into energy-output states, followed by achieving a change in the half-life of the isomer into a shorter-lived state; design electrolytes and their interfaces to avoid degradation for multivalent electrode chemistries that if successful, will reveal new chemistries to enable higher capacity batteries while avoiding degradation; explore new nitride ferroelectric and anti-ferroelectric materials with enhanced polarization, temperature stability, and robustness. ***FY 2025 Plans:*** Will explore the synthesis and characterization of new materials, taking advantage of the multi-pathway conductive nature of rare earth oxides towards novel single-phase oxides suitable for electrode and electrocatalytic applications such as novel batteries and fuel cells; conduct research on reversible non-passivated electrodeposition of highly reducing multi-electron redox couples	-	2.792	2.607

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
to enable use of these materials to achieve high-capacity systems; investigate mechanisms to achieve half-life modification of materials that allow for energy release on demand by understanding how to manipulate those materials by electron interactions affecting their energy states. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects the planned lifecycle of the effort.			
Title: HBCU/MI Early Career Award for Science and Engineering ***Description:*** The HBCU/MI Early Career Award for Science and Engineering (HBCU/MI ECASE) is modeled from the Presidential Early Career Award for Science and Engineering (PECASE) award, which embodies the high priority placed by the government on maintaining the leadership position of the United States in science by producing outstanding scientists and engineers and nurturing their continued development. The HBCU/MI ECASE awards will specifically seek outstanding U.S. citizen scientists and engineers beginning their careers at HBCU/MIs. Each award will provide significant support for students and internships within DEVCOM ARL or at Army-funded academic laboratories. ***FY 2024 Plans:*** Will support basic research contributing to Army modernization needs conducted by outstanding scientists and engineers beginning their careers at HBCU/MI institutions; award 8 new HBCU/MI Early Career Awards at a cost of $1.1875M each over a duration of 5 years. ***FY 2025 Plans:*** Will continue supporting basic research contributing to Army modernization needs conducted by outstanding scientists and engineers beginning their careers at HBCU/MI institutions through HBCU/MI Early Career Awards at a cost of $1.1875M each over a duration of 5 years. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase in FY 2025 reflects additional research in Army relevant problems being conducted by HBCU/MI Early Career Awards recipients.	-	1.000	1.503
Title: Minerva Research Initiative (MRI) ***Description:*** The MRI is a university-based social science research program initiated by the Secretary of Defense. It focuses on areas in the social sciences of strategic importance to national security policy. It seeks to increase the Department's intellectual capital in basic social science research to address future challenges by bringing together universities in multidisciplinary approaches to address global social and geopolitical questions. MRI will bring together universities, research institutions, and individual scholars to support multidisciplinary and cross-institutional projects addressing specific topic areas determined by the Department.	-	2.000	2.004

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
FY 2024 Plans: Will investigate individual and group generated methods and signals (such as open-source data, geophysical signals, spatial data, population mobility patterns, and/or bioinformation) to predict when, where, and how conflict is likely to emerge. ***FY 2025 Plans:*** Will support fundamental research to understand and model the cross-level influences ranging from individuals to small groups to large populations on emergence and sustainment of factors predictive of nation-state and non nation-state characteristics (such as stability, interests, and potential for conflict). ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Accomplishments/Planned Programs Subtotals	94.959	108.599	108.011

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army											Date: March 2024	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA4 / *Training and Human Science Research*			
COST ($ in Millions)	**Prior Years**	**FY 2023**	**FY 2024**	**FY 2025 Base**	**FY 2025 OCO**	**FY 2025 Total**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**Cost To Complete**	**Total Cost**
AA4: *Training and Human Science Research*	-	21.677	21.024	19.865	-	19.865	19.517	21.654	22.132	22.493	0.000	148.362

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 integration with intelligent technologies and autonomous agents. This Project researches optimal methods for information exchange between Soldiers and intelligent technologies including 1) human performance in automated, mixed-initiative (human control-machine control) environments; 2) visual scanning and target detection; 3) performance-related Soldier state changes; 4) integration across multiple sensory modalities; and 5) collaborative (team) and independent multi-task, multi-modal, multi-echelon Soldier-system performance - all cast against the influx of emerging intelligent technologies and autonomous systems. 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. 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 critical aspects of human-agent teaming.

In the area of translational neuroscience, 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 for 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.

This Project also investigates 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

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

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.

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

Work is performed by the Army Research Laboratory (ARL), and Army Research Institute for the Behavioral and Social Sciences (ARI).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Translational Neuroscience	4.162	4.399	4.329
Description: This effort integrates neuroscience with traditional approaches to understanding Soldier behavior to enable system designs that maximize Soldier performance. ***FY 2024 Plans:*** Will combine multiple models of abstract representation into a single unified map to simulate spatial reasoning; create neural network with features that mirror the mammalian spatial reasoning system to improve network performance in a spatial reasoning task; investigate the inter-brain system interactions underlying human-technology systems solving complex problems with creative solutions. ***FY 2025 Plans:*** Will expand simulation models to generate novel abstract mapping relationships that go beyond what has been observed in mammalian brain activity; expand the capabilities of brain inspired spatial reasoning neuronal networks to include tasks that require flexibility and adaptation; explore the translation of breakthroughs in understanding multi-timescale and time-invariant mathematical relationships in the brain to represent human technology coordination. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.			
Title: Human System Integration	4.494	4.228	4.048
Description: This effort applies 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 informational approaches to extend the scope of interaction beyond individual systems to the full network context. ***FY 2024 Plans:*** Will generate models and approaches capable of predicting changes in the adaptation state of human-human teams over time using neuro/physiological measurements; investigate the emergent properties of non-linear machine and human performance			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
across tasks unique to the capabilities of machines and humans; examine human-system mutual adaptation in response to varying human-in-the-loop adaptive paradigms; generate models and approaches that enable stable machine learning from sparse group feedback. ***FY 2025 Plans:*** Will investigate extending single agent human-guided machine learning techniques to multi-agent reinforcement learning settings; explore novel approaches to integrate generative language models and human feedback to speed up learning; create algorithms to incorporate ranking-based feedback from small groups of humans for the adaptation of multi-agent systems; explore ensemble-based techniques to improve uncertainty-based reasoning for human-guided machine learning. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.			
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***Description:*** This effort investigates technologies that provide the foundation for future Army systems to adapt to individual Soldier states, behaviors, and intentions in real-time. Enable high fidelity, continuous prediction that can account for continuous changes in Soldier physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. ***FY 2024 Plans:*** Will quantify improvements of predictive models that transfer knowledge based on measurements over long timescales (e.g., 1 month) to the performance of tasks measured over shorter timescales; characterize the generalizability of complexity matching for behavior prediction better than current state-of-the-art across diverse tasks and measures; improve predictive models of individual performance and long term ability over models based on typical sample sizes (n < 100) by using very large sample sizes (n > 100,000). ***FY 2025 Plans:*** Will explore initial ideas for the application of theory-driven approaches and methods to the analysis of very large datasets to identify the potential for generalizability of approaches across a wide range of human-centric data sets; assess computational/ statistical models consistent with a theory-driven Big Data framework to establish initial empirical baselines. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned support of the creation of Human-Agent Interactions and Trust for Scalable Cross-echelon Command and Control in PE 0601102A Project AA9 Information and Networking.	4.571	3.248	2.062
Title: Novel Forms of Joint Human-Intelligent Agent Decision Making ***Description:*** This effort investigates 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	1.042	1.062	1.068

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
performance. This effort emphasizes deep learning approaches that function under conditions of limited, mismatched, or dynamic data. ***FY 2024 Plans:*** Will investigate techniques using human feedback that will enable a human to easily train and adapt multi-agent systems that can be generalized to perform a variety of teaming tasks with minimal training. ***FY 2025 Plans:*** Will investigate distributed forms of information processing where joint human-intelligent agent decision making is performed while aggregating informational elements from many human and non-human sources. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects an economic adjustment.			
Title: Hybridization of Team Thinking ***Description:*** This effort merges novel advances in human-system sciences with neuroscience and training sciences to reconceive human brain processes and optimize human-machine thinking to allow humans to influence technology enabled decisions previously believed to be outside of human capabilities. The effort aims to optimize how humans could think within complex human-technology ecosystems to maximize human potential to adapt the Army on the battlefield. ***FY 2024 Plans:*** Will investigate the limitations of machine and augmented human intelligence in a complex decision-making task; investigate the hybridization of the capabilities of multiple humans with machine intelligence to increase the speed of decisions; perform experiments that hybridize the human learning process with technology to more rapidly adapt to changing conditions in open-ended scenarios. ***FY 2025 Plans:*** Will investigate large-scale, multi-human, multi-agent complex decisions that require many diverse and complex subtasks; perform experiments that target surveying a large decision space and rapidly settle on creative solutions in a hybrid human-technology complex scenario; investigate avenues of decision correction with rapidly evolving contextual and/or environmental changes across a hybrid human-technology team composed of many humans and intelligent entities. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects an economic adjustment.	2.259	2.914	3.142
Title: Science of Measurement of Individuals and Collectives	2.092	2.100	2.107

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Description: This basic research effort develops advanced psychometric theory and measurement of Soldiers and teams in order to maximize talent management. ***FY 2024 Plans:*** Will conduct research to develop novel approaches to measurement of cognitive and non-cognitive knowledge, skills, and abilities. ***FY 2025 Plans:*** Will conduct research on novel approaches to assess multiple cognitive (e.g., ability to learn new information) and non-cognitive (e.g., personality) constructs; will conduct research to improve prediction of individual and team performance. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects an economic adjustment.			
Title: Understanding Multilevel and Organizational Dynamics ***Description:*** This basic research effort develops advanced methods and models to understand the relationship of human states, traits, and behaviors on individual, group, and organizational dynamics. ***FY 2024 Plans:*** Will conduct research to develop new methods and computational models for assessing, predicting, and optimizing team and organizational dynamics and operational effectiveness. ***FY 2025 Plans:*** Will conduct research to improve scientific models of organizational functioning (e.g., team and multi-team performance and organizational effectiveness). ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects an economic adjustment.	2.045	2.000	2.079
Title: Formal and Informal Learning and Development ***Description:*** This basic research effort develops a holistic model to understand and inform individual and group learning across assignments, platforms, and contexts throughout the career span. ***FY 2024 Plans:*** Will conduct research to develop theory and practices conducive and specific to adult learning. ***FY 2025 Plans:***	1.012	1.073	1.030

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will conduct research to optimize learning and development across the lifecycle of a Soldier's career. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease supports planned lifecycle of the effort.			
Accomplishments/Planned Programs Subtotals	21.677	21.024	19.865

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army			Date: March 2024
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA5 / *Biotechnology and Systems Biology*	

COST ($ in Millions)	Prior Years	FY 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total	FY 2026	FY 2027	FY 2028	FY 2029	Cost To Complete	Total Cost
AA5: *Biotechnology and Systems Biology*	-	6.366	6.547	8.999	-	8.999	9.007	9.941	9.904	9.999	0.000	60.763

A. Mission Description and Budget Item Justification

This Project conducts fundamental research of biological systems and materials engineered for transformational Army capabilities. This Project focuses on technical core competencies including: Materials from Biology; Biological/Abiological Interfaces; Systems Biology; Computational Biology; Synthetic Biology, and how those competencies address Army needs to reduce logistics burden, increase situational awareness, and improve protection. Research will advance from manipulation of single microorganisms to designed microbial consortia for conversion of flexible feedstocks (indigenous and waste) into consistent products for energy and agile expedient manufacturing; advancing from the production of individual small molecules to gradient/precision/specialty materials for production of hierarchical and metamaterials for sensing and protection; and advance from laboratory use to ruggedized organisms and materials for field deployment enabling dynamic, responsive materials, advanced sensing, and materiel protection/denial. Further, understanding the state-of-the-art in genetic engineering and control of biological systems in military environments will allow for understanding the pacing synthetic biology threat to the future operating environment.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Engineered Biotechnology	2.722	2.788	2.873
Description: This effort investigates biological materials for devices and sensors that can be used in the future by the Army to improve force protection and reduce logistical burden. Investigates biological construction of novel materials, structures, and processes for future development of biologically derived materials, sensing materials, information processing, and power and energy to transcend critical gaps in adaptability, manufacturability, and stability in Army relevant environments.			
FY 2024 Plans: Will investigate the relationship of environmental parameters on modulated microbes and natural communities; investigate sense and respond processes in modulated organisms and how they affect material specific communities and the strength of the response; design community models for modulating the response.			
FY 2025 Plans: Will explore the effects of altering communities of environmental microbes to achieve predictable responses and build an understanding of community interactions towards predictive models; continue to investigate sense and respond processes and			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA5 / *Biotechnology and Systems Biology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
mechanisms in modulated organisms and identify targeted affects for models; identify novel pathways from natural organisms for modulation of environmental microbial communities. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Synthetic Biology for Dynamic Materials ***Description:*** This effort researches the concept of responsive materials imparting living functions for operation in Army-relevant environments to enable 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 2024 Plans:*** Will continue to investigate novel synthetic biology control mechanisms for indigenous (local to Army environment) organisms and tune the synthetic biology tools for temporal and or spatial control; study how control mechanisms for indigenous organisms function in laboratory contained environments in the presence of natural communities; investigate synthetic biology tools for in situ modification of indigenous organisms and study specificity of these tools; pioneer synthetic biology tools for new Army relevant sense and reporter mechanisms. ***FY 2025 Plans:*** Will use synthetic biology to investigate and tune novel sense and reporter mechanisms to expand range of processes for modulation of organisms; study the effects of control mechanisms on the temporal and spatial control of the new sense and respond mechanisms in organisms across Army environments; study how sense and respond mechanisms affect organisms and their environment over time and distance; continue to investigate synthetic biology tools for in situ modification of microbial communities and study specificity, stability, and control of these tools. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.	3.644	3.759	3.754
Title: Complex Adaptive Mechanisms ***Description:*** Multi-disciplinary effort to understand and characterize emerging energy field biological effects to address the need to develop a mechanistic understanding, from the molecular/cellular level and beyond, which energy delivery can produce tracible biological effects. Discover transformational mechanisms by which energy fields affect biological function or structure, via experimentation, modeling, and simulation. Create knowledge products and materials towards sensors, energy scavenging, and other adaptive measures. Integrate physical and biological models with experimentation to understand energy propagation, coupling, and effects on biological materials and systems.	-	-	2.372

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA5 / *Biotechnology and Systems Biology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
FY 2025 Plans: Will establish laboratory facilities and equipment to investigate biological effects from energy fields; conduct initial laboratory experimentation at the molecular/cellular level to discover the mechanisms by which energy fields at frequencies higher than typically characterized in biological studies affect biological functions such as charge transfer; conduct initial assessment of laboratory data compared to ongoing modeling/simulation. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding realigned in FY 2025 from Ballistics Mechanics Research and High Deformation Rate Materials in PE 0601102A Project AA7 Mechanics and Ballistics, Beyond Novel Materials in PE 0601102A Project AA8 Sensing and Electromagnetics, and Assured Operations in the Physical Social and Cyber Domain in PE 0601102A Project AA9 Information and Networking.			
Accomplishments/Planned Programs Subtotals	6.366	6.547	8.999

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

N/A

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army			Date: March 2024
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA6 / *Robotics and Mobile Energy*	

COST ($ in Millions)	Prior Years	FY 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total	FY 2026	FY 2027	FY 2028	FY 2029	Cost To Complete	Total Cost
AA6: *Robotics and Mobile Energy*	-	21.458	25.268	27.522	-	27.522	27.565	27.592	27.865	28.144	0.000	185.414

A. Mission Description and Budget Item Justification

This Project fosters basic research to expand the Army's capabilities in the area of propulsion, platform mechanics, and autonomous air and ground platforms. This includes research to enable the investigation of risk-based design methodologies and control algorithms for enduring operation of rotorcraft and ground vehicles, artificial intelligence, and novel mobility mechanics to enable robotic systems to serve as productive embodied teaming agents. This effort researches propulsion and alternative energy systems to increase the reliability, efficiency, and survivability of air and/or ground platforms.

This Project also conducts research in support of advanced military vehicle technology with emphasis on 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.

The work in this Project supports Program Element (PE) 0602148A (Future Vertical Lift Technology), PE 0602145A (Next Generation Combat Vehicle Technology), and PE 0601104A (University and Industry Rsch Ctrs).

Work in this Project is performed by the Army Research Laboratory (ARL), Aviation and Missile Center (AvMC), and Ground Vehicle Systems Center (GVSC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Vehicle Propulsion and Power Research	1.603	1.706	1.718
Description: Basic research to investigate concepts and theories to provide enhanced tools, methods, and innovative concepts to enable improvements in propulsion power density, energy efficiency, reliability, and lifecycle costs for increased performance and capabilities in future Army systems.			
FY 2024 Plans: Will explore advanced combined-cycle aeroengine concepts; investigate full-engine simulations and engine component interactions for turbulent flow effects; investigate thermo-mechanical and electromagnetic characteristics of advanced ultra-high temperature ceramics (UHTC) and high entropy ceramics.			
FY 2025 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will explore modeling and simulation approaches to understand the interaction between high-speed aerothermodynamics and material surface at extreme temperature and austere conditions; examine control and actuation modalities for adaptive engine and morphing hypersonic systems; investigate experimental and computational methods to assess thermal, dielectric, oxidative and ablative properties of ultra-high temperature propulsion materials. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Novel multi-fuel tolerant small vehicle power ***Description:*** Basic research to enable highly efficient, multi-fuel conversion in small engines with reduced sensitivity to fuel property variation and extreme ambient conditions. This includes research to characterize and investigate extreme fuel properties on ignition chemistry, variable spark enabling concepts for robust ignition, and lightweight highly durable materials for reduced heat loss and wear characteristics. ***FY 2024 Plans:*** Will augment existing fuel ignition models with a greater range of fuels and improve fidelity of detailed and reduced order combustion simulations; investigate optimized small combustor geometry at expanded operating regimes; assess miniaturized in-line fuel sensor; assess component scale aluminum alloy production weights and volumes for aviation applications; identify chemical interactions between fuels and optimized materials to understand damage resistance when lubricated with lowest lubricity fuels; assess protective behavior between synergistic material pairs in complex geometries in fuels. ***FY 2025 Plans:*** Will characterize sustainable aviation fuel (SAF) ignition and integrate SAF into fuel ignition modeling; implement miniaturized fuel sensor and sensing models into engine control algorithms; assess thermo-mechanical and fatigue properties of advanced aluminum alloys in cast production conditions for aviation components; assess additive manufacturing process control impacts on lightweight alloy properties and performance for complex propulsion component geometries; determine the material and processing parameters of optimized materials for integration into complex mechanical interfaces under fuel lubrication. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.	3.119	3.163	3.183
Title: Fundamentals for Alternative Energy ***Description:*** Explore novel concepts in energy generation and capture 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 electrochemical materials and processes for energy storage and conversion, and new approaches for solar energy harvesting.	0.973	1.005	1.012

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
FY 2024 Plans: Will investigate the chemical mechanisms and impact of electrocatalytic and photothermocatalytic processes at nanocatalyst interfaces for relevant chemical reactions to energy conversion using electrochemical and spectroscopic methods; examine and assess the impact of broadening and excited configurations on the theoretical prediction of isomer switching efficiency using nuclear excitation by electron capture. ***FY 2025 Plans:*** Will experimentally examine photothermal electrocatalytic and thermocatalytic performance criteria for photocatalyzed chemical fuels to drive chemical reactions; validate nuclear excitation by electron capture theoretical models that add broadening and excited configurations to improve isomer switching efficiency predictions. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Reconfigurable Platform Mechanics and Propulsion ***Description:*** Basic research in reconfigurable platform mechanics and propulsion science to investigate technologies to enable subsystem configuration concepts for efficient hover and high-speed/range Vertical Take-Off and Landing (VTOL) aircraft. ***FY 2024 Plans:*** Will explore aeromechanics analysis and design tools for reconfigurable/morphing technologies to enable agile and weaponized kinematics platform; investigate bio-inspired active materials suitable for actuation mechanism that will enable complex dynamic behavior of air vehicles; design a methodology for mechanical systems to describe platform agnostic reflexive mobility. ***FY 2025 Plans:*** Will investigate interactional aerodynamics, system identification, and flight controls for vertical takeoff platforms that can transition from hover to wing-borne flight; explore attitude sensing and automated transition using traditional flight controls and machine learning-based flight control; explore machine learning based approaches to design a reconfigurable platform to traverse through a complex environment; investigate text inspired models for guiding the physics, structural design, and morphological control into an algorithmic design process and assess with a physics simulator. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.	1.027	1.061	1.068
Title: Robotics Autonomy and Human Robotic Interface Research ***Description:*** Basic research focused on enabling robust autonomous mobility for small and human-scale robotic systems, including autonomous teaming behavior with hybrid human-robotic teams. Enablers for robust autonomous mobility include	1.811	1.878	1.889

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
planning, behaviors, energy efficient maneuver, and the interface of manipulation technologies to support manned-unmanned teaming constructs. ***FY 2024 Plans:*** Will further assess algorithms that enable autonomous energy distribution between ground and air vehicles for sustained increase in operational duration, and identify methods for multiple size, weights, and types of robotic vehicles; examine the predictive capabilities and communication requirements of the algorithms for optimized vehicle route planning for robot teams which factor energy availability and mission constraints; continue to identify candidates for alternative power generation methods that will extend autonomous vehicle endurance in logistically uncertain and contested environments. ***FY 2025 Plans:*** Will validate algorithms that enable autonomous energy distribution between ground and air vehicles for sustained increase in operational duration; investigate algorithms for optimized vehicle route planning for robot teams which factor in energy availability into mission constraints; conduct experiments for alternative power generation methods that will extend autonomous vehicle endurance in uncertain and contested environments; explore methods of whole body manipulation autonomy for improved energy awareness. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Intelligent Systems ***Description:*** Pursue research in autonomous systems that supports and unburdens Soldiers in a flexible, robust, survivable, and comprehensive manner. This work addresses the cognitive requirements of humans and (non-human) agents, both hardware and software based, operating individually or in collaboration, on the battlefield. Emphasis is placed on perception, reasoning, and collaboration techniques that can apply to and transfer between a broad range of systems (i.e., adaptive communication and data collection networks; crowd-sourcing and information retrieval software agents; and predictive and explanatory decision support systems). ***FY 2024 Plans:*** Will continue to investigate alternative navigation techniques capable of assessing route options in partially known environments while adapting based on limited human examples and system safety criteria; further assess the best algorithms that allow for rapid adaptation to incomplete or unexpected semantic observations in the environment; study autonomous vehicle endurance metrics of navigation algorithms which utilize all available resources for route planning while assessing multiple courses of action to optimize system performance for longer planning horizons; investigate the best algorithms that intelligently share representations and distributed context to enable planning across multiple vehicles. ***FY 2025 Plans:***	6.326	6.652	6.801

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will explore new architectures and navigation techniques that are resilient to unexpected operational and environmental conditions; develop algorithms capable of determining salient observations over long duration (hours) of operation; develop methods and techniques for increasing robustness of state estimation with limited sensor inputs; continue to investigate novel metrics for measuring complex autonomous system performance across multiple novel system architectures; study potential applicability of limited human input for real time system adaptation; explore perception and reasoning approaches for legged robotic autonomy and methods for heterogeneous teaming for multi-domain maneuver. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Structurally-Adaptive Unmanned Air Systems Research ***Description:*** Basic research focused on topics that contribute to the body of knowledge required to create future intelligent, unmanned air systems that can effectively team with manned and unmanned aircraft, ground platforms, and human teammates. Emphasis is placed on topics of control and aeromechanics that expand the operational envelope for unmanned systems and enable maneuverability in complex, interactive, and mission relevant environments. ***FY 2024 Plans:*** Will continue to analyze the effects of unsteady environments that includes gusts, turbulence, and vehicle wakes, by performing basic research in a wind tunnel facility to identify active and passive control designs as well as novel maneuvers critical for advancing the underlying autonomy needs and design features; analyze newly created computational modeling methods, active flow controls, and passive vehicle structural designs to mitigate negative impacts of unsteady fight conditions through wind tunnel experiments; further examine concepts for small unmanned aerial systems (UAS) that include reconfigurable and resilient structures, super maneuverability, and extreme endurance; explore a machine learning computational framework driven design of UAS platform enabling increased agility of UAS; further investigation of evolutionary algorithms for design of autonomous platforms exhibiting reflexive agility and embodied intelligence to enhance mobility in terrain/environments, including control systems approaches and implications of air vehicle structures. ***FY 2025 Plans:*** Will investigate modeling and simulation software tools to enable structural, aerodynamic, and power and energy analysis of new concepts for small unmanned aerial systems (UAS) that include reconfigurable and resilient structures, super maneuverability, and extreme endurance; conduct basic experimental fluid mechanics studies leveraging dynamic model positioning to allow for the integration of control schemes in an aerodynamic test environment; investigate relevant unsteady fluid dynamics and structural responses to inform basic understanding of dynamic maneuvers like perching or small UAS at extreme range; investigate controls methods for extending small UAS mission life to include landing on a moving vehicle for energy resupply; explore topology	3.141	3.247	3.269

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
optimization tools to design a small UAS wing and/or tail reconfiguration in air to take advantage of environmental conditions to extend the range. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Air Mobility ***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 2024 Plans:*** Will conduct experimental investigations of the flow field surrounding a rotor hub to understand the effect of unsteady hub flow on the flow separation on fuselage/pylons, and to exploit these flow interactions in the hub wake to generate useful forces and moments; develop a formal uncertainty quantification framework to account for and document uncertainties in high-fidelity computational fluid dynamics (CFD) predictions to facilitate adoption of CFD for engineering applications. ***FY 2025 Plans:*** Will execute fundamental research in rotary-wing aeromechanics to lay the foundation for technologies relevant to future vertical lift such as advanced flow diagnostics and control techniques and automation for high-performance computing; conduct experimental measurements of interactional aerodynamics of multi-rotor and rotor-propeller configurations to validate complementary high-fidelity computational fluid dynamics simulations. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.	2.682	2.769	2.791
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency ***Description:*** Research in support of advanced military mobility technologies with emphasis on Terramechanics (vehicle-terrain interaction), and complex vehicle dynamics and simulation. This includes developing the data and underlying models to simulate and predict autonomous vehicle mobility in soft soil and complex organic terrain under a variety of environments. Research is directed at understanding advanced mathematical and computational methodologies using state-of-the-art analytical and empirical procedures. ***FY 2024 Plans:*** Will develop novel modeling and simulation computational approaches for complex, interdisciplinary, multi-physics, multi-scale systems, namely autonomous military ground systems in unstructured off-road environments; continue expanding the use of	0.776	0.803	0.850

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
gaming engine algorithms for enhanced off-road mobility and further development of terrain identification for Go-No Go map in unknown and changing environments; continue to research power and energy dense highly mobile systems for improved battlefield energy characterization, optimization, and control; expand the use of modeling and simulation tools to verify and validate performance of autonomous systems across the spectrum of use and alleviate the need for physical testing. ***FY 2025 Plans:*** Will continue investigating novel modeling and simulation approaches for autonomous military ground systems in unstructured off-road environments to include the development of novel computational approaches of multi-physics and reduced order models of ground systems, and the integrated use of gaming engine algorithms and modeling approaches for ground vehicle development and algorithm edge case development; continue researching novel and sustainable power and energy systems, expand the digital verification and validation of autonomous systems, and continue to enhance terrain identification and characterization methods and models for Go-No Go mapping of unknown and changing environments. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Foundational Energy for Sustained Operations	-	2.984	3.013
Description: Explore novel concepts in safe, domestic, high energy density storage and generation to meet and sustain the increasing energy needs of current and future Army technologies such as realizing electrification for autonomous systems, silent watch, and mounted/dismounted platforms. Conduct basic research on new materials for energy storage and generation through the exploration of isomers, multi-fuel tolerant materials, energy conversion approaches, rechargeable multivalent batteries, and conversion cathode battery chemistries. ***FY 2024 Plans:*** Will explore machine learning based analysis techniques and tools to accelerate processing of gamma spectroscopic data resulting from nuclear excitation by electron capture experiments; analyze experimental designs for implantation approaches to switch isomer materials based on nuclear excitation by electron capture; study electrode material candidates and design experiments that can investigate the impact on solid oxide fuel cell stack lifetime when operating from sulfur containing fuels at low temperatures; study multivalent battery chemistry candidates and explore electrolytes and additives that impact utilization and cycle efficiency; investigate conversion and hybrid cathodes and design experiments to investigate dissolution and degradation. ***FY 2025 Plans:*** Will explore candidate multivalent and beyond Lithium battery cathode chemistries that can improve performance and minimize supply chain constraints; conduct research on aqueous and non-aqueous electrolytes for multivalent and beyond Lithium chemistries to understand their interactions; study cycle behavior, utilization, and thermal dependence of multivalent and beyond Lithium electrodes; identify switching pathways within isomers with lifetimes of greater than 1 year that are compatible with nuclear			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
excitation by electron capture; establish baseline solid oxide fuel cell button cell performance and explore anode materials that improve resistance to coke formation and carbon sintering. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Reflexive Mobility of Platforms ***Description:*** Basic research focused on enabling a sustainable ecosystem of air/ground reconfigurable platforms for expeditious delivery to dominate over complex terrains. Explore concepts with integrated energy, sensing, and controls to not only provide actuation response but also possess biological type functions (adaptation, tunable stiffness). Conduct research in designing a platform with reflexive behaviors, distributed energy and control, 10x improvement in system energy density, and untethered and electric controls. ***FY 2025 Plans:*** Will explore distributed actuation schemes with multiple degrees of freedom; explore developing materials with continuous state, rather than discrete states (on, off, conductive, non-conductive); investigate reflexes as passive response to stimuli and incorporate intrinsic sensing using materials that can sense the environment and act on those sensations; investigate estimation and control (theory and implementation) and the ability to estimate the state based on sensory measurements and the system's state evolution in time; spread cognitive ability throughout the morphology of the system as low-level cognitive response and design the control policy to be encoded in the physical design. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding realigned to Reflexive Mobility of Platforms from Air Vehicle Structures and Dynamics Research within this Project. Funding for Air Vehicle Structures and Dynamics Research was eliminated from FY22-24 to fund higher priority artificial intelligence efforts in the Army. The funding for Air Vehicle Structures and Dynamics Research began again in FY 2025 at which point it was realigned to Reflexive Mobility of Platforms.	-	-	1.928
Accomplishments/Planned Programs Subtotals	21.458	25.268	27.522

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army			Date: March 2024
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA7 / *Mechanics and Ballistics*	

COST ($ in Millions)	Prior Years	FY 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total	FY 2026	FY 2027	FY 2028	FY 2029	Cost To Complete	Total Cost
AA7: *Mechanics and Ballistics*	-	34.586	35.014	34.685	-	34.685	34.726	37.595	38.343	38.729	0.000	253.678

A. Mission Description and Budget Item Justification

This Project conducts basic research in materials and ballistic science to create higher performing, lighter weight, lower cost materials and processes, discover new ways to store and release chemical energy from novel energetic materials, explore fundamental chemistry and physics controlling the launch and flight of gun-launched projectiles and missiles, and understand the interaction of these weapons with armored targets, including the high deformation rate behavior of materials and the mechanics of threat impact and penetration of armored targets. Research involves the study of new experimental capabilities to measure, characterize, and visualize complex phenomena with high temporal and spatial resolutions as well as the development of state-of-the-art computational models that provide predictive capabilities based on at-scale and cross-scale numerical frameworks that capture the relevant physical phenomena. Research in atmospheric science seeks 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, the propagation of full-spectrum electro-magnetic and acoustic energy and physics-based multi-scale models for electronic, optical, mechanical, and chemical materials. Efforts seek to explore methodologies and computational capabilities for the quantification of uncertainty in predictive modeling enabling risk-informed decision analysis multi-scale material models and environmental impacts on complex Army systems (manned and unmanned). This research also conducts research in chemistry and physics controlling ballistic propulsion and launch; creating aerodynamic forces on flight bodies to permit radical maneuver at high speeds, and high altitude glide and flight maneuver for increased range of gun launched projectiles. This research results in knowledge products that lead to new materials for armor and armaments, disruptive explosives and propellants, more accurate and non-lethal (NL)/lethal projectiles and missiles, omnisonic maneuver of projectiles, and advanced armors for increased survivability of Army combat systems. This research also funds efforts 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.

Work in this Project supports key Army needs and provides the technical underpinnings for several PEs to include PE 0602145A (Next Generation Combat Vehicle Technology); PE 0602146A (Networks C3I Technology); PE 0602147A (Long Range Precision Fires Technology); PE 0602141A (Lethality Technology), and PE 0602143A (Soldier Lethality Technology).

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

Work in this Project is completed by the Army Research Laboratory (ARL), Armaments Center (AC), Chemical Biological Center (CBC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Protection Sciences	5.471	5.658	5.691

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Description: This effort seeks to improve fundamental knowledge of mechanisms that can be exploited to ensure the next generation of lightweight and efficient armor technologies. Provides physics-based discovery of novel Soldier protection mechanisms through increased understanding of wave propagation through tissue and the resulting deformation and damage of tissue during ballistic and blast events. ***FY 2024 Plans:*** Will investigate how mechanical forces can be manipulated within materials and structures to optimize stresses and control deformation and penetrator-target interactions; conduct experiments with transient magnetic fields affecting phase transformation; conduct simulations of dynamic impact including tailored waveforms under fluctuating magnetic fields; investigate possible effects of magnetic fields on ballistic penetration resistance. ***FY 2025 Plans:*** Will investigate how mechanical, chemical, and electrical forces can be manipulated within structural and biological tissues to optimize stress management and control deformation when different forms of energy are coupled to a target; conduct experimental-computational studies to interrogate critical deformation mechanisms that govern strength and failure under extreme dynamic loading and temperatures; explore improved material properties for ballistic and warhead applications. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Microscopic/Nanostructural Materials ***Description:*** This effort explores new materials and creates new computational capabilities based upon fundamental concepts derived from studies of structure, process, and property relationships at the microscopic and nanostructural levels. Research includes synthesis, processing, characterization, and modeling of novel metal alloys and armor ceramics, including control and manipulation of nanostructural features, grain boundaries, texture, and other nano-to-microscale structure. ***FY 2024 Plans:*** Will develop computational physics-based and data-driven models to exploit and discover mesoscale compositional and processing methodologies to design and predict microstructural properties and extreme performance of materials; develop multiscale materials design tools for damage tolerant, structural composite materials. ***FY 2025 Plans:*** Will investigate the addition of synthetic microstructures to inform a robust machine learning model that is generalizable to multiple materials systems; analyze microstructural contributions to property predictions to further fundamental understanding of the composition-process-structure-properties-performance relationships in metal alloys and armor ceramics. ***FY 2024 to FY 2025 Increase/Decrease Statement:***	3.442	3.559	3.582

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Funding increase is an economic adjustment.			
Title: High Deformation Rate Materials ***Description:*** This research addresses Army-unique issues in fundamental materials research involving the performance of advanced materials at high deformation rates for applications including armor and armaments. Fundamental understanding is developed to enable design, processing, and characterization of materials specifically intended for high loading-rate applications, including improved physics based models, methods to characterize materials microstructure, interfaces, and defects and their role on materials response, and the determination of rate-dependent constitutive and failure/fracture behavior of materials. ***FY 2024 Plans:*** Will develop a materials-by-design methodology to identify failure mechanisms resulting from a combination of dynamic events, such as coupled ballistic loading and extreme heating. ***FY 2025 Plans:*** Will investigate methods for studying damage progression and interactions between dissimilar materials at microscale for materials under extreme thermal and mechanical loading. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding reduced in FY 2025 to support the creation of Complex Adaptive Mechanisms in PE 0601102A Project AA5 Biotechnology and Systems Biology.	3.549	2.470	1.682
Title: Materiel Research and Processing Using High Energy Fields ***Description:*** Explore interactions between materials and intense energy fields (e.g., 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 2024 Plans:*** Will develop energy field-driven post-processes to create novel complex shapes and properties by design; develop exceptional classes of materials designed to take advantage of emerging convergent manufacturing processes (including but not limited to combinations of additive manufacturing, traditional subtractive manufacturing, and energy-field driven processes) to embed integrated functionalities with complex shape and geometrical structures. ***FY 2025 Plans:*** Will produce bi-material samples for characterization and refinement of convergent manufacturing processes, including combinations of additive and subtractive manufacturing, and energy-field driven processes; investigate non-equilibrium methods	2.593	2.681	2.698

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
for modeling heat transfer in these materials; perform dynamic nano-indentation and modeling to refine constitutive parameters fed into this dynamic macroscale model. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: One Dimensional (1D) and Two Dimensional (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 1D and 2D building block materials and associated assembly into protective membranes, smart fibers and films, and other molecular composite architectures. ***FY 2024 Plans:*** Will develop multifunctional material design framework to construct and optimize conduction / insulation with anisotropic material properties; develop tunable interfaces under extreme dynamic thermomechanical loading or environmental conditions; develop mechanistic understanding of the dissimilar material interfaces functionally created by design. ***FY 2025 Plans:*** Will explore the role of temperature and high-pressure in processing of films and develop an understanding of the impact to ballistic performance; develop films that exploit non-linear behavior to tune optical properties; study modeling to design structures and phase compositions for desired ballistic protection and optical properties. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.	1.746	1.807	1.820
Title: Bio-enabled 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 local thermodynamics and kinetics to govern reactions and molecular assembly, thereby providing completely new pathways for materials discovery. ***FY 2024 Plans:*** Will investigate the link between genetic sequence with tuning interfaces and assembly of materials to obtain desired material properties across length scales; leverage bioinformatics and material informatics to inform the genotype to phenotype link and identify new control mechanisms to alter material properties; pioneer high throughput methods to screen across sequence and material space. ***FY 2025 Plans:***	1.878	1.941	1.954

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will investigate how synthetic biology enabled modifications of interfaces affect different combinations of composites; explore impacts of bioderived materials on thermal, mechanical, electrical, and other performance parameters to understand consequences of substituting biomanufactured materials for those derived from traditional manufacturing methods; explore high throughput methods for screening materials to investigate synthetic biology techniques as control mechanisms for material properties. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles ***Description:*** Improve the fundamental understanding of the mechanisms controlling the launch and flight of gun-launched projectiles and missiles and understand the interaction of these weapons with armored targets. ***FY 2024 Plans:*** Will continue exploration of basic fluid mechanics such as turbulence, separation, transition, and flow interactions relevant to military vehicles; pursue novel maneuver mechanisms; formulate basic algorithms for low- (vehicle) and high- (mission) level control; synthesize model-based and data-driven approaches for high-speed, multi-agent perception, action, and communication. ***FY 2025 Plans:*** Will explore innovations in the estimation, control, and autonomy of complex, high-speed agents constrained by energy, size, and time; define appropriate models of physics and chemistry associated with reacting high-speed flows and incorporate into credible computational toolsets; conduct experiments to validate flight dynamic models. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding reduced in FY 2025 to support the creation of Complex Adaptive Mechanisms in PE 0601102A Project AA5 Biotechnology and Systems Biology.	3.344	3.461	3.115
Title: Energetic Materials Research ***Description:*** Expand and confirm physics based models and validation techniques to enable design of novel insensitive propellants and explosives with tailored energy release for revolutionary future force survivability and weapons effectiveness. ***FY 2024 Plans:*** Will discover and synthesize novel high-temperature organic-based and organometallic (or metallic alloy) based energetic materials for use in explosives and propellants; explore mesoscale models striving for 100s of microns in length regime, as well as machine learning models to accelerate kinetic rate equations used for propellant and explosive applications. ***FY 2025 Plans:***	3.767	4.049	3.922

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will explore novel co-crystal energetic materials, air stabilized metallic fuels, and high power energetic materials and plasticizers for use in explosive and propellant applications; investigate feasibility and transferability of machine learning models of reaction rates for propellants; develop and validate coarse-grained mesoscale models capturing relevant chemistry and physics for explosives. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.			
Title: Theory in Atmospheric Characterization, Sensing, and Modeling	4.330	3.578	4.003
Description: New algorithms and methods are developed to account for a variety of complex-terrain physical processes in microscale models. Novel instrumentation and observational methods are developed to advance the understanding of physical processes in the atmosphere. Employ optical techniques to advance detection methods for chemical/biological agents mixed in with atmospheric constituents. Data from high-resolution instrumentation arrays are used to advance and verify evolving atmospheric characterization theory focused on complex terrain and dense urban areas. ***FY 2024 Plans:*** Will conduct multi-national field assessment to investigate environmental effects on acoustic and electromagnetic signal propagation in urban environments; refine machine-learning methods enabling multi-modal sensor adaptability and optimal data fusion; continue to investigate impacts of atmospheric and boundary-layer processes on electromagnetic/radio frequency propagation and signature; develop new optical methods and techniques to advance capabilities for optical detection and characterization of biological, chemical and other threat materials; explore methods to connect microscopic scattering processes with detection and bulk impact of aerosols on energy transfer; study aerosol transport due to terrain-related variability in the boundary-layer momentum and heat fluxes. ***FY 2025 Plans:*** Will analyze data collected in field experiments to investigate environmental effects on acoustic and electromagnetic signal propagation in urban environments; investigate new machine learning methods enabling informed multi-modal sensor adaptability and operation; investigate new technologies applicable to remote sensing of atmospheric and boundary-layer processes; explore new optical methods and techniques to exploit optical characteristics of aerosols for optical detection and characterization of biological, chemical, and other threat materials; analyze field experimental data and 3-Dimensional cloud monitoring via all sky imagers and machine learning techniques to understand the impact of surface energy budget processes to Directed Energy propagation; study interactions between locally and non-locally generated turbulence and the contribution to momentum, heat, and aerosol transport in the atmospheric boundary layer. ***FY 2024 to FY 2025 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Funding increase in FY 2025 supports additional research in the area of optical methods and techniques to exploit optical characteristics of aerosols.			
Title: Environmental Quality ***Description:*** This effort conducts research on innovative environmentally-friendly technologies that support the warfighter focusing on pollution prevention technologies. ***FY 2024 Plans:*** Will explore the systematic study of environmental friendly energetics and processing methods; investigate the degradation of current and potential monomers for the demilitarization of cast cured explosives; analyze alternatives to hazardous chemicals to prevent corrosion to metals and reduce environmental, safety, and occupational health issues. ***FY 2025 Plans:*** Will conduct research into alternatives to hazardous chemicals and processes in the development of new and existing energetic materials, to include the study of the development of halogen free binders for the replacement of fluorinated polymers, per and poly-fluoroalkyl substances (PFAS); conduct research into alternatives to hazardous chemicals pertaining to environmental, safety, and occupational health issues. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.	1.164	1.204	1.211
Title: Surface Science Research ***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.	2.487	-	-
Title: Terminal Ballistic Design and Evaluation for Next Generation Materials ***Description:*** Research will focus on novel terminal ballistic designs utilizing engineered materials to provide lightweight protection and low-energy penetrator solutions for combat-relevant threats. Specific architecture materials will be identified and utilized based on high-throughput material synthesis and characterization, and data-driven physics based modeling approaches. ***FY 2024 Plans:*** Will continue computational modeling in the design of structural alloys; implement synthesis and characterization via high-throughput methodologies to assess use in armor systems. ***FY 2025 Plans:***	0.815	0.834	0.841

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will conduct synthesis and characterization studies to assess use of novel designs in armor systems; perform initial ballistic design and assessment. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Additive Manufacturing Sciences ***Description:*** The research in this Project focuses on manufacturing processes to achieve transformational lethality. This involves the development of converging virtual manufacturing using heterogeneous materials in one platform, while implementing additive, subtractive, transformative, and bulk manufacturing. ***FY 2024 Plans:*** Will investigate interfacial microstructural kinetics from precision additive and transformative manufacturing and bonding of dissimilar materials. ***FY 2025 Plans:*** Will develop an understanding of the gradient layers among dissimilar materials, utilizing advanced composites and functionally graded materials for the fabrication of high performance and multifunctional structures. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase supports additional research into gradient layers among dissimilar materials.	-	1.200	1.511
Title: Chemical-Biological Advanced Materials and Manufacturing Science (CBAMMS) ***Description:*** Chemical-Biological Advanced Materials and Manufacturing Science (CBAMMS) program activities are related to performing basic research in chemistry, biology, physics, and material science to investigate interactions between materials and surfaces and between materials, catalysis, and energy dispersion/disruption that will advance the knowledge related to chemical and biological sensors, obscurants, and bio-manufacturing. ***FY 2024 Plans:*** Will conduct basic research from competitively selected proposals related to fundamental studies and predictive modeling for advanced materials processes as it relates to chemical-biological materials and sensors; study basic principles of biological systems to broaden our understanding of detection and our ability to exploit these principles to aid in detection; expand the body of knowledge related to material processing and properties and the impact of surface interactions on the performance of protective materials; explore novel sensing phenomenology along with new biosynthetic processes for the development of new or existing materials; study the fundamental properties of materials in addition to the impact of existing and novel manufacturing processes	-	2.572	2.655

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
on critical performance characteristic of materials; study particle dispersion and novel material properties for utilization in next generation obscurants and novel pyrotechnics. ***FY 2025 Plans:*** Will continue studies in predictive modeling, for advanced materials processes as it relates to chemical-biological materials and sensors, while incorporating research in the areas of physics and engineering principles of biomaterials and additive materials of processing and manufacturing; conduct fundamental studies that will be used in predictive modeling for advanced materials processes as it relates to chemical-biological materials and sensors; expand the body of knowledge related to processing parameters, structure property relationships, surface interactions and performance of materials and sensors with respect to chemical/biological exposure, decontamination, aging and use in extreme temperatures; explore the utilization of novel manufacturing processes such as 3-dimensional bio-printing, integrated heterogeneous materials (i.e. Metal-Organic Frameworks) and in-situ polymerization and/or component integration during processing; advance fundamental scientific understanding of particle dispersion for novel utilization of next generation obscurants with novel pyrotechnics in areas such as disrupting command, control, and communications; investigate advanced/multispectral obscurant payload or concealment/camouflage/ deception/false targets resulting in overall signature management or sensor defeat; leverage academic discoveries in new materials and processes along with addressing emerging threats in the topics identified in FY2024. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Accomplishments/Planned Programs Subtotals	34.586	35.014	34.685

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army			Date: March 2024
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA8 / *Sensing and Electromagnetics*	

COST ($ in Millions)	Prior Years	FY 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total	FY 2026	FY 2027	FY 2028	FY 2029	Cost To Complete	Total Cost
AA8: *Sensing and Electromagnetics*	-	13.402	16.383	25.634	-	25.634	31.208	29.397	33.471	33.806	0.000	183.301

A. Mission Description and Budget Item Justification

This Project conducts basic research on semiconductor materials, layered structures, and novel devices for optical sources, detectors, integrated optoelectronic circuits, and energy generation and storage devices. Efforts include multiscale modeling, material and structure growth and characterization, and novel device design and fabrication. The research has application to Soldier power, sensors, lower power communications, quantum networks; unattended sensor networks, including distributed sensor fusion; ground vehicle sensors and auxiliary power systems; alternative position, navigation, and timing (PNT) systems for Global Positioning System (GPS)-denied environments; and sensors and power for small unattended ground and air vehicles.

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

Work in this Project is performed by the Army Research Laboratory (ARL) and Soldier Center (SC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Advanced Materials Research	1.533	1.562	1.056
Description: This effort conducts research in modeling, fabrication, and characterization of semiconductor materials and structures that leads to revolutionary device functionality in sensing, low power electronics, quantum networks, and power generation. This effort investigates novel complex crystal structures that can lead to devices with performance beyond normal semiconductor transistors, including neuromorphic computing structures and topological insulator based heterostructure with low operating voltage.			
FY 2024 Plans: Will model advanced functional materials (i.e. topological materials and two dimensional materials) and heterostructures for use in low power device concepts; investigate different modalities of negative electron affinity materials (such as diamond) for use in radio frequency (RF) and sensor applications. The work will include different terminations of the diamond surface and assessment of their electronic and environmental stability.			
FY 2025 Plans: Will conduct experimental and theoretical studies of topological materials, two-dimensional materials, and heterostructures for use in low-power sensing concepts; utilize referenced studies to understand interactions between electromagnetic waves and related nascent materials.			
FY 2024 to FY 2025 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Funding reduced in FY 2025 to support the creation of Complex Adaptive Mechanisms in PE 0601102A Project AA5 Biotechnology and Systems Biology.			
Title: Materials Science for Army Power and Communications ***Description:*** This research includes modeling of advanced battery materials and structures, and modeling of electromagnetic fields interacting with catalytic materials. High bandgap materials including silicon carbide and gallium nitride with modified composition will be used to fabricate diodes for improved performance as optical communication sources, sensors, and high power components. Materials, designs, and fabrication techniques will be studied for the future development of Micro-Electro-Mechanical Systems (MEMS) for radio frequency (RF) devices and sensors. ***FY 2024 Plans:*** Will examine effects of impact ionization rates, doping, and device fabrication on spatial uniformity of electric fields (E-fields) under high E-field conditions; investigate role of ionic solvation, ordering, and structure on transport, reactivity, and charge transfer at electrochemical interphases; examine and validate a temperature model for local nanoscale photothermal heating driving chemical reactions; research novel material approaches and micro structures for low-size, weight, and power (SWaP) free-space optical time transfer unit. ***FY 2025 Plans:*** Will examine models for ensemble level understanding of multiparticle energy/heat transfer interactions involved in photothermal, electrocatalytic, and thermocatalytic processes of photocatalyzed chemical fuels reactions; conduct research to develop and validate molecular scale model for electrolyte reaction with a battery cathode to examine degradation mechanisms; investigate ionic transport in bulk electrolytes through modeling; validate modeling predictions by comparison with experiments; conduct research on low-dimensional, meta-optic materials for low-size, weight, and power (SWaP) free-space optical time and positioning unit. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.	1.248	1.709	1.711
Title: Fundamentals for Precision Measurement for Contested Environments ***Description:*** This effort explores new materials, novel device architectures, and unique processing techniques to successfully maintain communication and information sharing protocols in GPS-denied, actively jammed, or austere environments. ***FY 2024 Plans:***	0.765	0.789	0.891

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will develop integrated micro-resonator optical frequency comb that is waveguide coupled with an injection-locked laser; investigate injection-locking mechanisms to generate and lock a soliton-based optical frequency comb; design and fabricate next-generation epsilon-near-zero metamaterial-based environmental insensitive resonators. ***FY 2025 Plans:*** Will identify and explore a fully integrated, deterministic, injection-locking mechanism to generate and lock a stable, single soliton-based, optical frequency comb; validate characteristics of next-generation epsilon-near-zero, metamaterial-based, environmental insensitive resonators for over-arching, optical clock concepts. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Functional Materials ***Description:*** This effort supports basic research in polymer science and textile technology, nano and biotechnology, and multifunctional materials to achieve technologies that support the Soldier of the future through multi-functional materials with clothing/protective equipment functionality that also embody electronic functionality. ***FY 2024 Plans:*** Will investigate cephalopod-derived reflectin protein conformation dynamics and ability to tune reflected color under electrical stimulation to inform advances in materials for self-healing, chemical protection, and signature management applications; identify and model fundamental material failure mechanisms of coated polycarbonate resulting from high-velocity impacts to support advances in eye protection and transparent armor technologies. ***FY 2025 Plans:*** Will investigate foundational understanding for unique multifunctional materials for temperature and electrical response; research infrared and optical properties to thermal response; characterize electrochromic, optical rectification, and thermochromic properties of different plasmonic materials. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.	1.290	1.332	1.341
Title: High Energy Laser (HEL) Materials and Thermal Management ***Description:*** This effort investigates and matures novel laser gain materials and other laser components with advanced thermal, thermo-mechanical, and thermo-optical properties. This effort investigates new materials and methods for controlling thermal transients to reduce the size and weight of thermal management components while increasing the energy magazine of systems operating in burst modes. ***FY 2024 Plans:***	1.030	1.062	1.063

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will investigate, explore, and assess multi-constituent phase change thermal materials, architectures, and modeling approaches to understand and tune transient/dynamic thermal transfer; explore novel glass core compositions for Raman fibers with greatly enhanced Raman gain and maximized thermal conductivity; investigate novel alternative crystalline fiber core materials with greatly improved thermal properties. ***FY 2025 Plans:*** Will explore innovative silica fiber designs combining enhanced Raman gain with advanced, intrinsic, spectral filtering for parasitic 2nd Raman suppression; investigate, explore, and assess novel dynamic materials for transient thermal transfer and control; explore composite materials and phase change architectures to maximize heat transfer from Raman gain media. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
Title: Physics-Informed Machine Learning for Complex Phenomena ***Description:*** Existing machine-learning approaches are not guided by the laws governing physical systems and unable to provide predictions of a physical system response with quantifiable uncertainty. Research will explore and develop modeling techniques incorporating machine-learning approaches to support fundamental studies of physical systems. Resulting models will be used to design and develop novel physical systems, such as diamond for high power RF applications. ***FY 2024 Plans:*** Will explore existing methods for dimensionality reduction in machine learning when applied to physical systems; validate most promising approaches for construction of surrogate models of relevant physical systems based on previous assessment of geometrical methods for constraints in machine-learning models of physical systems; identify knowledge gaps in methods for assimilating of multiple-fidelity data into machine-learning models of physical systems; identify means of addressing deficiencies based on previous analysis of techniques for uncertainty quantification of machine-learning models. ***FY 2025 Plans:*** Will conduct research into new methods of dimensionality reduction in machine learning when applied to physical systems; investigate new geometrical methods for constraints in machine learning models of physical systems; continue to identify knowledge gaps in methods for assimilating multiple-fidelity data into machine learning models of physical systems; conduct research into new methods for incorporating uncertainty into machine learning models of physical systems.	3.381	3.498	3.498
Title: Semiconductor Modeling for Advanced Electronics ***Description:*** 3D numerical modeling basic research activities are scattered and insular, not effectively leveraging the combined capabilities of Government, Academia, and Industry. The problems are diverse and complicated and need a focused and multi-disciplinary approach to gain fundamental understanding. This effort will build an ecosystem for foundational modeling and research in semiconductor materials and devices that leverages the broad combined knowledge base from academia,	0.956	0.693	0.521

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
industry, and government laboratories to develop new and advanced semiconductor materials and devices for sensors, emitters, neuromorphic, and topological device applications. ***FY 2024 Plans:*** Will utilize high fidelity modeling codes to formulate new sensing modalities; develop and apply techniques to assess sub-wavelength imaging; develop models of neuromorphic devices and small circuits incorporating standard semiconductors with emerging materials to gain understanding of material interactions and function; update models of beta and alpha particle interactions with ultra-wide bandgap semiconductors to include experimental data to study defect generation and radiation tolerance of ultra-wide bandgap semiconductors. ***FY 2025 Plans:*** Will develop models and numerically explore carrier manipulation at ferroelectric/semiconductor nitride interfaces; investigate theory and models of the interaction between electromagnetic waves, from optical to terahertz frequencies, and advanced electronic materials, such as topological, two-dimensional materials, and heterostructures. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease in FY25 reflects a reduction in research in the area of beta and alpha particle interactions models.			
Title: Foundational Distributed Radar ***Description:*** This research seeks to investigate novel signal processing techniques to develop distributed, Global Positioning System (GPS)-independent, autonomous capabilities. This effort investigates tools and techniques for modeling, simulations, and emulation of distributed radio frequency (RF) sensors and effectors. This research investigates advanced materials-based antennas for low size, weight, power, and cost (SWaP-C), multi-function systems. ***FY 2024 Plans:*** Will investigate increasing the complexity of electromagnetic environments and investigate the distributed aspects to gains for distributed RF sensors; identify and study distributed RF sensor capabilities through adaptive signal processing techniques to address traditional RF sensor short-comings and solutions to overcome via distributed approaches when used in cluttered Electromagnetic Environment (EME); explore analysis of software-controlled and adaptive Software Defined Radar (SDRadar) concepts for developing signal processing techniques and approaches to provide increased capabilities to the warfighter. ***FY 2025 Plans:*** Will conduct research into distributed RF sensors for on-the-move advantages that enable detection while linked to various platforms, such as ground vehicles and small unmanned aerial vehicles (sUAVs); identify unique waveforms and investigate reconfigurable hardware for autonomous decision-making, in sub-second timeframes, for decisive military actions. ***FY 2024 to FY 2025 Increase/Decrease Statement:***	1.211	1.248	1.249

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Funding increase reflects planned lifecycle of this effort.			
Title: Foundational Sensing	1.988	1.606	2.365
Description: This effort explores innovative methods to remotely sense and discriminate threat vehicle formations deep in the battlefield. This effort investigates novel mechanical wave sensing physics to enhance signal features in complex and high noise environments as well as investigates fundamental properties of electric field (E-field) and Magnetic (H)- field signals in cluttered environments. ***FY 2024 Plans:*** Will leverage and extend multi-modal sensing and incorporate a priori environmental and target knowledge to maximize likelihood of detection and identification; characterize and extend sensor models to enhance robustness of detection and fusion; develop network adaptation techniques, both algorithmic and physical, to enhance detection capability or lower expended power; develop methodologies to efficiently store and recall sensing and environmental data to support learning and adaptation over extended periods of time; investigate high-performance modeling and simulation tools for efficient prediction and processing methods of magnetic and electric field sensor data. ***FY 2025 Plans:*** Will analyze high performance modeling and simulation tools for efficient prediction and processing of integrated, multi-modal sensor data; investigate at-the-edge, multi-modal sensing and fusion models supporting robust detection, enhanced by environmental and target knowledge that incorporates multi-modal sensing within a larger relevant validation of the networked sensing pipeline; explore neural machine learning (ML) data processing and network adaptation to scenarios that emulate real-world conditions for model validation. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase in FY25 reflects additional research in the area of high-performance modeling and simulation tools for sensor data.			
Title: Complex Effects Understanding and Modeling	-	1.514	4.504
Description: This effort seeks to develop the fundamental understanding necessary to realize complex effects utilizing multiple geographically distributed sensor-effector nodes. This effort will develop new computational methods to accomplish simulations of complex systems that are intractable with current methods due to required interactions of multiple, dynamic physics formulations. This effort will pursue modelling and simulation to identify robust state spaces for distributed apertures capable of beam-forming, cross modal, and coherent sense and effect. Additionally, this effort will investigate sensitivity to synchronization quality and identify opportunities for cancellation and self-referencing. Focal instances include electronic warfare (EW), laser sense and effect, and kinetic effects. Science of design concepts will be investigated to efficiently pare down complex physical systems into tractable solutions including topology optimization and co-design.			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
FY 2024 Plans: Will investigate new computational methods to accomplish simulations of currently intractable physical systems due to the required interaction of multiple, dynamic physics formulations; investigate geometric methods for reducing the dimensionality of inputs under complex interacting physical processes. ***FY 2025 Plans:*** Will investigate multi-use photonic structures capable of performing precision ranging, timing, and data transfer within a single design construct; investigate spatial filtering of acoustic vector and meshed seismic sensing in a streamlined, algorithmic form for ultra-efficient processing; investigate fusion methodologies to support coherent sensing, assuming both current and anticipated future accuracy associated with relative timing and localization; conduct research on how to fuse geometrical methods with classical numerical techniques to simulate multiple, interacting aspects of physics in high dimension; explore manifold discovery techniques for dimensionality reduction in high dimensional models of time-dependent physical systems. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase in FY 2025 supports additional research in the area of multi-use photonic structures capable of performing precision ranging, timing, and data transfer within a single design construct.			
Title: Compact Non-Linear Elements and Non-Linear Arrays ***Description:*** This effort seeks to identify novel materials, physics, and architectures to achieve highly non-linear and high-density effects when synchronized in distributed arrays. Research will focus on enablers for emerging applications including electromagnetic (EM) windows for operation in hypersonic plasmas, compact, efficient, and multi-field array elements, intelligent-agent schemas for dynamic arrays, and novel materials for alternate EM bands. ***FY 2024 Plans:*** Will investigate techniques to accelerate the feedback loop for informing dynamic control across the full EM spectrum, for correcting distortions due to complex physical processes; investigate novel energy and power methods for distributed sensing; conduct research into novel ultra-efficient nodes for distributed aperture sensing; investigate fast computational imaging techniques to inform feature detection in infrared (IR) camera images. ***FY 2025 Plans:*** Will investigate frequency tunable, ultra-low size, weight, power, and cost (SWaP-C) devices that offer passive voltage amplification and determine the best technology for different frequency ranges; explore methodologies and materials for the creation of convergent electronic/photonic hybrid architectures and advanced photonics circuitry; study non-linear, optical processes in topological materials and reveal physics that enables polarization of signals or other modalities of electromagnetic (EM) signals to be efficiently detected in various bands; investigate highly sensitive radio frequency (RF) detection components conforming to an ultra-low SWaP-C architecture through the study of fundamental loss limits of ferrimagnetic, high-quality-factor,	-	1.370	4.349

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
thin film materials; extend computational imaging techniques for application to feature detection in turbulence distorted, thermal images. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase in FY 2025 supports additional research in the area of methodologies and materials for the creation of convergent electronic/photonic hybrid architectures and advanced photonics circuitry.			
Title: Novel Materials and Architectures for Emerging Bands and Modalities ***Description:*** This effort seeks to identify novel physics, materials, and architectures for extending spectrum use beyond the current state-of-art (e.g., heavy use of radio frequency (RF) and infrared (IR) bands with classical network topologies). This effort will investigate novel energy efficient materials, structures, and storage for powering distributed sensors. ***FY 2025 Plans:*** Will develop temperature-stable ferroelectric nitride materials based on silicon carbide templates for enabling high temperature memory operation; explore physical mechanisms and materials exhibiting multicaloric transitions at high temperatures; assess multicaloric architectures for energy storage and conversion under new modalities and environments; investigate novel wave phenomena in low dimensional, meta-optics architectures; investigate novel materials and unique heterostructures and device designs to uncover light-matter interactions in non-traditional electromagnetic (EM) bands, such as ultraviolet (UV) and terahertz (THz). ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase in FY 2025 supports additional research in the area of temperature-stable ferroelectric nitride materials based on silicon carbide templates.	-	-	3.086
Accomplishments/Planned Programs Subtotals	13.402	16.383	25.634

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army												Date: March 2024
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA9 / *Information and Networking*			
COST ($ in Millions)	**Prior Years**	**FY 2023**	**FY 2024**	**FY 2025 Base**	**FY 2025 OCO**	**FY 2025 Total**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**Cost To Complete**	**Total Cost**
AA9: *Information and Networking*	-	42.581	43.075	43.808	-	43.808	44.155	49.240	49.796	50.268	0.000	322.923

A. Mission Description and Budget Item Justification

This Project supports basic research to enable intelligent and survivable command, 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 addresses the areas of information assurance, signal processing for wireless battlefield communications, information extraction from multi-modal data human-agent naturalistic communication, and intelligent systems for C4I. Research will focus on understanding and solving 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 the edge, 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, and information warfare threats. These C4I technologies must accommodate heterogeneous security infrastructures, multi-service and multi-national interoperability, and information exchange/security mechanisms between multiple levels of security. The intelligent systems for C4I research focus on providing machine learning methods to overcome noisy, sparse, and heterogeneous data with artificial intelligence algorithms that can transfer learning from one domain to another. This foundational research will help identify 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 theoretical underpinnings for Program Element (PE) 0602146A (Network C3I Technology), PE 0602143A (Soldier Lethality Technology), and PE 0602145A (Next Generation Combat Vehicle Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Communications in Complex Dynamic Networks	5.621	5.739	5.779
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. This research includes techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldier 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.			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
FY 2024 Plans: Will explore analysis and simulation frameworks for multi-hop multi-modal routing protocols that optimize multiple simultaneous flows; analyze performance/overhead tradeoffs associated with the degree of integration of heterogeneous networks; investigate techniques to dynamically and efficiently adapt intelligent networked services that enhance performance of complex analytics in dynamic networks and environments; study approaches to efficiently orchestrate complex network resources using software defined networks and virtualized or containerized services; explore experimentation capabilities that deploy large-scale emulation-based experiments within high-performance, hardware-based next-generation software defined network switching/routing environments; explore techniques for managing and analyzing experimental data from large-scale simulation and emulation-based experiments; conduct experiments on network protocols for increased robustness and optimized planning; explore emerging quantum network simulation technology and conduct Army-feasibility experiments on quantum network protocols. ***FY 2025 Plans:*** Will investigate novel decentralized strategies leveraging learning-based approaches for the control of extremely heterogeneous networks; explore directional networking capabilities within extremely heterogeneous networks through opportunistic beamforming to increase network performance and enhance stealth; explore resource-adaptive analytics techniques in multi-domain environments to account for dynamic environments with constrained network and computing resources; explore novel methods for resilient, dynamic, multilayer network analytics in complex network environments; investigate machine learning-based techniques for efficient and distributed placement and adaptation of complex analytics; analyze performance of the software-defined, network based, large scale emulation experimentation environment to determine scalability limits and performance bottlenecks; explore methods for validating quantum networking simulation results against real-world benchmarks involving multi-node networks, air-to-air links, and alternative protocol implementations. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Data to Knowledge to Support Decision Making (Information Mediation)	4.459	4.554	2.980
Description: Research 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 2024 Plans:*** Will investigate the effect of visual information overload across different types of display modalities, specifically augmented reality, virtual reality, and traditional single screen displays; investigate how a human's perception degrades under high visual workloads;			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
explore the effects of head and eye movement tracking and display technology on dense search space; create algorithms to enable agents to interpret multisource information to infer meaning, create shared understanding, and support decision-making; investigate methods to enable autonomous systems to create mission relevant narratives using natural language text or audio; define causal inferencing algorithms to derive context from multimodal content for semi-autonomous decision-making and course of action generation. ***FY 2025 Plans:*** Will explore eye movement tracking in augmented reality (AR) display for controlling autonomy assets for human-agent teaming; investigate rule-based algorithms and data-driven machine learning methods for knowledge network construction and information extraction approaches applied to natural language interpretation to enable effective automated text generation for information management tasks; conduct fundamental research into computational models of artificial reasoning to enable automated decision making that considers the impact of uncertainty and associated risks, multiple criteria, and mission context. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding reduced in FY 2025 to support the creation of Battlefield Representation and Intelligent Agents for Scalable Cross-echelon Command and Control within this Project.			
Title: Information Protection in Mobile Dynamic Networks	5.363	5.570	5.512
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 2024 Plans:*** Will develop and assess computationally efficient methods for characterizing entangled states in network scenarios, enabling high-fidelity simulations of quantum networks; experimentally investigate the transmission of quantum states through a series of linked quantum networking elements, such as switches concurrently serving several network users; conduct research on hybrid quantum networking processes, including quantum frequency conversion; investigate network routing strategies with global multi-objectives accounting for message priority, latency, covertness, and robustness. ***FY 2025 Plans:*** Will analyze the accuracy and resource requirements of competing approaches for quantum state characterization in networks, including shadow tomography, full-state tomography, and machine learning-based techniques; study various approaches and platforms for performing basic quantum networking tasks, such as quantum frequency conversion and low-loss optical switching; study entanglement distribution over long fiber links, extending to remote physical sites, to assess realistic environmental noise and decoherence impacts; research basic algorithms and methodologies to encapsulate the technical foundations of an			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
autonomous, intelligent cyber-defense agent for traditional networks and non-traditional networks like those found on vehicle platforms and weapon systems. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.			
Title: Advanced Computing Architectures and Algorithms ***Description:*** Investigate advanced computing and high performance computing (HPC) networking architectures, memory/ storage architectures, processing algorithms, and visualization techniques to support advanced battle command applications for Command, Control, Communications, Computers, and Intelligence (C4I) systems. ***FY 2024 Plans:*** Will explore model simulation and emulation of neural network designs employed in open-source field programmable gate arrays (FPGAs); assess the potential of neural network designs employed in open-source FPGAs in a hybrid central processing unit with specialized neural networking elements in order to maximize computational efficiency while minimizing energy usage for tactical edge processing of image data obtained in a multi-domain operating environment; create a specialized domain specific computer programming language for neural network design in order to interface with processors using a co-neural network processor order to perform federated and distributed tactical learning in a hierarchical neural networking topology. ***FY 2025 Plans:*** Will study field programmable neural array (FPNA) to understand performance and computational efficiency on small neural networks; conduct research on analog neurons and use for complex, symbolic processing and inferencing; investigate strategies to characterize and predict analytic performance in resource-constrained, heterogeneous operational regimes; explore methods to identify poor analytic performance due to dynamic or complex information and resolve analytic accuracy with decentralized and distributed model learning; investigate methods to autodetect referenced model architecture, key features, framework, and its attributes in order to prioritize specific model optimizations and partitioning tailored to constrained communication networks and computing domains; identify the best locations in a neural network where it can be split among multiple devices to increase processing speed or stop early when there is high confidence in the result to reduce computational resource usage. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.	4.124	4.212	4.241
Title: Assured Operations in the Physical, Social and Cyber Domain ***Description:*** Conduct research that will enhance the survivability of information by radically dispersing and continuously moving data across a multitude of inter-networked devices. This effort seeks to address the growing demands on information assurance, reliability, and transmission in resource constrained environments. Theories and methods will be investigated for securing information across heterogeneous devices/sources and networks, detecting and creating information obfuscation and deception	6.505	5.144	4.166

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. ***FY 2024 Plans:*** Will explore distributed methods to efficiently maintain situational awareness of multilayer networked information and dynamic network environments; investigate dynamic programming and distributed optimization techniques for resource allocation of complex analytics; develop algorithms and methodologies for automated network analytics, and integrated Machine Learning techniques and Machine Learning Poisoning mitigation; research methods for cyber situational awareness and threat classification methods; investigate theories and machine learning algorithms that automate cyber defense reasoning; develop a concept for an algorithm for prioritizing and filtering information in dynamic tactical environments, allowing the right information to reach the right Soldier at the right time; investigate the contexts and features of the Soldier state and information space which influence the value of information and derive information utility accordingly. ***FY 2025 Plans:*** Will investigate and understand commercial off the shelf (COTS), domain specific processors for perception algorithm inference performance with splicing and partitioning of large neural networks; study methods of real time processing to support autonomous systems; research machine learning techniques for the cyber/electromagnetic domain, robust to adversarial detection and interference; explore machine learning techniques to identify and correct atmospheric distortions to support assured targeting; investigate methods for deep reinforcement learning based on novel information criteria; conduct research on bounded, incremental learning in real-time systems; investigate transfer of machine learning models trained in simulated environments to emulated and real systems for cyber defense. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding reduced in FY 2025 to support the creation of Complex Adaptive Mechanisms in PE 0601102A Project AA5 Biotechnology and Systems Biology.			
Title: Machine Learning for Intelligent Agent and Human Decision Making ***Description:*** This effort researches methodologies and algorithms for machine learning with incomplete, unstructured, potentially deceptive, and heterogeneous information, enabling joint decision making for Intelligent Agent-Human teams which adapt to unknown environments and missions. Research includes methods for learning and decision making that occur under short time frames and constrained resources (e.g., computation, power, spectrum, and networks). ***FY 2024 Plans:*** Will investigate methods for multi-agent systems to autonomously adapt group behaviors through reinforcement learning and computational models of coordination; define modeling and simulation frameworks with context-aware agents and reinforcement learning approaches to enable artificial intelligence (AI)-driven course of action analysis; investigate multimodal content to	6.066	6.291	5.980

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
determine context and build a consistent world view within intelligent systems; use Machine Learning (ML) methods to enable autonomous systems to interact with Soldiers through natural communication and maintain shared understanding of task goals; explore coordination strategies that allow teams of autonomous agents to share environmental observations with limited network connectivity; create algorithms that enable distributed task planning in partially observable environments. ***FY 2025 Plans:*** Will investigate and conduct research on methods grounded in information theory and/or game theoretic approaches for collaborating multi-agent systems to share information in constrained environments; investigate machine learning (ML) methods for computer vision to enable autonomous systems to detect objects in high dynamic range (HDR) environments; conduct experiments with small teams of multi-agent systems to assess ability to autonomously adapt group behaviors based on partially observed reinforcement learning signals; investigate methods and techniques that allow multi-agent systems to adapt role assignments based on high level, human defined strategies; conduct research on algorithms that allow for shared representations with a small number of observations; investigate distributed data processing methods on heterogeneous size, weight, and power (SWaP) constrained systems for perception algorithms. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding reduced in FY 2025 to support the creation of Battlefield Representation and Intelligent Agents for Scalable Cross-echelon Command and Control within this Project.			
Title: Image Analytics and Understanding ***Description:*** This effort investigates new methodologies and techniques for improved scene and situational understanding using multi-modal imaging sensors from heterogeneous air and ground platforms. This work explores novel machine learning approaches for applications in resource constrained environments. ***FY 2024 Plans:*** Will investigate Machine Learning (ML) methods for situational understanding based on multi-modal sensors onboard size, weight, and power (SWaP)-constrained platforms (Unmanned Aerial Vehicles or Unmanned Ground Vehicle) subject to austere and adverse imaging conditions, such as high altitudes, high winds, drone vibration, and low illumination, producing shaky images/videos with degraded image quality; investigate robust scene synthesis methods that utilize hybrid datasets of real and synthetic images of objects and activities of interest to optimize ML models representing varying battlefield conditions to ensure pre-deployment operational readiness at the tactical edge; investigate fundamental limits and boundary conditions of ML models to reduce prediction uncertainty and increase the trustworthiness of the ML outcome at the tactical edge given operational requirements; investigate joint learning of synthetic foregrounds and backgrounds of a variety of scenes of interest using advanced rendering tools to achieve rapid per-deployment adaptation of ML models. ***FY 2025 Plans:***	2.366	2.416	1.330

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will investigate self-supervised, multimodal perception models on size, weight, and power (SWaP)constrained, mobile platforms combined with natural language supervision to address the austere operating conditions, including the data scarcity problem, in rapidly learning, critical battlespace representations in tactical environments; investigate a combined synthetic rendering and perception model that enhances the realism of scene synthesis, while creating large scale, unseen novel view images with high fidelity to significantly enhance perception performance at the edge. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding reduced in FY 2025 to support the creation of Battlefield Representation and Intelligent Agents for Scalable Cross-echelon Command and Control within this Project.			
Title: Fundamentals for Energy Efficient Electronic & Photonic Components	2.064	2.109	2.123
Description: This effort addresses the power draw (demand) of radio frequency (RF) front ends for communication and electronic materials for the digital back-end, as well as efficient materials for delivery of power (supply) for electronics on energy constrained platforms. The work explores new materials with inherently higher energy efficiencies in conjunction with advances in circuits and systems to provide improvements in power efficiencies, linearity, and noise at the subsystem level for unique Army requirements for demand and supply electronics. ***FY 2024 Plans:*** Will validate and measure metasurface aperture designs; investigate devices based on functional materials for analog compute-in-memory and efficient neural network hardware architectures; investigate the thermal properties of diamond transistors and heterostructures for increased efficiency RF systems; study the radiation tolerance of Ultra-Wide Bandgap (UWBG) semiconductors by investigating different alpha and beta-voltaic structure designs and assess device lifetimes under high energy radiation; examine the ability to achieve anitferroelectric behavior in a nitride material system and explore the energy density and thermal stability performance; investigate mechanical interfaces for thru-metal acoustic wave wireless power transfer with peripheral electronics for control of power transfer based on arbitrary placement of a receiver. ***FY 2025 Plans:*** Will conduct research into microelectronic design processes and techniques that renders device purpose unclear to frustrate reverse engineering while preserving efficiency and function; explore diamond heterostructure and transistor acceptor layer material properties; identify charge traps, impurities, and interface atomic bonding characteristics in order to improve the efficiency of radio frequency (RF) diamond transistors; examine high electron mobility transistor switch with a ferroelectric nitride to understand improved energy efficiency savings; explore Ultra-Wide Bandgap (UWBG) device designs that maximize lifetime under high energy alpha and beta radiation. ***FY 2024 to FY 2025 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Funding increase is an economic adjustment.			
Title: Quantum Information Sciences	6.013	6.140	6.181
Description: This effort investigates interactions between light and quantum systems, including atoms, ions, and solid-state materials, for developing the fundamental building blocks of distributed quantum systems. A particular emphasis is efficient light matter interfaces, including optical cavities, nanophotonics, and high density atomic systems. This effort also explores quantum algorithms for entanglement distribution. ***FY 2024 Plans:*** Will investigate approaches for strong light matter interfaces for next-generation clocks, sensors, and quantum information components; investigate solid-state defects confined to microwave resonators as an athermal frequency standard; investigate growth processes in Silicon Carbide (SiC) for magnetometry and qubit operation; explore atoms strongly coupled to radio frequency (RF)/microwave resonators for sensitive measurement of electric fields; investigate collective, long-range atom-atom interactions in nanofibers; investigate quantum-enhanced gravimeters. ***FY 2025 Plans:*** Will investigate new resonator geometries for field concentration that improves efficiency in light-matter coupling; investigate trade-offs between small mode volume waveguides/resonators and perturbations to material quantum bits from nearby surfaces; explore new geometries for resonant coupling, including 2-Dimensional and 3-Dimensional designs, and characterize the relative quality factors, coupling strengths, repeatability, and scalability; analyze approaches for both vapor-phase atoms and solid-state atom-like color centers and explore these in the context of improving quantum clocks, sensors, and quantum bit processing capabilities. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Assessing and Mitigating Climate Risk for Decision Making	-	0.900	0.907
Description: Lead Army-focused environmental basic research within climatological time frames (multi-year to decades), specifically researching changes and impacts of dynamic processes in the lower atmospheric boundary layer in Multi Domain Operation (MDO) environments (complex terrain and dense-urban) as underpinning science to inform applied research projects in climate impact decision support systems. ***FY 2024 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will investigate the development of a climatological database derived from a Distributed Virtual Proving Ground (DVPG) instrumentation array in New Mexico; design computational tools to predict the magnitude and impact of climate change on operations, weapon systems, and personnel utilizing the DVPG climatological database. ***FY 2025 Plans:*** Will analyze Distributed Virtual Proving Ground (DVPG) meteorological array databases to understand the evapotranspiration cycle and flash drought onset; investigate and understand boundary layer process impacts on climatology in complex environments. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Title: Battlefield Representation and Intelligent Agents for Scalable Cross-echelon Command and Control ***Description:*** Description: Discover foundational methods and approaches critical to developing intelligent Command and Control (C2) agents and shared representation of the battlefield to humans and intelligent C2-agents for planning and decision support. These foundational research approaches ultimately enable operations across echelons capable of (1) identifying Windows of Superiority (WoS) from data too large and complex for humans, (2) identifying normally missed, critical decision points, and (3) creating multiple plans with metrics that support Commander assessment and confidence in a fraction of the time currently required. ***FY 2025 Plans:*** Will conduct research on architectures and representations for joint object detection, localization, and classification from multiple sensor modalities; research techniques for on-demand generation of synthetic data and model tuning for adapting to changing environments; investigate methods to manage information flow and communicate in a timely, effective, and adaptive manner across domain and echelon; investigate information dynamics and behaviors to develop tactics, techniques, and procedures toward resiliency against adversarial campaign; investigate novel, artificial reasoning techniques for robust, automated decision making; investigate fundamental techniques for natural language interpretation to create shared understanding through situated dialogue and example-based human-agent interaction; explore deep learning language models and generative artificial intelligence methods for automated generation of natural language artifacts for tactical operations. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding realigned in FY 2025 from Image Analytics Understanding, Data to Knowledge to Support Decision Making, and Machine Learning for Intelligent Agent and Human Decision Making within this Project to support the creation of Battlefield Representation and Intelligent Agents for Scalable Cross-echelon Command and Control.	-	-	3.407
Title: Human-Agent Interactions and Trust for Scalable Cross-echelon Command and Control	-	-	1.202

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Description: This effort investigates novel theoretical and methodological approaches to human-agent interactions that enable trustworthy intelligent and survivable command and control, communication, computing, and intelligence for the future force. The effort focuses on creating theory and methods that scale across different combinations of human-machine teams, formation dispersion, and information systems capabilities. This effort focuses on approaches that allow humans to guide multi-scale command and control with reduced human burden. ***FY 2025 Plans:*** Will conduct research on initial human-guided machine learning approaches using large language models to generate courses of actions at different scales; investigate how human-guided machine learning-based course of action generation influences trust amongst human users with different roles. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding realigned in FY 2025 from Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies in PE 0601102A Project AA4 Training and Human Science Research to support the creation of Human-Agent Interactions and Trust for Scalable Cross-echelon Command and Control within this Project.			
Accomplishments/Planned Programs Subtotals	42.581	43.075	43.808

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army			Date: March 2024
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*	

COST ($ in Millions)	Prior Years	FY 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total	FY 2026	FY 2027	FY 2028	FY 2029	Cost To Complete	Total Cost
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	4.294	4.508	4.672	-	4.672	4.649	4.652	4.704	4.751	0.000	32.230

A. Mission Description and Budget Item Justification

This Project builds fundamental scientific knowledge contributing to the sustainment of United States Army scientific and technology information to solving military medical problems related to infectious diseases, operational medicine, and combat care. This Project provides the means to exploit scientific breakthroughs and avoid technological surprises, and fosters innovation in areas where there is little or no commercial investment due to limited markets (e.g., drugs and treatments for tropical diseases) and maintains laboratory capability to perform these functions.

The work is consistent with the Under Secretary of Defense (Research and Engineering) science and technology focus areas and the Army Modernization Strategy.

Work is performed at United States Army Research Institute of Environmental Medicine (USARIEM).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Injury Prevention and Reduction	1.074	1.803	1.957
Description: This effort identifies biological patterns of change in Warfighters during states of physical exertion and physiological (human physical and biochemical functions) mechanisms of physical injury and exertion that will predict musculoskeletal (muscle, bone, tendons, and ligaments), sensory (auditory, ocular, and vestibular), and blunt, blast or accelerative injury. ***FY 2024 Plans:*** Will finalize mechanistic translational models from cellular and tissue level to the whole body in order to develop strategies to mitigate injury risk and performance degradation. ***FY 2025 Plans:*** Refine mechanistic translational models and provide final recommendations to support the development of injury risk mitigation strategic plans to protect Warfighters in training; will enhance trainee readiness through evidence-based training programs to mitigate injury risk and performance degradation. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
Title: Physiological Health	1.416	1.443	1.364

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Description: This effort conducts fundamental research on the physiological mechanisms of sleep, fatigue, and nutrition on Soldier health, readiness, and performance. In addition, this effort discovers basic understanding of physiological and genetic processes leading to biomedical performance enhancement in in the physical, cognitive, and psychological domains. ***FY 2024 Plans:*** Will finalize mechanistic translational models from cellular and tissue level to the whole body in order to develop strategies to mitigate injury risk and performance degradation. Will continue research prebiotic and probiotic modulation of the microbiota-gut-brain axis during acute stress to inform the role of nutrition support for metabolic recovery from military activity. ***FY 2025 Plans:*** Conclusion of prebiotic and probiotic modulation of the microbiota-gut-brain axis during acute stress to inform the role of nutrition support for metabolic recovery from military activity. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.			
Title: Environmental Health ***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 2024 Plans:*** Will research animal models for basic mechanisms of injuries from heat and cold exposure and those factors that accelerate improved recovery; will determine preclinical efficacy of interventions to improve performance in high CO2 and low O2 environments. ***FY 2025 Plans:*** Research the development of a next generation thermal strain medical health application for enhanced mission-specific work/rest guidance when operating under dynamic conditions in extreme temperatures. Determine biomarkers specific to exertional heat stroke (EHS) and determine factors that are related to optimal outcomes following a heat casualty (i.e., brief hospitalization and quick return-to-duty). ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.	0.988	1.262	1.351
Title: Soldier Performance Augmentation	0.816	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Description: This effort investigates and defines fundamental physiological mechanisms underlying Soldier capabilities to execute military tasks. Understands basic biological mechanisms underlying Soldier capabilities to include physical endurance, cognitive capacity, and individual and group decision making.			
Accomplishments/Planned Programs Subtotals	4.294	4.508	4.672

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army											Date: March 2024	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*			
COST ($ in Millions)	**Prior Years**	**FY 2023**	**FY 2024**	**FY 2025 Base**	**FY 2025 OCO**	**FY 2025 Total**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**Cost To Complete**	**Total Cost**
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	18.739	19.564	19.900	-	19.900	20.065	20.684	20.904	21.113	0.000	140.969

A. Mission Description and Budget Item Justification

This Project advances fundamental science in areas of military engineering, biosciences, geospatial, and data sciences. The Project expands basic understanding of complex biological, chemical, geospatial, and material properties and processes at varying scales and time to support applied research and advanced technology development in the future.

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

Work is performed by the United States (U.S.) Army Engineer Research and Development Center.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Mapping, remote sensing, signature physics and terrain state	4.174	4.358	4.369
Description: Investigates compact mathematical representations of terrain data; explores automated learning of built elemental features unique to location; formulates new techniques for automatically retrieving Earth surface features, properties and patterns; explores sensing phenomenology and surface state as affected by terrain and weather; studies optimizing and adapting decision making based on changing geospatial conditions. The U.S. Army Corps of Engineers, Engineer Research and Development Center executes this research at the organization's laboratories to include the Coastal and Hydraulics Laboratory, Cold Regions Research and Engineering Laboratory, Construction Engineering Research Laboratory, Environmental Laboratory, Geospatial Research Laboratory, Geotechnical and Structures Laboratory, and Information Technology Laboratory			
FY 2024 Plans: Will pursue fundamental and novel research on understanding Earth surface attributes and processes. Will investigate emergent patterns and behaviors derived from complex geospatial and ancillary numerical and/or semantic data. Will explore whether critical surface features identified from Deep Learning models can retrieve the observed subsurface features. Will examine the intrinsic properties of snow governing acoustic propagation and inverting formulated acoustic models for estimating snow properties.			
FY 2025 Plans: Will continue to pursue fundamental research to understand Earth surface attributes and dynamic terrain processes affecting the situational understanding of military multi-domain operations from a geospatial perspective. Will investigate emergent geospatial patterns or behaviors derived from complex emerging, high dimensional, numerical, semantic, or ancillary data. Will perform			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
experiments to identify physical phenomena important to model the acoustic response of very thin ice. Will seek an understanding of how the physical and optical properties of man-made materials relate to light polarization. Will explore the signature physics of non-stationary hydrodynamic processes in ground-based imagery of water flow fields. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase due to economic adjustment from planned lifecycle.			
Title: Fundamental Adaptive Protection and Projection Research	4.667	4.865	5.169
Description: Conduct fundamental studies on the theory and modeling of future revolutionary geological, structural, and signature reducing materials; and examine, investigate and model complex geophysical, littoral, and other environments that fill critical Army knowledge gaps in adaptive protection and projection. The U.S. Army Corps of Engineers, Engineer Research and Development Center executes this research at the organization's laboratories to include the Coastal and Hydraulics Laboratory, Cold Regions Research and Engineering Laboratory, Construction Engineering Research Laboratory, Environmental Laboratory, Geospatial Research Laboratory, Geotechnical and Structures Laboratory, Information Technology Laboratory. ***FY 2024 Plans:*** Will gain fundamental scientific knowledge of the environmental phenomena that impact engineering system performance. Will investigate multi-scale characterization and modeling of materials. Will pursue the discovery and design properties of engineered materials with enhanced performance, improved function, and reduced weight for future force protection and force projection applications. Will explore the near-surface turbulent flow problem from a holistic environmental-system perspective with emerging data-driven machine learning methods. Will study complex nanoscale structure-property relationships of interfaces and soft/hard layers and apply a materials by design strategy for shock mitigation. ***FY 2025 Plans:*** Will continue to gain fundamental scientific knowledge of the environmental phenomena that impact engineering system performance. Will investigate multi-scale characterization and modeling of materials. Will pursue the discovery and design properties of engineered materials with enhanced performance, improved function, and reduced weight for future force protection and force projection applications. Will investigate tunability for laser protective materials via a novel class of metallic supramolecular-based materials capable of reverse saturable absorption (RSA), the mechanism responsible for the nonlinear optical (NLO) limiting effect. Will explore structure-property relationships of polyurethane-based aerogels during high thermal and kinetic energy events. Will investigate variability in thermo-hydromechanical properties of arctic soils and how soil property relationships are sustained. Will gain understanding of surf-zone processes during delayed arctic freeze-up. Will investigate near-offset seismic wave propagation in elastic media. Will investigate adaptive acoustics in atmospheric turbulence and design principles of extremely tough and stretchable hydrogels. ***FY 2024 to FY 2025 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Funding increase reflects planned lifecycle of this effort.			
Title: Fundamental Infrastructure Sciences ***Description:*** Explores fundamental research informing infrastructure science, robotics, autonomous construction, three-dimensional (3D) printing materials, self-assembly and advanced or innovative material science as related to advancing future military infrastructure, construction, and Engineer operations. The U.S. Army Corps of Engineers, Engineer Research and Development Center executes this research at the organization's laboratories to include the Coastal and Hydraulics Laboratory, Cold Regions Research and Engineering Laboratory, Construction Engineering Research Laboratory, Environmental Laboratory, Geospatial Research Laboratory, Geotechnical and Structures Laboratory, Information Technology Laboratory. ***FY 2024 Plans:*** Will explore fundamental elements of natural or manmade processes and materials, data science, complex systems, and energy science to inform future advances in Army infrastructure. Will explore computational underpinnings for the design of high-entropy alloy nanomaterials and control of atomic arrangement using thermal annealing. Will seek to understand the diffusion of elements such as liquid Gallium and Aluminum to inform control of the alloying process for future fabrication of components. ***FY 2025 Plans:*** Will continue to explore fundamental elements of natural or manmade processes and materials, data science, and energy science to inform future advances in Army infrastructure. Will pursue fundamental research to understand the interplay between pH gradients and mineral formation using novel correlated chemical and physical probe techniques. Will pursue fundamental research to computationally and empirically elucidate the effect of extreme temperature on the efficiency of spray-printed photothermal conversion co-crystals, opening a fundamental line of inquiry that may inform future solar heat harvesting. Will investigate ways to use earthen materials to create a medium to transport ionic materials. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding decrease reflects planned lifecycle of this effort.	1.963	2.051	1.879
Title: Biological, Chemical and Physical Sciences ***Description:*** Explore novel approaches of innovative data analytics, bio-inspired materials, and chemical experimentation to understand basic principles of biological and chemical mechanisms, organisms, and natural processes of the environment. The U.S. Army Corps of Engineers, Engineer Research and Development Center executes this research at the organization's laboratories to include the Coastal and Hydraulics Laboratory, Cold Regions Research and Engineering Laboratory, Construction Engineering Research Laboratory, Environmental Laboratory, Geospatial Research Laboratory, Geotechnical and Structures Laboratory, Information Technology Laboratory. ***FY 2024 Plans:***	7.935	8.290	8.307

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Will conduct fundamental research into novel biological mechanisms or natural and geological processes. Will pursue basic research in biotechnology to understand biological approaches and mechanisms for future Army technology advancements. Will investigate complex environmental, chemical, and biological processes and features to fill knowledge gaps and inform future Army applications. Will explore foundational research associated with extreme environments, to include cold regions. Will explore genetic adaptations that enable lichens to tolerate harsh conditions. Will evaluate the signal propagation properties of intracellular fungal melanin to determine characteristic frequency range at which it can propagate signals without attenuation. Will utilize cryptanalysis techniques to extract hidden structure in noise, providing an understanding of dynamics driving the collective motion of animals from tracking data. ***FY 2025 Plans:*** Will continue to conduct fundamental research into novel biological mechanisms or natural and geological processes. Will pursue basic research in biotechnology to understand biological approaches and mechanisms for future Army technology advancements. Will investigate complex environmental, chemical, and biological processes and features to fill knowledge gaps and inform future Army applications. Will investigate Lanthanide Binding Peptides (LBP) and LBP-derived visible and near infrared (VIS/NIR) materials using high-throughput genetic engineering, scanning antenna molecules for amplification across the VIS/NIR spectra. Will provide fundamental knowledge on the effects of indigenous soil microbial community, soil redox and water saturation on bioreporter volatile organic compound viability/generation/propagation. Will pursue transplant of gut bacterial communities from the waxworm to the mealworm to inform future opportunities in material degradation. Will explore if post-fire sorptivity, which is the ability of an unsaturated porous material to absorb fluids by capillary action, can be determined from measurable soil and fire characteristics. Will build scientific knowledge to mine near-infrared proteins to increase understanding in developing biosensors and explore ways to manipulate plant enzyme as candidate for use in producing biofuel. Will attempt using volatile compounds to detect permafrost thaw and provide critical information for improved interpretation of permafrost degradation by understanding macro-scale electrical conductivity mechanisms to reduce error in soil measurements. Will investigate how cold temperatures alter root secretions and recruitment of root-soil microbes. Will investigate PFAS adsorption and removal based on chemical interactions. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
Title: Foundational Computational Sciences	-	-	0.176
Description: This effort explores the foundational, computational, data, and mathematical scientific underpinnings required to inform accurate and rapid simulations of physical, environmental, and fiduciary components of complex military systems. The effort seeks to provide fundamental discoveries to support digital engineering processes and accelerate the future Army's digital transformation strategy. The U.S. Army Corps of Engineers, Engineer Research and Development Center executes this research at the organization's laboratories to include the Coastal and Hydraulics Laboratory, Cold Regions Research and Engineering			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Laboratory, Construction Engineering Research Laboratory, Environmental Laboratory, Geospatial Research Laboratory, Geotechnical and Structures Laboratory, Information Technology Laboratory. ***FY 2025 Plans:*** Will explore foundational computational, data, and mathematical scientific underpinnings to provide new innovations and knowledge to inform complex military systems. Will investigate foundational methods and data analytics to inform future computational modeling of physical, environmental, and military systems. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	18.739	19.564	19.900

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

N/A

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army			Date: March 2024
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) CH9 / *Advancing Concepts and Technology Forecasting*	

COST ($ in Millions)	Prior Years	FY 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total	FY 2026	FY 2027	FY 2028	FY 2029	Cost To Complete	Total Cost
CH9: *Advancing Concepts and Technology Forecasting*	-	3.712	3.862	3.903	-	3.903	3.908	3.911	3.954	3.993	0.000	27.243

A. Mission Description and Budget Item Justification

This Project works across the Army Futures Command Combat Capabilities Development Command, with the Futures and Concepts Center, and the Directorate of Intelligence and Security to identify emerging and disruptive basic scientific research outcomes to translate, integrate, and ingrain research outcomes with Army Warfighting Concepts. Army Warfighting Concepts describe how the Army will fight in the far-term future and the Future Operational Environment contextualizes projected basic research in the deep future. Outcomes describe the projected future operational effects of science in the context of Army Concepts and the Future Operational Environment to enable informed decision making and mitigate risk for future Army capabilities.

Advancing Concepts ensures Army Concepts are grounded by recent and anticipated discoveries in basic scientific research. Army basic research is use-inspired to address the future capability needs identified in the Army Concepts, and learning opportunities are created to advance Army Concepts and operationalize science for transformational overmatch.

Technology Forecasting develops timely, objective, scientifically-grounded projections of scientific advances that hold promise to impact future operational capabilities for the Army. Emerging scientific areas are described and communicated across the Army Modernization Enterprise to inform Science and Technology decisions.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
Title: Advancing Concepts and Technology Forecasting	3.712	3.862	3.903
Description: Advancing Concepts identifies emerging and disruptive basic scientific research outcomes in order to translate, integrate, and ingrain research outcomes with Army Warfighting Concepts which describe how the Army will fight in the far-term future. Technology Forecasting provides long-range, scientifically grounded technology forecasts of basic research topics to enable informed decision-making.			
FY 2024 Plans: Will integrate outcomes of far-term Army Warfighting Concept priorities for decision advantage into emerging basic scientific research programs in distributed sensing and artificial intelligence for agile command and control, and for sustained operations into emerging basic scientific research programs in energy sciences; provide objective estimates of anticipated basic scientific			

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** CH9 / *Advancing Concepts and Technology Forecasting*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024	FY 2025
research advances of emerging scientific areas (novel computing architectures, alternative power sources, new communications mechanisms) with high relevance to the Army. ***FY 2025 Plans:*** Will identify mid- and far-term Army learning demands and key insights from Army Concept priorities to inform basic scientific research programs in offensive and defensive fires and platform survivability; explore objective estimates of anticipated basic scientific research advances of emerging opportunities, including the biosciences, novel position-navigation-and-timing methodologies, and deep sensing approaches, to advise Army decision-makers. ***FY 2024 to FY 2025 Increase/Decrease Statement:*** Funding increase is an economic adjustment.			
Accomplishments/Planned Programs Subtotals	3.712	3.862	3.903

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army			Date: March 2024
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 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total	FY 2026	FY 2027	FY 2028	FY 2029	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	112.500	-	-	-	-	-	-	-	-	0.000	112.500

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.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024
Congressional Add: Program increase - EXPLOSIVES AND OPIOIDS DUAL-USE UV DETECTION	10.000	-
FY 2023 Accomplishments: Congressional Interest Item funding provided for EXPLOSIVES AND OPIOIDS DUAL-USE UV DETECTION		
Congressional Add: Program Increase - DIGITAL THREAD FOR ADVANCED MANUFACTURING	9.500	-
FY 2023 Accomplishments: Congressional Interest Item funding provided for DIGITAL THREAD FOR ADVANCED MANUFACTURING		
Congressional Add: Program Increase - JOINT RESEARCH LABRATORIES	18.000	-
FY 2023 Accomplishments: Congressional Interest Item funding provided for Joint Research Labrotories		
Congressional Add: Program Increase - ARTIFICIAL INTELLIGENCE (AI) FUSION	2.500	-
FY 2023 Accomplishments: Congressional Interest Item funding provided for ARTIFICIAL INTELLIGENCE (AI) FUSION		
Congressional Add: Program Increase - BASIC RESEARCH	25.000	-
FY 2023 Accomplishments: Congressional Interest Item funding provided for Basic Research		
Congressional Add: Program Increase - CENTER FOR UAS PROPULSION	5.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2025 Army		Date: March 2024
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)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2023	FY 2024
FY 2023 Accomplishments: Congressional Interest Item funding provided for CENTER FOR UAS PROPULSION		
Congressional Add: Program Increase - COUNTER UAS TECHNOLOGY RESEARCH ***FY 2023 Accomplishments:*** Congressional Interest Item funding provided for COUNTER UAS TECHNOLOGY RESEARCH	5.000	-
Congressional Add: Program Increase - HIGH ENTROPY METALLIC ALLOYS ***FY 2023 Accomplishments:*** Congressional Interest Item funding provided for High Entropy Metallic Alloys	5.000	-
Congressional Add: Program Increase - RENEWABLE ENERGY TECHNOLOGIES ***FY 2023 Accomplishments:*** Congressional Interest Item funding provided for Renewable Energy Technologies	15.000	-
Congressional Add: Program Increase - SUSTAINABLE AVIATION FUEL PROPULSION ***FY 2023 Accomplishments:*** Congressional Interest Item funding provided for Sustainable Aviation Fuel Propulsion	7.500	-
Congressional Add: Program Increase - UNMANNED AERIAL SYSTEMS HYBRID PROPULSION ***FY 2023 Accomplishments:*** Congressional Interest Item funding provided for UNMANNED AERIAL SYSTEMS HYBRID PROPULSION	10.000	-
Congressional Adds Subtotals	112.500	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A