Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army												Date: March 2023
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 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
Total Program Element	-	358.521	391.642	296.670	-	296.670	309.571	320.379	340.802	350.897	0.000	2,368.482
AA1: *ILIR - AMC*	-	10.486	11.532	11.758	-	11.758	12.070	12.084	12.092	12.224	0.000	82.246
AA2: *ILIR - SMDC*	-	0.957	1.039	1.068	-	1.068	1.096	1.073	1.074	1.086	0.000	7.393
AA3: *Single Investigator Basic Research*	-	86.464	97.025	108.599	-	108.599	107.794	112.803	123.367	127.116	0.000	763.168
AA4: *Training and Human Science Research*	-	20.862	22.180	21.024	-	21.024	21.026	20.979	24.112	24.397	0.000	154.580
AA5: *Biotechnology and Systems Biology*	-	5.842	6.421	6.547	-	6.547	6.614	6.622	9.555	9.518	0.000	51.119
AA6: *Robotics and Mobile Energy*	-	19.857	21.854	25.268	-	25.268	27.467	27.511	27.538	27.811	0.000	177.306
AA7: *Mechanics and Ballistics*	-	32.114	35.234	35.014	-	35.014	35.482	35.525	37.889	38.635	0.000	249.893
AA8: *Sensing and Electromagnetics*	-	13.092	13.619	16.383	-	16.383	26.083	31.647	29.340	33.406	0.000	163.570
AA9: *Information and Networking*	-	38.956	42.839	43.075	-	43.075	43.520	43.568	46.644	47.199	0.000	305.801
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	36.137	4.405	4.508	-	4.508	4.664	4.641	4.644	4.696	0.000	63.695
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	17.311	19.201	19.564	-	19.564	19.860	20.026	20.644	20.863	0.000	137.469
CH9: *Advancing Concepts and Technology Forecasting*	-	3.443	3.793	3.862	-	3.862	3.895	3.900	3.903	3.946	0.000	26.742
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	73.000	112.500	-	-	-	-	-	-	-	0.000	185.500

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 is no commercial investment due to limited markets (e.g., vaccines for tropical diseases).

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army	Date: March 2023
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*

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, 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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total
Previous President's Budget	368.751	279.328	283.521	-	283.521
Current President's Budget	358.521	391.642	296.670	-	296.670
Total Adjustments	-10.230	112.314	13.149	-	13.149
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	112.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-10.230	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	13.149	-	13.149
• FFRDC Transfer	-	-0.186	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2022	FY 2023
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Program increase*	25.000	-
Congressional Add: *Program increase - EXPLOSIVES AND OPIOIDS DUAL-USE UV DETECTION*	5.000	10.000
Congressional Add: *Program Increase: Cell-Free Expression for Biomanufacturing*	10.000	-
Congressional Add: *Program Increase - DIGITAL THREAD FOR ADVANCED MANUFACTURING*	5.000	9.500
Congressional Add: *Program Increase - JOINT RESEARCH LABRATORIES*	20.000	18.000
Congressional Add: *Lightweight High Entropy Metallic Alloy Discovery*	3.000	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army	Date: March 2023
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 2022	FY 2023
Congressional Add: *Unmanned Aerial Systems Propulsion*	5.000	-
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
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	73.000	112.500
Congressional Add Totals for all Projects	73.000	112.500

Change Summary Explanation

Increased funding to support basic research enhancements for strategic competition.

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA1: *ILIR - AMC*	-	10.486	11.532	11.758	-	11.758	12.070	12.084	12.092	12.224	0.000	82.246

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, 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.

Work in this Project is performed by the United States Army Futures Command (AFC).

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 2022	FY 2023	FY 2024
Title: Edgewood Chemical Biological Center (ECBC)	0.968	1.064	-
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.			
FY 2023 Plans: Conduct novel basic science research on the phenomenology of principal components in chemical and biological sciences, focused on the utilization of materials by design concepts (modeling, synthesis, and characterization) of synthetic biology for the development of novel physical/biological materials, new sensing materials, threat detection and characterization. Employ Artificial intelligence, machine learning and predictive modeling for the identification of emerging threats, enhancement of performance and/or truncation of the development cycle.			
FY 2023 to FY 2024 Increase/Decrease Statement: Funding realigned to Chemical Materials - ILIR within this Project.			
Title: Armaments Research, Development and Engineering Center (ARDEC)	1.426	1.539	-
Description: Funds basic research in weapons component physics, explosives synthesis/detection, and the fundamental science base of area denial.			
FY 2023 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Conduct research on methods to simulate breakup, ablation, and component connectivity change on novel composite structural materials for light weight armament systems. Conduct research on methods to directly model surface texture and its modification to alter mechanical response. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Structural Materials - ILIR within this Project.			
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. ***FY 2023 Plans:*** Conduct competitively-selected, basic, in-house research to improve the fundamental understanding of ground vehicles and establish the underlying physics in such areas as semi- and fully autonomous vehicles; soft soil mobility modeling; active protection and signature management; advanced combustion engine thermal control; multi-physics battery modeling and simulation; lightweight materials and additive manufacturing; corrosion modeling; cognitive loading and crew station design; vehicle control systems; and cybersecurity threat detection. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Advanced Mobility - ILIR within this Project.	1.189	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. ***FY 2023 Plans:*** Examine the effects of diverse food forms (e.g. varied compression and lipid levels) on human systems and perception to understand the impact of condensing and altering combat ration components in support of improved Soldier performance and sustainment. Characterize optoelectronic and electronic properties of two-dimensional materials (MXenes) and investigate molecular structure-function relationships. Interpret results to advance understanding related to the use of unique two-dimensional materials for controlling conductivity and EMI shielding efficiency. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Functional Materials - ILIR within this Project.	1.112	1.214	-
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts (AMRDEC-MI)	2.310	2.460	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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. ***FY 2023 Plans:*** Explore the fundamental nature of complex dynamics in networks of coupled identical oscillators using the experimental unclocked Boolean circuit for secure communications and device protection; continue to explore and begin experimentation with compressive sensing techniques based on deep learning methods to augment existing sensor suites and maximize information collected from sensor hardware while reducing size, weight, power, and cost (SWAP-C); continue basic research into advanced modeling techniques to investigate, simulate, and fabricate new proof-of-principle designer devices and artificial materials to enable disruptive opto-electro-plasmonic systems for sensors and devices for sensor protection and masking; study the role of temperature on noise and entangled photon generation in a Josephson junction based quantum integrated circuit; investigate the fundamental models that could enable the use of machine learning techniques to predict new materials and the provide direction for their synthesis. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Optical Electronics - ILIR (Aviation and Missile Center, Missile Technology) within this Project.			
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. ***FY 2023 Plans:*** Develop a permeable-surface acoustics formulation that will accurately capture the acoustic scattering and shielding effects due to impingement of pressure waves on solid surfaces prevalent in emerging configurations with multiple rotors/propulsors and lifting surfaces; conduct experimental tests to better understand fundamental behavior of single and coaxial propeller over a range of configurations and operating conditions. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Sol Struct Mech - ILIR within this Project.	1.327	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. ***FY 2023 Plans:***	2.154	2.298	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Research unconventional vision-aided landmark navigation using spectral signature beacons; investigate methods for wireless power transfer; study thermal runaway inhibitors to reduce cell charge transfer at elevated temperatures in lithium-ion batteries; investigate algorithms to fuse different aspects of Lidar and Radar data for improve target tracking; characterize and analyze material inhomogeneity in type-II superlattice materials for infrared detectors; investigate the use of electron channeling contrast imaging (ECCI) to identify and characterize crystalline defects in epitaxial materials grown for infrared detectors; investigate atmospheric properties of the intraThermal Infrared (intraTIR) spectral band (4.5 - 8.5 um). ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Comms Cyber IR RF-ILIR within this Project.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.227	-
Title: Chemical Materials - ILIR ***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. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Edgewood Chemical Biological Center (ECBC) within this Project.	-	-	1.081
Title: Structural Materials - ILIR ***Description:*** Funds basic research in weapons component physics, explosives synthesis/detection, and the fundamental science base of area denial.	-	-	1.590

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Armaments Research, Development and Engineering Center (ARDEC) within this Project.			
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Tank Automotive Research, Development and Engineering Center (TARDEC) within this Project.	-	-	1.328
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Natick Soldier Research, Development and Engineering Center (NSRDEC) within this Project.	-	-	1.240
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.	-	-	2.630

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Aviation and Missile Research, Development and Engineering Center: Missile Efforts (AMRDEC-MI) within this Project.			
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Aviation and Missile Research, Development and Engineering Center: Aviation Efforts (AMRDEC-AV) within this Project.	-	-	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:*** 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	-	-	2.409

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Communications Electronics Research and Engineering Directorate (CERDEC) within this Project.			
Accomplishments/Planned Programs Subtotals	10.486	11.532	11.758

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA2: *ILIR - SMDC*	-	0.957	1.039	1.068	-	1.068	1.096	1.073	1.074	1.086	0.000	7.393

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, 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.

Work in this Project is related to, and fully coordinated with efforts in PE 0602150A Air and Missile Defense Technology / DC1 (Next GEN DE Concept Development and Analysis

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: SMDC In-house Laboratory Independent Research (ILIR)	0.957	1.015	1.068
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 directed energy phenomena with the goal of developing technologies that will significantly reduce size, weight and power requirements for laser systems.			
FY 2023 Plans: Will expand atmospheric propagation data collection to include slant and vertical path to investigate the boundary layer as a function of time of day, weather conditions, solar loading, and terrain parameters. Will expand models to better match data. Will collect data using the Ultra Short Pulsed Lasers (USPL) lab capability to investigate propagation and filamentation phenomenology and material interaction.			
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			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.024	-
Accomplishments/Planned Programs Subtotals	0.957	1.039	1.068

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army										Date: March 2023		
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 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
AA3: *Single Investigator Basic Research*	-	86.464	97.025	108.599	-	108.599	107.794	112.803	123.367	127.116	0.000	763.168

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

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 2022	FY 2023	FY 2024
Title: Basic Research in Life Sciences	10.115	10.975	11.721
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 2023 Plans: Will dissect and characterize the L-form phenotype in specific prokaryotes to be able to induce it temporarily or permanently as a key step forward for bioengineering, as L-form prokaryotes induce less or no host response and are anticipated to be able to better release their payload, that if successful may enable the Army to produce new types of materiel and to enable new systems for better warfighter protection; attach nickel catalysts and photocatalysts to a variety of specific bioconjugation sites within different cross-linked protein crystals and characterize the structures and catalytic properties of the resulting hybrid materials			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
that if successful, will be a key step toward using porous protein frameworks as scaffolds to organize dual abiotic catalysts to enable new-to-nature chemical transformations for the synthesis of Army-relevant materials including energetic materials, precursors to energetic materials, polymers, and composites; measure the native growth activity of microbial communities in cold region ecosystems and provide the foundation for establishing how microbial activity in these cold environments responds to environmental change which, if successful, will contribute to the Army's strategy in regaining Arctic dominance by providing the Soldier with new tools to assess the impact of warming in Arctic environments on the integrity of infrastructure assets in these regions; measure changes in brain oxygenation with a genetically encoded bioluminescence reporter in rodents, that if completed will offer a precise tool to determine whether sleep deprivation affects oxygen tension under operationally-relevant functional tasks and pave a path to link overall brain metabolism with Soldier cognitive performance and the impacts of brain aging on resilience to disease or sleep deprivation. ***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 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Basic Research in Chemical Sciences	10.950	10.361	10.587
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 2023 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Will identify the physical limitations to the rate of water dissociation in bipolar membranes and how they can be used to pass ionic current commensurate with currents observed in practical reversible fuel cells that if successful, will potentially enable the next generation of polymer electrolyte fuel cells with the goal of reducing soldier-borne weight associated with power generation; develop a quantitative model that links the molecular structures, adsorption strengths, and oxidation kinetics of organics in the aqueous phase of complex environmental matrices that if successful, will be a key step towards designing novel waste stream remediation technologies or reducing corrosion rates and surface film formation to protect the Soldier and materiel; integrate polymer science and biostatistical sequence analysis to better understand the fundamental design rules needed to rationally design polymeric materials to effectively interface with biological proteins that if successful, may lead to new functional hybrid biomaterials with enhanced stability and activity of proteins in non-biological environments, enabling new technologies for energy harvesting and conversion, catalysis, sensing, and bioremediation. ***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 functionality in future electrochemical energy conversion devices including batteries, fuel cells, electrolyzers, and chemical sensors. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Basic Research in Physics	11.522	12.488	13.220
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 2023 Plans:*** Will devise new theoretical approaches for analyzing quantum systems using light-matter coupling through the tuning of material properties via strong coherent coupling to vacuum fluctuations of terahertz (Thz) metamaterials and analyze properties of electrons in mono- and twisted bilayer two-dimensional materials embedded in terahertz cavities that if successful will enable the creation of materials with new functionalities for sensing, information storage, and processing; advance recent demonstrations			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
of second-order nonlinear interactions in Aluminum Nitride (AlN) optical parametric oscillators (OPO) by utilizing chip-based coherent sources of light in the visible (VIS) and near-infrared (NIR) to construct broadband, self-referencing optical frequency combs that if successful, will enable fieldable light sources able to provide precise frequency standards for inertial sensors with increased sensitivity; identify challenges associated with the nature of fundamental structural and electronic microwave properties of superconductor-semiconductor interfaces to work toward optimal interfaces for qubits that if successful, will possess properties ideal for quantum computation platforms that are amenable for scaling up to the number of qubits necessary to carry out computations of Army relevance such as those related to optimization, logistics, and advanced material simulation. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Basic Research in Electronics and Photonics	8.453	9.324	9.312
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 2023 Plans:*** Will study the fundamental structure/property relationship between metasurface geometries and Silicon Germanium Oxide (SixGeyO1-x-y) sensing layers for uncooled microbolometers that if successful, will enable improved sensitivity and resolution in night vision imaging systems; investigate ultrafast dynamics and coherent control on the surfaces of Weyl semimetals using a novel terahertz scanning tunneling microscope technique that if successful, may lead to new electronic device concepts capable of operating at THz frequencies supporting next generation high bandwidth communication systems; study extracellular bioelectrical stimulation and theoretical modeling with other published technologies to understand the impact of extracellular bioelectric fields on the structures and functions of intracellular liquid condensates that if successful, may lead to new insights and therapies for traumatic brain injury; investigate silicon nitride on lithium niobate as an optoelectronics materials platform along with the necessary design, fabrication, and characterization processes to validate the material's unique capabilities for realizing			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
modulator architectures with unprecedented performance that if successful, will enable high performance computing hardware for artificial intelligence (AI) applications such as target recognition or natural language processing; study the nature of magnetic coupling across interfaces between topological materials and magnetic materials that if successful, will provide a foundation for new energy efficient electronic technologies that will enable Soldiers and small systems to extend mission length and reduce dependence on extensive portable power systems. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding decrease reflects the planned lifecycle of this effort.			
Title: Basic Research in Materials Sciences ***Description:*** Research that provides innovations in materials design and process through the elucidation of fundamental relationships linking composition, microstructure, defect structure, processing and properties of materials. Revolutionary materials provide support for the Army in firepower, mobility, communications, personnel protection, infrastructure and installations, and will directly affect virtually all mission areas. ***FY 2023 Plans:*** Will investigate the ability of polystyrene sulfonate and polyacrylic acid microgels to selectively sequester and release colistin and polypeptide-based anti-microbials using optical microscopy, electron microscopy, and computer simulations that could be used to tune these chemical interactions so that the microgels release their cargo in response to biologically and environmentally relevant changes in pH and ionic strength that if successful, could enable self-disinfecting surfaces, advanced surgical treatments, or systems for chemical-biological defense; identify thermodynamic, electronic, magnetic, and piezoelectric properties of twodimensional transition metal silicates and calculate oxidation states of the transition metals that if successful, will enable low power, more resilient electronics; identify phase transformation mechanisms of two dimensional materials under pressure and transition to structures with extraordinary mechanical properties that if successful, could enable Soldier protection systems which actively increase stiffness and strength in response to extreme events like blast and impact; conduct experiments to characterize the local heating stages of an ultrasonic consolidation method that is expected to enable safer processing of energetic materials	10.809	13.315	14.089

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
in order to understand the relationships between the processing conditions and the resulting material's microstructure and properties; develop supramolecular, nano-porous peptide materials that undergo localized reconfiguration upon selectively binding of target molecules that if successful, may lead to sensitive sensor platforms for Army needs in chemical and biological warfare agent detection. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Basic Research in Mechanical Sciences ***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 2023 Plans:*** Will derive precursors for the prediction of flow instabilities leading to separation around airfoils using partially observed states and validate a rigorous framework for the prediction of extreme events for specified quantities of interest, using partially observed states that if successful, will improve the control and maneuverability of rotorcraft; study how thermodynamic forces and information processing drive adaptive, emergent, and intrinsic computation in intelligent systems that if successful, could yield self-adapting autonomous systems; investigate high-pressure deformation mechanisms and constitutive behavior at grain boundaries, intermetallic inclusions, and nanoscale precipitates in aluminum 7075 that if successful, could enable lighter weight vehicle armor;	8.421	9.124	11.248

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
assess the hypothesis that crystallographic orientation and particle morphology are major contributors to fracture behavior of single and multiple silica sand particles during high strain rate loading and if successful, has the potential to improve the ground penetration of projectiles. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research into computational tools for materials behavior in extreme environments.			
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 2023 Plans:*** Will explore the theoretical underpinnings of vulnerabilities of deep learning and create robust methodology to defend against potentially backdoored Deep Neural Networks that if successful, will enable the detection of the presence of adversarial triggers (backdoors) and to accurately recover the correct output label even when presented with a poisoned/adversarial input; develop a dynamic learning framework that effectively extracts Activity-Based Intelligence in highly complex and plausible military operations, specifically, Dynamic Scene Graphs over large-scale multimodal time series data may be such a candidate for representation learning; determine how systems that serve as the backbone of modern computing infrastructure can exploit heterogeneous storage to achieve faster performance at a lower cost by incorporating heterogeneous storage into databases, which are a core system of any computing application in any environment; investigate how meta-learning and multi-task learning methods can adapt to both changes in the environment and changes in specific tasks by developing online meta-learning methods that can use past experiences of adapting to changes in the environment and task and by distilling this past experience into a compositional and modular multi-task representation. ***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,	6.342	7.358	7.335

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding decrease supports planned lifecycle of this effort.			
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 2023 Plans:*** Will develop wireless networking algorithms for ultra-reliable-low-latency communications with various constraints, such as strict deadline constraints and age of information constraints, facilitated by network function virtualization, starting with single hop contention based network and working towards multi-hop wireless; develop multi-Agent Reinforcement Learning algorithms in networked autonomous systems that operate in dynamic, uncertain, and possibly adversarial environments to support autonomous behavior of agents working in concert to accomplish a mission, including transfer learning for agents from each other, as well as learning the objectives of other agents from their actions and identify agents whose objectives might diverge from the mission goals; explore control methodologies to reduce the error rates of qubits in quantum systems to enable scalable quantum computers and efficient quantum communication systems; investigate quantum error correction codes to ensure that they can produce useful virtual qubits from a practically realizable number of physical qubits; assess human-agent teaming to reduce errors associated with knowledge handoffs during human shift changes in complex intelligence activities, with specific focus on reduction in the risk inherent in human processing of intelligence, particularly in settings where the body of information is so complex it requires a team of analysts to execute the mission; investigate the use of interactive agents to assess the impact on communication and coordination problems such as blind spots, biases, and human-introduced inaccuracies during shift handovers of intelligence work; develop a method to use Neural Networks to identify events, given that identification of events depends on contextual information, and how to bring the context into Deep Neural Networks while processing text. ***FY 2024 Plans:***	10.453	11.470	12.017

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Basic Research in Mathematical Sciences	7.011	7.868	8.173
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 2023 Plans:*** Will develop new methods for manipulating and synthesizing large amounts of noisy data to characterize in a more mathematically structured form, and therefore a form that may be ultimately more useful in applications; investigate the foundations of mathematics based on type theory in order to develop a fusion of logic and computation that is capable of developing scale-bridging mathematical modeling methodologies; will solve some of the key difficulties in heterogeneous data analysis like the individual difficulties of identifying what portions of the data are related and which are not, and then developing principled methods to partition, while also identifying key relationships between partitions; investigate the homotopical certification of algorithms to be used in complex data analysis, which have shown potential in areas such as self-assembly of micro or nano-structures, where structural evolution and energy release are mapped out so as to cooperatively construct useful structures in situ, such as for material healing or in-body drug assembly/activation; explore homotopy methods for hierarchical control in the previously			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
mentioned contexts; explore homotopy methods in other multiscale applications of Army interest, such as in characterizing the dynamical and state properties of complex biological systems. ***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 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: HBCU/MI Single Investigator ***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 2023 Plans:*** Continue to 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. ***FY 2024 Plans:*** 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/	2.388	2.677	5.105

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional infrastructure and research capabilities that will be developed at the HBCU/MI institutions.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	2.065	-
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Basic Research in Electronics and Photonics and Basic Research in Chemical Sciences in FY 2024 to support research in Energy Sciences within this Project.	-	-	2.792
Title: HBCU/MI Early Career Award for Science and Engineering	-	-	1.000

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research in support of establishing true partnerships with outstanding U.S. citizen scientists and engineers beginning their careers at HBCU/MIs.			
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. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research in social sciences to enhance national security.	-	-	2.000
Accomplishments/Planned Programs Subtotals	86.464	97.025	108.599

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA4: *Training and Human Science Research*	-	20.862	22.180	21.024	-	21.024	21.026	20.979	24.112	24.397	0.000	154.580

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

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Translational Neuroscience	3.827	4.162	4.399
Description: This effort integrates neuroscience with traditional approaches to understanding Soldier behavior to enable system designs that maximize Soldier performance. ***FY 2023 Plans:*** Combine multiple models of embedded abstract representations to simulate interactions between brain regions observed in the mammalian spatial reasoning system; embed abstract representations discovered from the mammalian spatial reasoning system into topological neuronal networks; integrate opportunistic signals collected during search task with machine learning models to optimize search performance within human-machine teams; apply novel approaches to simultaneous neural recordings from multiple individuals working together as a team. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Human System Integration	5.063	4.671	4.228
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 information approaches to extend the scope of interaction beyond individual systems to the full network context. ***FY 2023 Plans:*** Create approaches that enable intelligent systems to predict changes in human adaptation over time to drive optimal human-machine mutual adaptation; discover human-in-the-loop approaches to guide human-machine adaptation by isolating and prioritizing task-relevant information in the environment; create novel biometric-based objective functions that can improve the			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
rate of mutual human-machine adaptation; uncover approaches to gather critical information from groups of people to guide stable machine learning; create mathematical approaches to resolve conflict within groups of people when guiding machine learning. ***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 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Hybridization of Team Thinking within this Project in order to support increased research in human-systems science.			
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 2023 Plans:*** Identify which contextual history features and timescales (e.g., days, weeks) explain the most variation in human decisions within human-autonomy teams; create models that characterize human variability of irrational decision making and its contextual correlates; advance human physiological complexity matching indices to enhance predictability of human brain and heart variability; quantify influences of long-timescale processes (> weeks) on human performance variability as compared to short- and mid-timescale processes. ***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 2023 to FY 2024 Increase/Decrease Statement:***	4.207	4.571	3.248

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Funding realigned in FY 2024 to PE 0601102A Project AA6 Robotics and Mobile Energy to increase research in Foundational Energy for Sustained Operations.			
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance and behavior. Understand the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to affect performance similar to that in an operational environment. Characterize the appropriate use of different classes of simulated environments to ensure valid results. Develop guidelines for using mobility platforms in simulators to induce physical and cognitive stress representative of the operational environment. Implementation of these guidelines will enhance training effectiveness.	1.285	-	-
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 performance. This effort emphasizes deep learning approaches that function under conditions of limited, mismatched, or dynamic data. ***FY 2023 Plans:*** Investigate human-in-the loop artificial intelligence (AI) algorithms that can rapidly learn a wide range of skills to be able to adapt to novel tasks with minimal additional training. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of the effort.	0.939	1.042	1.062
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 2023 Plans:***	-	2.259	2.914

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Merge novel advances in human-guided machine learning with novel advances in neuroscience into a hybrid thinking experimental test-bed; conduct laboratory experiments to show hybrid human-machine adaptation for decisions at the edge of human capability. . ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Human System Integration within this Project in order to support increased research in human-systems science.			
Title: Science of Measurement of Individuals and Collectives ***Description:*** This basic research effort develops advanced psychometric theory and measurement of Soldiers and teams in order to maximize talent management. ***FY 2023 Plans:*** Conduct research to advance psychometric theory and measurement of Soldiers and teams to improve selection and assignment. ***FY 2024 Plans:*** Will conduct research to develop novel approaches to measurement of cognitive and non-cognitive knowledge, skills, and abilities. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.	1.851	2.092	2.100
Title: Context of Behavior in Military Environments ***Description:*** This basic research effort develops an integrative theory to understand and model the contextual drivers of individual and group performance.	0.932	-	-
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 2023 Plans:***	1.771	2.045	2.000

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Conduct research to develop multilevel models of teams in complex organizations to advance understanding of 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding decrease supports planned lifecycle of the effort.			
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 2023 Plans:*** Conduct research to advance theoretical understanding of learning methods to maximize the transfer of complex tactical, technical, and interpersonal skills from formal & informal learning environments. ***FY 2024 Plans:*** Will conduct research to develop theory and practices conducive and specific to adult learning. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of the effort.	0.987	1.012	1.073
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.326	-
Accomplishments/Planned Programs Subtotals	20.862	22.180	21.024

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA5: *Biotechnology and Systems Biology*	-	5.842	6.421	6.547	-	6.547	6.614	6.622	9.555	9.518	0.000	51.119

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/ultra-high molecular weight (UHMW)/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.

Work in this Project is performed by the United States Army Futures Command (AFC).

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 2022	FY 2023	FY 2024
Title: Engineered Biotechnology	2.478	2.722	2.788
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 2023 Plans: Investigate material specific microbes and communities based on analytical and computational techniques; explore synthetic biology genetic tool-kits on selected organisms to modulate microbial interactions with materials for controlled degradation and assembly; investigate the temporal and spatial properties of modulated microbial interactions with materials; investigate interactions of modulated organisms with natural microbial communities and explore the effects on the microenvironment of the materials during degradation and assembly; use predictive community models to identify designer communities for targeted degradation and assembly.			
FY 2024 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of the effort.			
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 2023 Plans:*** Pioneer synthetic biology and advanced analytical tools to drive selection of control mechanisms in indigenous (local to Army environment) organisms; investigate and explore tuning parts and control mechanisms for harnessing indigenous biology; investigate dynamic range of orthogonal tools in individual organisms and explore control across different organisms to understand agility; investigate control mechanisms in indigenous organisms exploring behavior in different laboratory contained environments (e.g, temperature, salinity); pioneer synthetic biology methods to tune sequence defined material properties and investigate interface and assembly of materials; explore and investigate strategies for using material analytics bioinformatics and material informatics to understand synthetic biology materials. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of the effort.	3.364	3.644	3.759
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:***	-	0.055	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638			
Accomplishments/Planned Programs Subtotals	5.842	6.421	6.547

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 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA6: *Robotics and Mobile Energy*	-	19.857	21.854	25.268	-	25.268	27.467	27.511	27.538	27.811	0.000	177.306

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 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 United States (U.S.) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Vehicle Propulsion and Power Research	1.332	1.603	1.706
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 2023 Plans: Perform experiments on smart materials that serve to articulate thin airfoils (e.g., turbine blades) to enable engines that operate efficiently at different speeds; explore discontinuous ultra-high temperature ceramic (UHTC) fibers to fabricate ceramic matrix composites for future hot engine components; develop high fidelity models to study interactions between gas turbine engine combustor and turbine sections.			
FY 2024 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
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 2023 Plans:*** Demonstrate aviation fuel ignition models at both high fidelity for combustion simulation and reduced order for engine control applications; investigate altitude ignition behavior for novel small combustor geometries; assess initial concepts for on platform fuel sensors; investigate production methods of advanced aluminum alloys in initial aviation engine combustion components; assess tailored materials and coatings for damage resistant fuel-lubricated mechanical interfaces with low lubricity fuels. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.	3.203	3.119	3.163
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. ***FY 2023 Plans:***	0.888	0.973	1.005

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Study electrocatalytic and thermocatalytic processes for chemical energy storage at the interfaces of liquid media, nanocatalysts, and visible/infrared absorbing nanoparticles using electrochemical and spectroscopic characterization methods; study the energy dependences of nuclear excitation by electron capture or other processes for on-demand isomer energy release; investigate isomer production approaches; design a proof-of-concept experiment for an isomer power source. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
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 2023 Plans:*** Explore optimization algorithms for vehicle reconfiguration and employ machine learning/molecular modeling approach to conceptualize new shape reprogrammable structures by introducing new bio-inspired functionalities for UAS platforms; explore the design space enabled by reconfiguration technologies; develop mathematical models of aeromechanics and flight control of morphing aircraft platform subsystems and incorporate them in the conceptual design framework to achieve extreme performance and agility attributes. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	0.937	1.027	1.061
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	1.559	1.811	1.878

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
planning, behaviors, energy efficient maneuver, and the interface of manipulation technologies to support manned-unmanned teaming constructs. ***FY 2023 Plans:*** Identify characteristics and continue to develop algorithms that enable autonomous energy distribution between ground and air vehicles for sustained increase in operational duration; create algorithms for optimized vehicle route planning for robot teams which factor energy availability and mission constraints; explore alternative power generation methods that will extend autonomous vehicle endurance in logistically uncertain and contested environments. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
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 2023 Plans:*** Explore navigation techniques capable of assessing route options in partially known environments, and adapting based on limited human examples; create algorithms that allow for rapid adaptation to incomplete or unexpected semantic observations in the environment; extend autonomous vehicle endurance through fundamental research in navigation algorithms which utilize all available resources for route planning while assessing multiple courses of action to enable longer planning horizons; validate algorithms that manage automated tuning of low level control parameters from limited human feedback; create algorithms that intelligently share representations and distributed context to enable planning across multiple vehicles. ***FY 2024 Plans:***	5.888	6.326	6.652

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
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 2023 Plans:*** Investigate novel active materials and structural design concepts to enable transformational capabilities within congested environments for advanced UAS platforms; explore 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; validate computationally efficient methods and functional models of aerodynamic interactions for near real-time flight dynamics in virtual environments; explore 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; create new computational modeling methods, active flow controls, and passive vehicle structural designs to mitigate negative impacts of unsteady fight conditions through wind tunnel experiments; pioneer new concepts for small UAS that include reconfigurable and resilient structures, super maneuverability, and extreme endurance. ***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	2.883	3.141	3.247

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
platforms exhibiting reflexive agility and embodied intelligence to enhance mobility in terrain/environments, including control systems approaches and implications of air vehicle structures. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
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 2023 Plans:*** Conduct high-fidelity computational simulations of detailed rotor wake structure to understand and quantify the vertical instabilities manifest as worm-like flow structures seen in high fidelity experimental measurements; explore reduced order models and machine learning algorithms to study interactional aerodynamics effects over a wide design space. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	2.460	2.682	2.769
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 2023 Plans:*** Continue investigative research into quantum computing approaches for computationally expensive multi-scale algorithms for modeling a military ground vehicle interaction with terrain / soft soil; expand research gaming engine algorithms for autonomous vehicle off-road mobility; continue researching the application of deep learning algorithms for generating Go/NoGo maps to other	0.707	0.776	0.803

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
geographic regions; investigate off-road intelligent autonomy for multi-scale vehicle fleets, including fleet energy management; investigative research into energy and power density for highly mobile systems, including reconfigurable in the context of energy routing to endure under potential damage. ***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 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.396	-
Title: Foundational Energy for Sustained Operations ***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	-	-	2.984

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from PE 0601102A Project AA4 Training and Human Science Research and PE 0601102A Project AA9 Information and Networking to support additional research in the area of energy science within this Project.			
Accomplishments/Planned Programs Subtotals	19.857	21.854	25.268

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA7: *Mechanics and Ballistics*	-	32.114	35.234	35.014	-	35.014	35.482	35.525	37.889	38.635	0.000	249.893

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Protection Sciences	5.193	5.471	5.658
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			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
mechanisms through increased understanding of wave propagation through tissue, and the resulting deformation and damage of tissue during ballistic and blast events. ***FY 2023 Plans:*** Develop computational toolsets and experimental techniques that provide core insight into fracture and failure of ceramics and dynamic response of multi material systems; improve understanding along the continuum of armor material response from current near-skin protection to those that may be decoupled from the human body; develop multi-scale modeling and simulations and conduct experiments to optimize performance leading to improved V50 penetration velocity metric in monolithic ceramic material with a goal of 25% predicted improvement in V50 over commercial monolithic ceramic materials; fabricate engineered multi-phase ceramic with structure and properties to provide optimum control and granular flow during a ballistic event. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
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 2023 Plans:*** Investigate active, tunable materials with high stiffness that can act over short time scales with minimal energy requirements for an integrated approach to Army structural, protection, and lethality applications; develop materials that focus on leveraging mesoscale material architecture modifications to intensify response mechanisms without sacrificing mechanical properties of the material. ***FY 2024 Plans:***	3.183	3.442	3.559

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
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 2023 Plans:*** Perform modeling and simulation of prescribed, simplified defect structures within metals, ceramics, and polymers, and correlate these results with measured properties from characterization efforts, laying the foundation for future predictive tools; investigate assessment methods that allow for rapid analysis of dominant failure modes and deformation mechanisms in specimens under high rate, high temperature conditions. ***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 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned from this effort to support research in Additive Manufacturing Sciences within this Project.	3.283	3.549	2.470
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 2023 Plans:*** Develop a theoretical framework to define the relationship between applied magnetic fields and diffusion mechanisms in alloy compositions; perform ballistic assessment of lightweight armor materials, developed utilizing novel synthesis techniques, for increased Soldier protection and mobility. ***FY 2024 Plans:***	2.395	2.593	2.681

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
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 2023 Plans:*** Develop unifying theory of 2D polymer failure at the molecular level and integrate into multiscale finite element models; implement AI/ML into multiscale models to predict mechanical properties and benchmark with experiments; develop optimal functional groups within 2D polymers for enhanced toughness, stiffness, and strength. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.	1.601	1.746	1.807
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 2023 Plans:*** Continue to identify compatible organisms and material scaffolds for precision placement and integration of biological and composite behavior; investigate and tune precision placement of compatible organisms and material scaffolds for improved meso-scale assembly; improve material, biopolymer, and composite properties for sequence-defined function properties during scalable	1.743	1.878	1.941

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
integration and processing; create predictive models of biopolymer meso-scale assembly for rational design of material scaffolds based on structure-function properties and sequence defined assembly. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle for this effort.			
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 2023 Plans:*** Investigate shock-boundary layer interactions and boundary layer stability/transition for canonical problems; establish feasibility of coupled discipline computational toolset; obtain experimental validation of aero-thermodynamics in sub-scale high-speed ballistic range facility; develop high uncertainty tolerant flight control algorithms for weapons; formulate data-driven multi-agent/sensor estimation algorithms for collaborative delivery; explore emergent behaviors for offensive strike using artificial intelligence and machine learning algorithms. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.	3.094	3.344	3.461
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 2023 Plans:***	3.486	3.767	4.049

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Explore and synthesize novel strained ring materials, extended solids, and core-shell nanometals for use in explosive and propulsion applications; explore mesoscale-continuum scale model coupling as well modeling and validation of novel rocket propulsion concepts for eventual transition to long-range fires. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
Title: Theory in Atmospheric Characterization, Sensing, and Modeling	4.007	4.330	3.578
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 2023 Plans:*** Conduct field experiments of environmental effects on acoustic and electromagnetic signal propagation in urban environments; validate machine-learning methods to enable multi-modal sensor adaptability and optimal data fusion; explore new formulations of thermal forcing in lattice-Boltzmann-based fluid dynamics models; explore algorithms to better simulate warm microphysics processes; study and validate methods to provide bulk characterization of atmospheric quantities such as turbulence, aerosol concentration, and thermal profiles based on non-traditional, limited atmospheric observations; explore methods to connect microscopic scattering processes with detection and bulk impact of aerosols on radiative transfer; investigate impacts of atmospheric and boundary-layer processes on electromagnetic/radio frequency propagation; study aerosol transport due to terrain-related variability in the boundary-layer momentum and heat fluxes and the evolution of transient and recurring flow instabilities on aerosol concentrations and transport; conduct experiments on promising methods for optical detection of biological materials. ***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			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, a portion of funding was realigned from this effort to PE 0601102A Project AA9 Information and Networking to support research in Assessing and Mitigating Climate Risk for Decision Making.			
Title: Environmental Quality ***Description:*** This effort conducts research on innovative environmentally-friendly technologies that support the warfighter focusing on pollution prevention technologies. ***FY 2023 Plans:*** Conduct research on environmental issues associated with the exploration of current and future energetic development to include: fundamental aspects of compounds, solvents, precursors, and bench scale synthesis; conduct research in the replacement of hazardous solvents and alternative methods to process chemicals for energetics to reduce environmental, safety, and occupational health (ESOH) issues. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	1.068	1.164	1.204
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. ***FY 2023 Plans:*** Conduct basic research related to fundamental studies, predictive modeling, for advanced materials processes as it relates to chemical-biological materials and sensors. Research will focus on expanding 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	2.297	2.487	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned to Chemical-Biological Advanced Materials and Manufacturing Science within this Project.			
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 2023 Plans:*** Combine computational modeling and automated processes to assist in the design and assessment of alloys as structural materials for use in armor and weapon systems applications. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	0.764	0.815	0.834
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.648	-
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:***	-	-	1.200

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Will investigate interfacial microstructural kinetics from precision additive and transformative manufacturing and bonding of dissimilar materials. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from High Deformation Rate Materials within this Project to support research in additive manufacturing sciences.			
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 on critical performance characteristic of materials; study particle dispersion and novel material properties for utilization in next generation obscurants and novel pyrotechnics. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned from Surface Science Research within this Project.	-	-	2.572
Accomplishments/Planned Programs Subtotals	32.114	35.234	35.014

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA8: *Sensing and Electromagnetics*	-	13.092	13.619	16.383	-	16.383	26.083	31.647	29.340	33.406	0.000	163.570

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.

Work in this Project is performed by the United States (U.S.) Army Futures Command (AFC).

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 2022	FY 2023	FY 2024
Title: Advanced Materials Research	3.333	1.533	1.562
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 2023 Plans: Investigate fundamental properties of acoustic, seismic, electric field, magnetic, gravimetric, passive radar, and integrated photonic analogs of macro-scale non-traditional sensor systems (e.g. laser vibrometry) to determine cross-correlative properties as a function of sensing vantage and range; research multi-modal and distributed sensing for detection confidence, clutter rejection, range enhancement, and Signal-to-Noise Ratio (SNR) improvement; investigate distributed sensor processing architectures for single and multi-agent state estimation, leveraging the ability to process sensor data locally with limited computational processing and distribute the processed data over an austere and intermittent network to achieve high confidence detection.			
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			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** This increase supports the planned lifecycle of this effort.			
Title: Distributed Sensor Research ***Description:*** This effort creates more survivable and secure sensors and displays, investigates new acoustic, seismic, magnetic- and electric-field sensor technologies for personnel, activity, vehicle, and weapon-fire, and develops means to correlate, fuse, and interpret data from diverse sensors. This effort investigates novel algorithms and electromagnetic models to better understand radio frequency (RF) propagation and exploitation in complex clutter environments for improved RF and radar sensing.	1.676	-	-
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 2023 Plans:*** Examine impact of planar versus vertical architectures on leakage currents in SiC diode structures under high electric (E)-fields; validate interfacial interactions of adsorbed chemical species and excited states; investigate novel materials and structures enabling low-size, weight, and power (SWaP) optical communication and time transfer and investigate material systems for chip-scale lasers for next-generation clocks and sensors; study the nature of how adsorbed species impact charge and thermal energy transfer across interfacial boundaries between photocatalytic substrates and reaction media and investigate how to modulate the thermal envelope around a plasmonic nano-heating reactor to control reaction rate dynamics when illuminated; study molecular and atomistic processes at interface in aqueous and multivalent battery systems and investigate ionic, electronic, and water transport at these interfaces to suggest model-based strategies to promote stable, high rate interfaces with enhanced cycle stability. ***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	1.132	1.248	1.709

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
chemical reactions; research novel material approaches and micro structures for low-size, weight, and power (SWaP) free-space optical time transfer unit. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research into ionization as it relates to E-fields.			
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 2023 Plans:*** Investigate epsilon-near-zero resonator bidirectional coupling mechanisms with purpose-built waveguides for advanced testing and future coupling to optical frequency comb micro-resonators; experimentally explore use of new locking mechanism of optical frequency comb to epsilon-near-zero resonator. ***FY 2024 Plans:*** 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	0.701	0.765	0.789
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 2023 Plans:*** Combine experimental and modeling approaches to investigate molecular structure, interactions, and dynamic behavior of mechanochromic liquid crystals incorporated within polymer matrices with varying mechanical properties. Results will support advances in smart materials that rapidly sense and respond to external stimuli for situational awareness and signature management applications; gain understanding of molecular-scale properties and dynamic deformation behavior of various polymer and composite materials to inform future development of material systems for improved Soldier protection. ***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	1.186	1.290	1.332

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
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 2023 Plans:*** Investigate and assess the tenability of phase change thermal materials and study the thermal transfer characteristics of the materials and interfaces; conduct laser experiments using fibers with advanced glass compositions aimed at improving thermo-mechanical and thermo-optical properties for better power scaling. ***FY 2024 Plans:*** 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort	1.241	1.030	1.062
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 2023 Plans:*** Explore methods to improve major deficiencies of existing machine-learning approaches when modeling physical systems; based on previous accuracy assessments, identify classes of physical systems on which to focus; examine the use of geometrical methods for incorporating physical constraints into machine-learning models of physical systems; validate most promising	3.150	3.381	3.498

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
methods for assimilating of multiple-fidelity data into machine-learning models of physical systems; analyze existing techniques for uncertainty quantification of machine-learning models for efficacy. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
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, industry, and government laboratories to develop new and advanced semiconductor materials and devices for sensors, emitters, neuromorphic, and topological device applications. ***FY 2023 Plans:*** Apply new materials understanding to Type-II super lattice (T2SL) device structures in collaboration with industry/academia materials to study performance; transition higher order modeling code for high field electro-optical simulations in house for investigation, design, and optimization of avalanche photodiodes (APDs); predict transport and magnetic exchange characteristics of low power switching electronic devices comprised of TI and either ferromagnetic or antiferromagnetic layers. ***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 2023 to FY 2024 Increase/Decrease Statement:***	0.673	0.956	0.693

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Funding decrease reflects a reduction in research specifically targeting new materials as research is now shifting to additional modeling.			
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 2023 Plans:*** Investigate concepts for novel radar and multi-function RF signal processing in distributed and complex environments; explore modeling, simulation, and emulation techniques for phenomenology of complex distributed environments for phase synchronous and distributed operation; explore concepts for reconfigurable materials-based antennas and harmonically-operated array elements. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	-	1.211	1.248
Title: Foundational Sensing ***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 2023 Plans:*** Investigate multi-component, reduced size, weight, and power (SWaP) acoustic, seismic, gravimetric, passive radar, and integrated photonic analogs of macro-scale non-traditional sensor systems (e.g. laser vibrometry) and sensing methods that are insensitive to decoys, obscurants, and jamming on ground or airborne platforms; validate sensor performance in tactical environments with improved wide-area modeling and simulation of sensor response and target signatures; research novel domain adaptive processing/learning algorithms for robust target tracking and implement distributed processing framework for single	-	1.988	1.606

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
and multi-agent state estimation, leveraging the ability to process target data locally with limited computational processing and distribute the processing of data over an austere and intermittent network. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding decrease reflects a reduction in research supporting the distributed processing framework as research is now shifting to additional modeling.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.217	-
Title: Complex Effects Understanding and Modeling ***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. ***FY 2024 Plans:***	-	-	1.514

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research into intractable physical systems and the computational methodologies needed to investigate them.			
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research into energy and ultra-efficient nodes for sensing applications.	-	-	1.370
Accomplishments/Planned Programs Subtotals	13.092	13.619	16.383

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army											Date: March 2023	
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 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
AA9: *Information and Networking*	-	38.956	42.839	43.075	-	43.075	43.520	43.568	46.644	47.199	0.000	305.801

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 focuses 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 PE 0602146A (Network C3I Technology), PE 0602143A (Soldier Lethality Technology), and PE 0602145A (Next Generation Combat Vehicle Technology).

Work in this Project is performed by the United States (U.S.) Army Futures Command (AFC).

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 2022	FY 2023	FY 2024
Title: Communications in Complex Dynamic Networks	5.128	5.621	5.739
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 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
FY 2023 Plans: Explore techniques and experimentation capabilities that dynamically monitor and identify adaptations of network resources and distributed analytics configurations to account for dynamics in-network resource availability and environmental state; conduct simulation- and emulation-based experiments to characterize performance of emerging networking capabilities, including high-speed networking technologies, unconventional spectrum, and joint classical/quantum networking; conduct research into heterogeneous networks comprising diverse communications capabilities, focusing on identifying and analyzing intelligent protocols for adapting to complex, dynamic, and/or spatially varying mission requirements and environments by leveraging unique features of component network technologies. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Data to Knowledge to Support Decision Making (Information Mediation)	4.063	4.459	4.554
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 2023 Plans:*** Investigate theories and fundamental models for facilitating increased comprehension, decreased uncertainty, and maintaining effective op-tempo decision making and responsive situational awareness and understanding; research design methods of visualizations to characterize impact of information in the dynamic operating environment under conditions of time sensitive and dynamically changing information; investigate gaps related to human cognition and system interface in decision making on			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
novel and emerging cross-reality visualization technologies; explore fundamental understanding of, and theories for, decision making phenomena in immersive environments and Joint, Coalition, and/or multi-domain data; investigate computational models, linguistic approaches, and rule-based algorithms for automated systems to detect, analyze, and interpret content from multimodal information sources and create methods and algorithms for knowledge networks for concept recognition, information foraging, semantic search, and advanced data analytics; explore theories for inferencing algorithms to derive context from multimodal, multisource information; investigate theoretical and computational models of causality, information uncertainty, and automated reasoning to recognize changing context, course of action recommendations, and ad hoc autonomous or collaborative decision making. ***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; 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Information Protection in Mobile Dynamic Networks ***Description:*** Perform research on protecting information in highly mobile, wireless tactical environments, where networks must operate under severe bandwidth, energy, and processing constraints, and without reliance on centralized security services. ***FY 2023 Plans:*** Conduct experiments on the direct transmission of entangled quantum states through various networking elements, including fiber and free-space channels, switches, and frequency converters; explore and analyze methods for creating, manipulating, and measuring hyper- and multipartite-entangled states; investigate defenses to adversarial machine learning based attacks on network security systems; reduce/eliminate misclassification of malicious network traffic as legitimate; reduce/eliminate misclassification of legitimate network traffic as malicious traffic to cause false positives; develop techniques to improve model performance through adversarial retraining. ***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	4.887	5.363	5.570

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
networking processes, including quantum frequency conversion; investigate network routing strategies with global multi-objectives accounting for message priority, latency, covertness, and robustness. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the 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 2023 Plans:*** Explore algorithms to discover and assess resource availability and capability in decentralized teams of agents; research optimized, constraints-based, resource allocation methodologies and algorithms for system of systems; analyze generalized algorithm reduction, compression, and scaling methodologies for size, weight, power and time constrained devices at the tactical edge; study emerging computing architectures designed specifically for neural network inferencing to determine best viable candidates; develop algorithms, benchmarks, and techniques to measure performance of a neural network on a specific architecture; engage in hardware / software co-design efforts to maximize inferencing performance; enable trade-space analysis of performance characteristics in order to meet specified requirements in machine learning inferencing. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.	3.757	4.124	4.212
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	6.084	6.505	5.144

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. ***FY 2023 Plans:*** Conduct research to develop algorithms to efficiently and robustly understand performance of complex analytics in a variety of situations and network and environmental states, and can optimally identify adaptation and reconfiguration strategies toward the allocation of network and analytics resources; study algorithms for multi-agent systems to allow optimal decision making in teams of agents that are resilient to critical failures; investigate scientific theories and methods that optimize information synthesis under constrained battlefield environment; research methodologies to identify and exploit high-value information from physical sensors, information assets, and intelligence given highly dynamic and optempo conditions, unreliable network, and adversarial presence; research contextually-sensitive resilient dissemination and mediation of multi-domain battlefield information based on value-based selection, prioritization, and mission factors; investigate theories and novel methods for resilient information-network that allow dynamic information pathways and improve time and reliability of information/data over constrained tactical networks; study new methods for single and multi-modal machine-learning based reconstruction algorithms for one-dimensional (1-D) and two-dimensional (2-D) signals; investigate machine-learning methods to derive controlling parameters from data in physical systems (inverse problems); assess performance of low-resource methods for aggregating and propagating uncertainty in physical systems. ***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 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned from this effort to PE 0601102A Project AA6 Robotics and Mobile Energy to support research in Foundational Energy for Sustained Operations.			
Title: Machine Learning for Intelligent Agent and Human Decision Making	5.533	6.066	6.291
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			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 Plans:*** Explore the tradeoffs of performance and accuracy in machine learning algorithms while exercising model-efficiency techniques; investigate ability to instantiate realistic honeynets in a novel multi-fidelity testbed; develop and assess proof-of-concept approaches for SDN-based technologies for tactical applications; examine phenomena and create theoretical approaches that allow small teams of heterogeneous agents to coordinate, decide, and act based on environmental context and observations for tactically relevant situations; determine best mathematical methods and create algorithms for shared representations across teams of heterogeneous assets using salient data streams; research collaborative game-theoretic Intelligence, Surveillance, Reconnaissance (ISR) task execution in contested environments, adversarial evasion, and autonomous maneuver to a position of advantage, and autonomous navigation to target location while avoiding detection; investigate fundamental methods for dynamic bi-directional interaction between Soldiers and autonomous systems to maintain a consistent world model and shared understanding during joint collaborative tasks; explore fundamental techniques to enable multi-agent systems to autonomously adapt group behaviors through machine learning and theoretical models of coordination. ***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 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
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 2023 Plans:*** Investigate machine learning methods for situational understanding based on vision sensor data for rapid decision-making in complex and dynamic environments with constrained computing resources; investigate methods for synthesizing image data	2.148	2.366	2.416

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
for training machine learning algorithms for improved real-world performance; investigate methods for fusing information from aerial geospatial data with ground data for context-aware route planning and autonomous navigation; conduct experiments with electro-optical infrared (EO/IR) data collections using unmanned aerial vehicles (UAVs) of humans performing activities; develop computer graphics and motion capture solutions to generate synthetic activity data, increasing the amount of data available over real-world only data for algorithm training. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Fundamentals for Energy Efficient Electronic & Photonic Components	1.872	2.064	2.109
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 2023 Plans:*** Investigate and identify limitations of radiation tolerance in Ultra-Wide Bandgap (UWBG) materials through modeling and alpha and electron beam radiation exposure assessments; investigate structurally metastable nitrides for electric field-induced phased transitions using x-ray crystallography and electrothermal characterization; explore the effects of metallization of additively manufactured composite materials on circuit performance in 3-Dimensional (3-D) printed structural power devices and electronics; design and fabricate metasurfaces specific for addressing future needs in imaging, radar, and communications applications. ***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			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Quantum Information Sciences ***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 2023 Plans:*** Investigate interfaces between electromagnetic fields and atomic/material systems for novel sensors, building blocks of entanglement distribution, and approaches to low size, weight, and power timekeeping; investigate experimental implementation of proposed techniques for quantum gate operations in atomic systems; explore 1-D physics of interacting quantum systems; explore sub-thermal readout of electric field sensors; investigate all-optical approaches to photonic qubits; explore effect of defect density on clock and sensor performance in solid-state sensors. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	5.484	6.013	6.140
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:***	-	0.258	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638			
Title: Assessing and Mitigating Climate Risk for Decision Making ***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:*** 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 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned from PE0601102A Project AA7 Mechanics and Ballistics to support research in climate risk for decision making.	-	-	0.900
Accomplishments/Planned Programs Subtotals	38.956	42.839	43.075

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	36.137	4.405	4.508	-	4.508	4.664	4.641	4.644	4.696	0.000	63.695

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 by the Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Pre-hospital tactical Combat Casualty Care ***Description:*** This effort conducts basic science studies to determine physiological responses to trauma and aid in development of life-saving interventions.	0.885	-	-
Title: Prolonged Field Care ***Description:*** This effort conducts basic research to study the physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties.	2.355	-	-
Title: Injury Prevention and Reduction ***Description:*** This effort identifies biological patterns of change in Warfighters during states of physical exertion, identifies physiological (human physical and biochemical functions) mechanisms of physical injury and exertion that will predict musculoskeletal (muscle, bone, tendons, and ligaments) sensory (auditory, ocular, and vestibular) and blunt, blast or accelerative injury. ***FY 2023 Plans:***	2.479	1.074	1.803

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Will develop models and basic science approaches to translate injury mechanisms from the cellular level to higher tissue and organ level to understand their applicability in injury prevention and performance sustainment. Will continue to develop scaling models for injury utilizing models to translate injury criteria for use in human Person Protective Equipment (PPE) development. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects to re-baselining of basic research efforts post-USAMRDC transition to DHA.			
Title: Physiological Health ***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 2023 Plans:*** Will finalize basic research to understand field-based impact of sleep on operational performance. Will initiate research to understand neurobiological mechanisms of chronic fatigue incurred during extended operational conditions. Will finalize definition of the role of nutrition support for metabolic recovery from military activity. Will initiate research to understand the interface of nutrition modulation and immune regulation of disease susceptibility and injury recovery. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	3.861	1.416	1.443
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 2023 Plans:***	1.090	0.988	1.262

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Will utilize models to identify basic mechanisms of heat-related injuries which could be exploited as factors to accelerate and improve recovery. Will determine the efficacy of inspiratory muscle training to improve performance in high Carbon dioxide (CO2) and low Oxygen (O2) 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Psychiological Health and Resilience ***Description:*** This effort conducts research into the basic mechanisms of the ability to overcome traumatic events including determination of underlying neurobiological mechanisms (nervous system control of cellular and molecular processes) related to Acute Stress Reactions, early characteristics of Post-Traumatic Stress Disorder (PTSD), depression, and other neuropsychiatric sequalae of trauma/stress.	0.787	-	-
Title: Biology of Operational Pain ***Description:*** This effort performs basic research to support development of novel, non-opioid drugs to treat pain in the austere battlefield environment with minimal side effects.	1.101	-	-
Title: Extremity Trauma ***Description:*** This effort performs basic research to support development of treatments to preserve tissues and function of severely mangled limbs.	0.565	-	-
Title: Expeditionary Medicine ***Description:*** This effort performs basic research to support development of treatments to protect non-injured and injured, but viable, tissues from oxygen deprivation, metabolic disruption, and further injury following severe trauma.	0.486	-	-
Title: Hemorrhage, Shock, Coagulopathy of Trauma ***Description:*** This effort conducts studies to define and identify cellular processes and metabolic (biochemical activity) mechanisms associated with excessive blood clotting to understand the relationships between the human immune processes and bleeding in trauma.	1.640	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Title: Endovascular Hemorrhage Control ***Description:*** This effort performs basic research to support development of devices that when introduced into arteries or veins may be used to stop internal bleeding.	0.467	-	-
Title: Burn Injury ***Description:*** This effort performs basic research to support development of treatment and clinical management tools for severe burns.	2.786	-	-
Title: TBI Neurotrauma/Brain Dysfunction ***Description:*** This effort conducts basic research in poly-trauma (multiple injuries)/Traumatic Brain Injury (TBI) model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI.	1.388	-	-
Title: Soldier Performance Augmentation ***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. ***FY 2023 Plans:*** Will continue to investigate basic mechanisms of non-invasive brain and peripheral nervous system (outside the brain and spinal cord) stimulation for enhancing operational performance. Will investigate physiologic, metabolic and genetic biomarkers of resilience to military stressors. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	1.871	0.816	-
Title: Prolonged Field Care - Infectious Diseases ***Description:*** Discover and identify new prophylactic and treatment (antibodies, drugs and biologics) approaches that will lead to the development of effective prevention and treatment strategies for combat wound infections and sepsis in a prolonged field care environment. Identify approaches to develop antibodies, drugs and biologics that achieve protective effectiveness and discover and identify correlates of protection from combat wound infections in models and in humans.	4.442	-	-
Title: Medical Readiness - Infectious Diseases	6.884	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Description: Discover and identify new prophylactics and treatment (antibodies, drugs and biologics) approaches that will lead to the development of effective prevention and treatment strategies for endemic bacterial and viral infectious diseases. Identify approaches to develop antibodies, drugs and biologics that achieve protective efficacy and discover and identify correlates of protection from endemic diseases in animal models and in humans.			
Title: Medical Computational Modeling ***Description:*** This effort uses mathematical models and AI algorithms to extract medical information from large-scale datasets (generated from the study of cellular genetic makeup, protein structures and function, wearables, and whole-organism responses) to improve understanding, prevention, diagnostics, and treatments of those injuries and diseases that post a threat to Warfighter readiness: e.g., musculoskeletal injury and fatigue, Post-traumatic stress disorder (PTSD), heat stress, and infectious diseases.	3.050	-	-
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638. ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638.	-	0.111	-
Accomplishments/Planned Programs Subtotals	36.137	4.405	4.508

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	17.311	19.201	19.564	-	19.564	19.860	20.026	20.644	20.863	0.000	137.469

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 and coordinated with U.S. Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Mapping, remote sensing, signature physics and terrain state	3.680	4.177	4.358
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.			
FY 2023 Plans: Investigate parameterized anomalous sound propagation effects derived from ground turbulence blocking to localize and track elevated acoustic sources. Investigate if a link exists between mechanical properties of snow permeability, elastic modulus, and acoustic response. Quantify thin snow absorption, emission, and scattering processes influencing radiative transfer. Use this fundamental research to inform deep learning models for a forest canopy that predicts understory parameters.			
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 2023 to FY 2024 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Funding change reflects the planned lifecycle of this effort.			
Title: Fundamental Adaptive Protection and Projection Research ***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. ***FY 2023 Plans:*** Determine if density class interactions in multiple density mixtures lead to nonlinear sediment transport curves based on the proportion of dense material. Use parallel treatment of grains and bonds to understand how microscale snow parameters, particularly sintered bonds, impact the macroscale compressive strength. Systematically investigate multi-scale steel fiber influence on damage processes in Ultra-High Performance Concrete (UHPC). Will combine this novel research and experimental data with recently available data-driven discovery methods to capture near-surface aerodynamics and wind-driven process characterizations in dry-land environments. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects the planned lifecycle of this effort.	4.470	4.670	4.865
Title: Fundamental Infrastructure Sciences ***Description:*** Explores fundamental theory of artificial intelligence, robotics, autonomous construction, three-dimensional (3D) printing materials, self-assembly and advanced or innovative material science as related to advancing military construction and Engineer operations. ***FY 2023 Plans:*** Investigate the protein responsible for the durable, water resistant and thermally regulated mud dauber wasp nest. Investigate characterizations of liquid Gallium diffusion in Aluminum to potentially inform future infrastructure engineering advancements. Use	1.730	1.912	2.051

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
dynamic hyperbolic data projection to reveal knowledge from hyperdimensional datasets that existing methods are incapable of exposing. ***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 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects the planned lifecycle of this effort.			
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. ***FY 2023 Plans:*** Investigate soil disturbance and emissions using volatile compounds. Explore the relationship between atmospheric phenomena and natural processes. Explore synthetic engineering of bacteria to function as a non-model synthetic biology chassis. Investigate fundamental principles of cryptobiosis by engineering mechanisms into cells. Explorative research to investigate current and signal propagation dynamics in fungal melanin. New research into genetic adaptations of lichens will be conducted to exploit biological engineering functionalities. Investigate biological reactivity of carbon nanofiber strength with select proteins; results acquired from Basic Research may inform future capability advancement and adverse impacts on Army operations. ***FY 2024 Plans:*** 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 2023 to FY 2024 Increase/Decrease Statement:***	7.431	7.980	8.290

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
Funding change reflects the planned lifecycle of this effort.			
Title: SBIR/STTR Transfer	-	0.462	-
Description: Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638.			
Accomplishments/Planned Programs Subtotals	17.311	19.201	19.564

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 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
CH9: *Advancing Concepts and Technology Forecasting*	-	3.443	3.793	3.862	-	3.862	3.895	3.900	3.903	3.946	0.000	26.742

A. Mission Description and Budget Item Justification

This Project works across the Army Futures Command Combat Capabilities Development Command and with the Futures & Concepts Center to identify 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. Outcomes describe the projected future operational effects of science in the context of Army concepts to enable informed decision making and mitigate risk for future Army capabilities.

Advancing Concepts ensures Army Concepts are grounded by recent 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 United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Advancing Concepts and Technology Forecasting	3.443	3.712	3.862
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 2023 Plans: Combine basic scientific research outcomes into emerging Army Warfighting Concept priorities for far-term decision dominance, deception and protection, sustained operations, and maximizing human potential; provide objective estimates of anticipated basic scientific research advances, across the Army Priority Research Areas, to Army decision-makers to aid in basic research program formulation.			
FY 2024 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023	FY 2024
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 research advances of emerging scientific areas (novel computing architectures, alternative power sources, new communications mechanisms) with high relevance to the Army. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.081	-
Accomplishments/Planned Programs Subtotals	3.443	3.793	3.862

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	73.000	112.500	-	-	-	-	-	-	-	0.000	185.500

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 2022	FY 2023
Congressional Add: Program increase ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Basic Research	25.000	-
Congressional Add: Program increase - EXPLOSIVES AND OPIOIDS DUAL-USE UV DETECTION ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Explosives and Opiods Dual-Use UV Detection ***FY 2023 Plans:*** Congressional Interest Item funding provided for EXPLOSIVES AND OPIOIDS DUAL-USE UV DETECTION	5.000	10.000
Congressional Add: Program Increase: Cell-Free Expression for Biomanufacturing ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Cell-Free Expression for Biomanufacturing	10.000	-
Congressional Add: Program Increase - DIGITAL THREAD FOR ADVANCED MANUFACTURING ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Digital Thread for Advanced Manufacturing ***FY 2023 Plans:*** Congressional Interest Item funding provided for DIGITAL THREAD FOR ADVANCED MANUFACTURING	5.000	9.500
Congressional Add: Program Increase - JOINT RESEARCH LABRATORIES	20.000	18.000

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023
FY 2022 Accomplishments: Congressional Interest Item funding provided for Joint Research Labratories ***FY 2023 Plans:*** Congressional Interest Item funding provided for Joint Research Labrotories		
Congressional Add: Lightweight High Entropy Metallic Alloy Discovery ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Lightweight High Entropy Metallic Alloy Discovery	3.000	-
Congressional Add: Unmanned Aerial Systems Propulsion ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Unmanned Aerial Systems Propulsion	5.000	-
Congressional Add: Program Increase - ARTIFICIAL INTELLIGENCE (AI) FUSION ***FY 2023 Plans:*** Congressional Interest Item funding provided for ARTIFICIAL INTELLIGENCE (AI) FUSION	-	2.500
Congressional Add: Program Increase - BASIC RESEARCH ***FY 2023 Plans:*** Congressional Interest Item funding provided for Basic Research	-	25.000
Congressional Add: Program Increase - CENTER FOR UAS PROPULSION ***FY 2023 Plans:*** Congressional Interest Item funding provided for CENTER FOR UAS PROPULSION	-	5.000
Congressional Add: Program Increase - COUNTER UAS TECHNOLOGY RESEARCH ***FY 2023 Plans:*** Congressional Interest Item funding provided for COUNTER UAS TECHNOLOGY RESEARCH	-	5.000
Congressional Add: Program Increase - HIGH ENTROPY METALLIC ALLOYS ***FY 2023 Plans:*** Congressional Interest Item funding provided for High Entropy Metallic Alloys	-	5.000
Congressional Add: Program Increase - RENEWABLE ENERGY TECHNOLOGIES ***FY 2023 Plans:*** Congressional Interest Item funding provided for Renewable Energy Technologies	-	15.000
Congressional Add: Program Increase - SUSTAINABLE AVIATION FUEL PROPULSION ***FY 2023 Plans:*** Congressional Interest Item funding provided for Sustainable Aviation Fuel Propulsion	-	7.500
Congressional Add: Program Increase - UNMANNED AERIAL SYSTEMS HYBRID PROPULSION	-	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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 2022	FY 2023
FY 2023 Plans: Congressional Interest Item funding provided for UNMANNED AERIAL SYSTEMS HYBRID PROPULSION		
Congressional Adds Subtotals	73.000	112.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A