Department of Defense
Fiscal Year (FY) 2023 Budget Estimates

April 2022

Army

Justification Book Volume 1a of 1

Research, Development, Test & Evaluation, Army

RDT&E − Volume I, Budget Activity 1

Volume 1a Table of Contents

UNCLASSIFIED
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, ARMY
APPROPRIATION LANGUAGE

For expenses necessary for basic and applied scientific research, development, test and evaluation, including maintenance, rehabilitation, lease, and operation of facilities and equipment, $13,703,609,000.00 to remain available for obligation until September 30, 2024.

The FY 2023 Overseas Operations accounted for in the base budget are as follows:

Combat or direct combat support expenses that discontinue once combat operations end at major contingency location $12,800,000.

In-theater and in-CONUS expenses that remain after combat operations cease and have been previously funded in OCO $5,875,000.

COST STATEMENT

The following Justification Books were prepared at a cost of $474,495.00: Aircraft (ACFT), Missiles (MSLS), Weapons & Tracked Combat Vehicles (WTCV), Ammunition (AMMO), Other Procurement Army (OPA) 1 – Tactical & Support Vehicles, Other Procurement Army (OPA) 2 – Communications & Electronics, Other Procurement Army (OPA) 3 & 4 - Other Support Equipment & Spares, Research, Development, Test and Evaluation (RDTE) for: Budget Activity 1, Budget Activity 2, Budget Activity 3, Budget Activity 4, Budget Activity 5A, Budget Activity 5B, Budget Activity 5C, Budget Activity 5D, Budget Activity 6, Budget Activity 7, and Budget Activity 8.

FY 2023 RDT&E, ARMY PROGRAM ELEMENT DESCRIPTIVE SUMMARIES
Introduction and Explanation of Contents

1.   **General.** The purpose of this document is to provide summary information concerning the Research, Development, Test and Evaluation, Army program. The descriptive summaries are comprised of R-2 (Army RDT&E Budget Item Justification – program element level), R-2A (Army RDT&E Budget Item Justification – project level), R-3 (Army   RDT&E Cost Analysis), R-4 (Schedule Profile Detail) and R-5 (Termination Liability Funding for MDAPs) Exhibits, which provide narrative information on all RDT&E program elements and projects through FY 2022.

2.   **Relationship of the FY 2023 Budget Submitted to Congress to the FY 2022 Budget Submitted to Congress.** This paragraph provides a list of program elements/projects that are major new starts, restructures, developmental transitions, and terminated programs. Explanations for these changes can be found in the narrative sections of the Program Element R-2A Exhibits.

New Start Programs:

Budget Activity	*OSDPE / Project*	*Project Title*
02	0602002A / DC4	Army Applied Innovation
02	0602002A / DC5	Team Ignite
02	0602141A / CI1	Advanced Armaments Lethality Technology
02	0602141A / CZ9	Foundational Hypersonic Weapons Research
02	0602144A / CV3	Engineer Enablers Maneuver, LOG, & Sustainment Apl
02	0602144A / DA1	SAFR Alternatives for Readiness Applied Research
02	0602145A / CU5	Platform Agnostic Armaments Applied Technology
02	0602146A / CU6	Adaptive Information Mediation and Analytics
02	0602146A / CV4	Pathfinder 3D Applied Technology
02	0602150A / CV7	High Energy Laser Direct Diode Apl Tech
02	0602150A / CV8	Vulnerability Modules for Multi-Domain Operations
02	0602150A / DA9	Radar Survivability through Dis Sensing Tech
02	0602180A / DA5	AI Enabled Talent Management Applied Research
02	0602180A / DA6	AI-Enabled Command and Coordination Apl Research
02	0602183A / CU7	Control & Autonomy for Tactical Superiority Tech
02	0602183A / CU8	Structures Tech for Enduring Efficient Resilience

02	0602183A / CU9	Systems Design Technology
02	0602184A / CV9	Technical-SAVVY Soldier Applied Research
03	0603025A / DA3	Army Advanced Innovation
03	0603040A / CN6	Predictive Maintenance Advanced Technology
03	0603040A / DA7	AI-Enabled Command and Coordination Adv Tech
03	0603041A / DA4	All Domain Convergence Engineering & Architectures
03	0603043A / CV1	Control & Autonomy for Tactical Superiority Adv
03	0603043A / CV2	Structures Platform Int Resilience & Efficiency
03	0603119A / CV5	Engineer Enablers Maneuver, LOG, & Sustainment Adv
03	0603119A / DA2	SAFR Alternatives for Readiness Advanced Tech
03	0603466A / CV6	Optimized High Energy Laser Source Adv Tech
03	0603466A / DB3	Radar Survivability through Dis Sensing Adv Tech
04	0604020A / DC8	Army Experimentation and Prototyping
05	0604641A / CF5	Robotic Combat Vehicle (BA5) NGCV-CFT
05	0604827A / S65	Platoon Power Generator
05	0604854A / 516	Paladin/FAASV
06	0605235A / CQ4	Mid-Range Capability

Program Element/Project Restructures:

Budget Activity	Old OSDPE / Project: Title	New OSDPE / Project
02	0602143A / BE6: Reactive/Resp Surfaces & Matls-Soldiers & Sys	0602184A / CW9
02	0602146A / AΘ2: Stand-In Advanced RF Effects (STARE)	0602146A / AP5
02	0602146A / AR3: Intelligent Environmental Battlefield Awareness	0602182A / CX3
02	0602146A / AR7: Sensing in Contested Environments Technology	0602182A / CX5
02	0602146A / AR9: Persistent Geophysical Sensing-Infrasound Tech	0602182A / CX4
02	0602146A / AT2: Subterranean Detection and Monitoring Technology	0602182A / CX6
02	0602146A / AV7: Atmospheric Modeling and Meterological Technology	0602182A / CW2
02	0602146A / CK1: Assured PNT Enabling Technologies	0602182A / CZ6
02	0602148A / AI9: Future UAS Engine Technology	0602183A / CW6

02	0602148A / AJ2: Next Generation Rotorcraft Transmission Technology	0602183A / CW8
02	0602148A / AJ6: Advanced Rotors Technology	0602183A / CW3
02	0602148A / AJ8: Experimental and Computational Aeromechanics Techn	0602183A / CW5
02	0602148A / AL2: High Performance Computing for Rotorcraft App Tech	0602183A / DC2
02	0602148A / AL4: High Speed and Efficient VTOL Vehicle Technology	0602183A / CW7
02	0602148A / AL5: Air Vehicle Structures and Dynamics Technology	0602183A / CW4
02	0602148A / AL8: Holistic Situational Awareness and Dec Making Tech	0602141A / CG4
02	0602150A / AD2: High Energy Laser (HEL) Enabling and Support Techn	0602150A / DC1
02	0602150A / AD3: Maneuver Air Defense Technology	0603466A / AD4
02	0602182A / CM9: Convergent CEMA Deception	0602182A / CZ7
03	0602145A / BJ9: Autonomous Mobility Tech	0603462A / BK1
03	0602146A / AM8: Protected SATCOM Technology	0603463A / AM9
03	0602148A / AK4: Multi-Role Small Guided Missile Technology	0603465A / AK5
03	0603463A / AR4: Intelligent Env Battlefield Awareness Adv Tech	0603042A / CX7
03	0603463A / AS9: Persistent Geophysical Sensing-Infrasound Adv Tech	0603042A / CX8
03	0603463A / AR8: Sensing in Contested Environments Adv Technology	0603042A / CX9
03	0603463A / AT3: Subterranean Detection and Monitoring Adv Technology	0603042A / CZ5
03	0603465A / AJ7: Advanced Rotors Advanced Technology	0603043A / CX1
03	0603043A / AJ3: Next Generation Rotorcraft Transmission Adv Technology	0603043A / CX2
03	0603043A / AL3: HPC for Rotorcraft Applications Adv Tech	0603043A / DC3
03	0603463A / AU2: Optimization of Geospatial Data for Visualization	0603463A / AT8
03	0603463A / AV1: GEOInt/Ops Logistics Integration-Planning Adv Tech	0603463A / AU4
03	0602147A / AF1: Long Range Maneuverable Fires (LRMF) Technology	0603464A / AF2
03	0603464A / AE8: Land-Based Anti-Ship Missile (LBASM) Advanced Tech	0603464A / CZ8
03	0603465A / CH6: Adapt & Resilnt Tach Autnmy Cont&Struct Adv Tech	0603043A / CV1
03	0603465A / CH6: Adapt & Resilnt Tach Autnmy Cont&Struct Adv Tech	0603043A / CV2
03	0603465A / CH8: UAS Survivability Advance Technology	0603465A / AK3
03	0603465A / CH8: UAS Survivability Advance Technology	0603465A / CG1
03	0602148A / BZ7: Future Vertical Lift Medical Technologies	0603465A / CJ5
04	0603466A / AD1: High Energy Laser Tactical Vehicle Demo Adv Tech	0604019A / BU9
04	0305251A / FA8: Cyberspace Operations Forces and Force Support	0305251A / DD3
04	0603801A / B47: Future Vertical Lift	0603801A / CS7
04	0604117A / FI4: Maneuver - Short Range Air Defense (M-SHORAD)	0604117A / CR9
04	0605054A / FI3: Rapid Capability Development and Maturation	0604117A / CR9
04	0604117A / FI4: Maneuver - Short Range Air Defense (M-SHORAD)	0604117A / CS1

04	0604644A / MR1: Mobile Intermediate Range Missile	0604135A / MR2
04	0604644A / MR1: Mobile Intermediate Range Missile	0604135A / MR3
04	0604644A / MR1: Mobile Intermediate Range Missile	0604135A / MR4
04	0604182A / HX1: Long Range Hypersonic Weapon	0604182A / HX3
04	0604182A / HX1: Long Range Hypersonic Weapon	0604182A / HX4
04	0604182A / HX1: Long Range Hypersonic Weapon	0604182A / HX5
04	0604182A / HX1: Long Range Hypersonic Weapon	0604182A / HX6
05	0604818A / EJ5: Mounted Computing Environment (MCE)	0604805A / 593
05	0605013A / T05: Army Business System Modernization Initiatives	0605013A / BY3
05	0608041A / CD1: Defensive Cyber - Software Prototype Devel	0605041A / XU3
05	0605042A / FA1: Manpack Radio	0605236A / CQ1
05	0605042A / FA2: Rifleman Radio (RR)	0605236A / CQ1
06	0605602A / 628: Developmental Test Technology & Sustainment	0605602A / FJ3
06	0605602A / 62C: Modeling and Simulation Instrumentation	0605602A / FJ3
07	0303142A / 456: MILSATCOM System Engineering	0303142A / CO7
07	0205778A / EG2: GMLRS Alternative Warheads	0205778A / EG3

Program Terminations (including transfers to Procurement and Sustainment):

Budget Activity	_OSDPE / Project_	_Project Title_
01	0601104A / CI9	University & Industry Rsch Ctrs / Strategic University Basic Research Alliance
02	0602141A / CJ6	Lethality Technology / Advanced Energetics for Missile Technologies
02	0602143A / BB9	Soldier Lethality Technology / Human Performance Tech for Mobility & Lethality
02	0602144A / CG5	Ground Technology / Ground Vehicle Sensor Concepts and Technologies
02	0602146A / AR1	Network C3I Technology / Robust, Resilient and Intelligent C3I Technology
02	0602150A / AD5	Air and Missile Defense Technology / Next Generation Fires Radar Technology
03	0603002A / MN3	Medical Advanced Technology / Immediate Cardiopulmonary Stabilization Adv Tech
03	0603002A / MN4	Medical Advanced Technology / Advanced Life Support Advanced Technology
03	0603002A / MN5	Medical Advanced Technology / Next Generation Blood Products Advanced Technology
03	0603002A / MN9	Medical Advanced Technology / Far Forward Behavioral Health Care Advanced Tech

03	0603463A / AN2	Network C3I Advanced Technology / Narrowband SATCOM Advanced Technology
03	0603466A / AD4	Air and Missile Defense Adv Technology / Maneuver Air Defense Advanced Technology
04	0604785A / DS4	Integrated Base Defense / Integrated Base Defense
05	0604854A / HB6	Artillery Systems EMD / Mobile 155MM Howitzer

3. **Classification:** This document contains no classified data. Appropriately cleared individuals can obtain further information on Classified/Special Access Programs by contacting the Department of the Army.

Department of the Army
FY 2023 President's Budget
Exhibit R-1 FY 2023 President's Budget
Total Obligational Authority   Apr 2022
(Dollars in Thousands)

Summary Recap of Budget Activities	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request
Basic Research	552,521	606,509	466,823
Applied Research	1,518,220	1,529,888	883,759
Advanced Technology Development	1,948,792	2,190,430	1,392,065
Advanced Component Development & Prototypes	3,589,313	3,818,276	4,098,749
System Development & Demonstration	2,979,946	3,254,230	4,031,334
Management Support	1,832,049	1,553,905	1,554,252
Operational Systems Development	1,719,691	1,466,180	1,188,403
Software and Digital Technology Pilot Programs	56,706	108,841	94,888
Total Research, Development, Test & Evaluation	**14,197,238**	**14,528,259**	**13,710,273**

Summary Recap of FYDP Programs	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request
General Purpose Forces	589,523	579,473	392,489
Intelligence and Communications	372,869	275,873	210,597
Research and Development	13,099,825	13,566,200	13,009,253
Central Supply and Maintenance	130,785	103,720	91,270
Administration and Associated Activities	253		
Classified Programs	3,983	2,993	6,664
Total Research, Development, Test & Evaluation	**14,197,238**	**14,528,259**	**13,710,273**

Department of the Army
FY 2023 President's Budget
Exhibit R-1 FY 2023 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Apr 2022

Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
1	0601102A	Defense Research Sciences	01	344,031	368,751	279,328	U
2	0601103A	University Research Initiatives	01	84,697	91,241	70,775	U
3	0601104A	University and Industry Research Centers	01	118,716	126,267	100,909	U
4	0601121A	Cyber Collaborative Research Alliance	01	5,077	5,067	5,355	U
5	0601601A	Artificial Intelligence and Machine Learning Basic Research	01		15,183	10,456	U
		Basic Research		**552,521**	**606,509**	**466,823**	
6	0602002A	Army Agile Innovation and Development-Applied Research	02			9,534	U
7	0602115A	Biomedical Technology	02	11,403	11,925		U
8	0602134A	Counter Improvised-Threat Advanced Studies	02	1,927	1,976	6,192	U
9	0602141A	Lethality Technology	02	117,484	91,626	87,717	U
10	0602142A	Army Applied Research	02	29,257	28,654	27,833	U
11	0602143A	Soldier Lethality Technology	02	201,511	205,058	103,839	U
12	0602144A	Ground Technology	02	159,358	216,550	52,848	U
13	0602145A	Next Generation Combat Vehicle Technology	02	258,341	245,525	174,090	U
14	0602146A	Network C3I Technology	02	202,256	164,804	64,115	U
15	0602147A	Long Range Precision Fires Technology	02	119,007	93,785	43,029	U
16	0602148A	Future Verticle Lift Technology	02	169,536	133,158	69,348	U
17	0602150A	Air and Missile Defense Technology	02	107,584	93,549	27,016	U
18	0602180A	Artificial Intelligence and Machine Learning Technologies	02		15,034	16,454	U
19	0602181A	All Domain Convergence Applied Research	02		25,967	27,399	U
20	0602182A	C3I Applied Research	02		12,406	27,892	U
21	0602183A	Air Platform Applied Research	02		6,597	41,588	U

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Total Obligational Authority
(Dollars in Thousands)

Apr 2022

Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
22	0602184A	Soldier Applied Research	02		11,064	15,716	U
23	0602213A	C3I Applied Cyber	02	18,816	12,119	13,605	U
24	0602386A	Biotechnology for Materials - Applied Research	02		20,643	21,919	U
25	0602785A	Manpower/Personnel/Training Technology	02	20,399	18,701	19,649	U
26	0602787A	Medical Technology	02	101,341	120,747	33,976	U
		Applied Research		**1,518,220**	**1,529,888**	**883,759**	
27	0603002A	Medical Advanced Technology	03	95,146	137,804	5,207	U
28	0603007A	Manpower, Personnel and Training Advanced Technology	03	11,344	14,273	15,598	U
29	0603025A	Army Agile Innovation and Demonstration	03		22,231	20,900	U
30	0603040A	Artificial Intelligence and Machine Learning Advanced Technologies	03		909	6,395	U
31	0603041A	All Domain Convergence Advanced Technology	03		17,743	45,463	U
32	0603042A	C3I Advanced Technology	03		3,151	12,716	U
33	0603043A	Air Platform Advanced Technology	03		754	17,946	U
34	0603044A	Soldier Advanced Technology	03		890	479	U
35	0603115A	Medical Development	03	26,711	26,508		U
36	0603116A	Lethality Advanced Technology	03		8,066	9,796	U
37	0603117A	Army Advanced Technology Development	03	64,163	76,815	134,874	U
38	0603118A	Soldier Lethality Advanced Technology	03	154,161	152,369	100,935	U
39	0603119A	Ground Advanced Technology	03	196,055	280,490	32,546	U
40	0603134A	Counter Improvised-Threat Simulation	03	24,087	24,747	21,486	U
41	0603386A	Biotechnology for Materials - Advanced Research	03		53,736	56,853	U
42	0603457A	C3I Cyber Advanced Development	03	43,357	61,426	41,354	U

Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
43	0603461A	High Performance Computing Modernization Program	03	221,161	229,123	251,964	U
44	0603462A	Next Generation Combat Vehicle Advanced Technology	03	309,860	299,712	193,242	U
45	0603463A	Network C3I Advanced Technology	03	215,337	211,068	125,565	U
46	0603464A	Long Range Precision Fires Advanced Technology	03	177,142	141,909	100,830	U
47	0603465A	Future Vertical Lift Advanced Technology	03	220,334	261,880	177,836	U
48	0603466A	Air and Missile Defense Advanced Technology	03	173,244	145,826	11,147	U
49	0603920A	Humanitarian Demining	03	16,690	19,000	8,933	U
		Advanced Technology Development		**1,948,792**	**2,190,430**	**1,392,065**	
50	0603305A	Army Missle Defense Systems Integration	04	139,518	56,702	12,001	U
51	0603308A	Army Space Systems Integration	04	25,584	25,755	17,945	U
52	0603327A	Air and Missile Defense Systems Engineering	04	47,098	15,000		U
53	0603619A	Landmine Warfare and Barrier - Adv Dev	04	56,067	46,637	64,001	U
54	0603639A	Tank and Medium Caliber Ammunition	04	106,881	73,844	64,669	U
55	0603645A	Armored System Modernization - Adv Dev	04	130,485	164,328	49,944	U
56	0603747A	Soldier Support and Survivability	04	5,312	2,897	4,060	U
57	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	182,400	113,365	72,314	U
58	0603774A	Night Vision Systems Advanced Development	04	15,179	62,820	18,048	U
59	0603779A	Environmental Quality Technology - Dem/Val	04	20,906	22,921	31,249	U
60	0603790A	NATO Research and Development	04	4,589	3,777	3,805	U
61	0603801A	Aviation - Adv Dev	04	694,296	1,178,460	1,162,344	U
62	0603804A	Logistics and Engineer Equipment - Adv Dev	04	15,287	11,055	9,638	U
63	0603807A	Medical Systems - Adv Dev	04	36,006	37,053	598	U

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Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
64	0603827A	Soldier Systems - Advanced Development	04	23,905	25,925	25,971	U
65	0604017A	Robotics Development	04	92,401	80,525	26,594	U
66	0604019A	Expanded Mission Area Missile (EMAM)	04		27,872	220,820	U
67	0604020A	Cross Functional Team (CFT) Advanced Development & Prototyping	04			106,000	U
68	0604021A	Electronic Warfare Technology Maturation (MIP)	04	15,034			U
69	0604035A	Low Earth Orbit (LEO) Satellite Capability	04	21,850	19,638	35,509	U
70	0604036A	Multi-Domain Sensing System (MDSS) Adv Dev	04		50,548	49,932	U
71	0604037A	Tactical Intel Targeting Access Node (TITAN) Adv Dev	04		28,347	863	U
72	0604100A	Analysis Of Alternatives	04	9,714	10,091	10,659	U
73	0604101A	Small Unmanned Aerial Vehicle (SUAV) (6.4)	04	1,328	926	1,425	U
74	0604113A	Future Tactical Unmanned Aircraft System (FTUAS)	04	59,183	76,349	95,719	U
75	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04	308,805	297,629	382,147	U
76	0604115A	Technology Maturation Initiatives	04	141,109	132,561	269,756	U
77	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04	5,776	39,376	225,147	U
78	0604119A	Army Advanced Component Development & Prototyping	04	167,990	189,483	198,111	U
79	0604120A	Assured Positioning, Navigation and Timing (PNT)	04	115,688	83,952	43,797	U
80	0604121A	Synthetic Training Environment Refinement & Prototyping	04	112,093	206,335	166,452	U
81	0604134A	Counter Improvised-Threat Demonstration, Prototype Development, and Testing	04	13,326	13,379	15,840	U
82	0604135A	Strategic Mid-Range Fires	04			404,291	U
83	0604182A	Hypersonics	04	841,666	315,131	173,168	U
84	0604403A	Future Interceptor	04		6,895	8,179	U
85	0604531A	Counter - Small Unmanned Aircraft Systems Advanced Development	04		19,148	35,110	U

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Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
86	0604541A	Unified Network Transport	04	39,192	35,172	36,966	U
87	0604644A	Mobile Medium Range Missile	04	88,100	286,445		U
88	0604785A	Integrated Base Defense (Budget Activity 4)	04	2,020	2,040		U
89	0305251A	Cyberspace Operations Forces and Force Support	04	50,525	55,895	55,677	U
		Advanced Component Development & Prototypes		3,589,313	3,818,276	4,098,749	
90	0604201A	Aircraft Avionics	05	7,011	6,654	3,335	U
91	0604270A	Electronic Warfare Development	05	56,624	30,840	4,243	U
92	0604601A	Infantry Support Weapons	05	89,497	79,339	66,529	U
93	0604604A	Medium Tactical Vehicles	05	8,213	9,524	22,163	U
94	0604611A	JAVELIN	05	5,983	7,094	7,870	U
95	0604622A	Family of Heavy Tactical Vehicles	05	22,254	28,445	50,924	U
96	0604633A	Air Traffic Control	05	3,383	4,405	2,623	U
97	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05			115,986	U
98	0604642A	Light Tactical Wheeled Vehicles	05	4,371	2,055		U
99	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05	123,992	122,778	71,287	U
100	0604710A	Night Vision Systems - Eng Dev	05	52,959	43,417	62,679	U
101	0604713A	Combat Feeding, Clothing, and Equipment	05	2,734	1,658	1,566	U
102	0604715A	Non-System Training Devices - Eng Dev	05	27,013	26,514	18,600	U
103	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	62,058	59,518	39,541	U
104	0604742A	Constructive Simulation Systems Development	05	9,779	22,240	29,570	U
105	0604746A	Automatic Test Equipment Development	05	5,375	8,807	5,178	U
106	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	7,605	12,453	8,189	U

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FY 2023 President's Budget
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(Dollars in Thousands)

Apr 2022

Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
107	0604768A	Brilliant Anti-Armor Submunition (BAT)	05	20,175			U
108	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	3,438			U
109	0604798A	Brigade Analysis, Integration and Evaluation	05	18,737	21,423	21,228	U
110	0604802A	Weapons and Munitions - Eng Dev	05	277,344	297,086	263,778	U
111	0604804A	Logistics and Engineer Equipment - Eng Dev	05	53,676	54,642	41,669	U
112	0604805A	Command, Control, Communications Systems - Eng Dev	05	10,674	20,107	40,038	U
113	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	48,285	44,400	5,513	U
114	0604808A	Landmine Warfare/Barrier - Eng Dev	05	9,239	29,137	12,150	U
115	0604818A	Army Tactical Command & Control Hardware & Software	05	126,676	155,017	111,690	U
116	0604820A	Radar Development	05	105,271	122,607	71,259	U
117	0604822A	General Fund Enterprise Business System (GFEBS)	05	15,428	15,979	10,402	U
118	0604823A	Firefinder	05	18,278			U
119	0604827A	Soldier Systems - Warrior Dem/Val	05	6,546	6,454	11,425	U
120	0604852A	Suite of Survivability Enhancement Systems - EMD	05	62,012	96,132	109,702	U
121	0604854A	Artillery Systems - EMD	05	36,187	25,000	23,106	U
122	0605013A	Information Technology Development	05	123,659	129,380	124,475	U
123	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	111,078	67,701	67,564	U
124	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	76,140	35,560		U
125	0605030A	Joint Tactical Network Center (JTNC)	05	15,671	16,350	17,950	U
126	0605031A	Joint Tactical Network (JTN)	05	30,540	28,905	30,169	U
127	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05	5,758			U
128	0605035A	Common Infrared Countermeasures (CIRCM)	05	29,770	16,630	11,523	U

Department of the Army
FY 2023 President's Budget
Exhibit R-1 FY 2023 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Apr 2022

Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
129	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05	4,669	7,618		U
130	0605041A	Defensive CYBER Tool Development	05	28,544	18,811	33,029	U
131	0605042A	Tactical Network Radio Systems (Low-Tier)	05	20,511	28,741	4,497	U
132	0605047A	Contract Writing System	05	22,025	20,960	23,487	U
133	0605051A	Aircraft Survivability Development	05	99,403	61,768	19,123	U
134	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05	152,399	182,257	131,093	U
135	0605053A	Ground Robotics	05	12,010	16,360	26,809	U
136	0605054A	Emerging Technology Initiatives	05	294,366	226,802	185,311	U
137	0605143A	Biometrics Enabling Capability (BEC)	05		4,326	11,091	U
138	0605144A	Next Generation Load Device - Medium	05		15,397	22,439	U
139	0605145A	Medical Products and Support Systems Development	05	919	962		U
140	0605148A	Tactical Intel Targeting Access Node (TITAN) EMD	05		54,972	58,087	U
141	0605203A	Army System Development & Demonstration	05	177,501	122,175	119,516	U
142	0605205A	Small Unmanned Aerial Vehicle (SUAV) (6.5)	05	5,780	2,275	6,530	U
143	0605224A	Multi-Domain Intelligence	05		9,313	19,911	U
144	0605225A	SIO Capability Development	05		22,713		U
145	0605231A	Precision Strike Missile (PrSM)	05		188,452	259,506	U
146	0605232A	Hypersonics EMD	05		111,473	633,499	U
147	0605233A	Accessions Information Environment (AIE)	05		16,790	13,647	U
148	0605235A	Strategic Mid-Range Capability	05			5,016	U
149	0605236A	Integrated Tactical Communications	05			12,447	U
150	0605450A	Joint Air-to-Ground Missile (JAGM)	05	7,566	2,134	2,366	U

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Exhibit R-1 FY 2023 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Apr 2022

Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
151	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	213,956	159,873	265,288	U
152	0605531A	Counter - Small Unmanned Aircraft Systems Sys Dev & Demonstration	05		33,386	14,892	U
153	0605625A	Manned Ground Vehicle	05	162,390	202,320	589,762	U
154	0605766A	National Capabilities Integration (MIP)	05	7,670	13,454	17,030	U
155	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	1,500	2,564	9,376	U
156	0605830A	Aviation Ground Support Equipment	05	1,413	1,201	2,959	U
157	0303032A	TROJAN - RH12	05	3,451	3,362	3,761	U
158	0303667A	Citizen Broadband Radio System	05	900			U
159	0303767A	AMBIT - Pre-Auctioned SRF	05	9,785			U
160	0304270A	Electronic Warfare Development	05	59,755	75,520	56,938	U
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		System Development & Demonstration		**2,979,946**	**3,254,230**	**4,031,334**	
161	0604256A	Threat Simulator Development	06	41,487	61,422	18,437	U
162	0604258A	Target Systems Development	06	35,279	42,404	19,132	U
163	0604759A	Major T&E Investment	06	119,231	93,617	107,706	U
164	0605103A	Rand Arroyo Center	06	12,989	32,296	35,542	U
165	0605301A	Army Kwajalein Atoll	06	221,949	240,877	309,005	U
166	0605326A	Concepts Experimentation Program	06	46,847	79,585	87,122	U
167	0605502A	Small Business Innovative Research	06	369,715			U
168	0605601A	Army Test Ranges and Facilities	06	390,366	367,125	401,643	U
169	0605602A	Army Technical Test Instrumentation and Targets	06	81,829	59,253	37,962	U
170	0605604A	Survivability/Lethality Analysis	06	36,001	36,370	36,500	U
171	0605606A	Aircraft Certification	06	2,736	2,489	2,777	U

Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
172	0605702A	Meteorological Support to RDT&E Activities	06	6,360	6,521	6,958	U
173	0605706A	Materiel Systems Analysis	06	21,830	21,558	22,037	U
174	0605709A	Exploitation of Foreign Items	06	8,936	13,631	6,186	U
175	0605712A	Support of Operational Testing	06	54,116	55,122	70,718	U
176	0605716A	Army Evaluation Center	06	56,827	65,854	67,058	U
177	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	2,478	2,633	6,097	U
178	0605801A	Programwide Activities	06	89,023	96,558	89,793	U
179	0605803A	Technical Information Activities	06	25,817	31,987	28,752	U
180	0605805A	Munitions Standardization, Effectiveness and Safety	06	50,648	63,042	48,316	U
181	0605857A	Environmental Quality Technology Mgmt Support	06	1,715	1,789	1,912	U
182	0605898A	Army Direct Report Headquarters - R&D - MHA	06	50,859	48,981	53,271	U
183	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06	74,089	80,921	90,088	U
184	0606003A	CounterIntel and Human Intel Modernization	06	5,200	5,363	1,424	U
185	0606105A	Medical Program-Wide Activities	06	18,973	39,041		U
186	0606942A	Assessments and Evaluations Cyber Vulnerabilities	06	6,496	5,466	5,816	U
187	0909999A	Financing for Cancelled Account Adjustments	06	253			U
		Management Support		**1,832,049**	**1,553,905**	**1,554,252**	
188	0603778A	MLRS Product Improvement Program	07	9,785	12,314	18,463	U
189	0605024A	Anti-Tamper Technology Support	07	8,436	8,868	9,284	U
190	0607131A	Weapons and Munitions Product Improvement Programs	07	24,666	35,828	11,674	U
191	0607134A	Long Range Precision Fires (LRPF)	07	100,146			U
192	0607136A	Blackhawk Product Improvement Program	07	8,300	14,773		U

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Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
193	0607137A	Chinook Product Improvement Program	07	49,409	67,872	52,513	U
194	0607139A	Improved Turbine Engine Program	07	232,159	260,024	228,036	U
195	0607142A	Aviation Rocket System Product Improvement and Development	07	11,321	12,417	11,312	U
196	0607143A	Unmanned Aircraft System Universal Products	07	19,460	4,594	512	U
197	0607145A	Apache Future Development	07	52,502	10,067	10,074	U
198	0607148A	AN/TPQ-53 Counterfire Target Acquisition Radar System	07		47,752	62,559	U
199	0607150A	Intel Cyber Development	07	14,652	3,611	13,343	U
200	0607312A	Army Operational Systems Development	07	35,851	28,029	26,131	U
201	0607313A	Electronic Warfare Development	07		5,673	6,432	U
202	0607665A	Family of Biometrics	07	1,276	1,144	1,114	U
203	0607865A	Patriot Product Improvement	07	178,984	125,932	152,312	U
204	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	43,060	25,489	19,329	U
205	0203735A	Combat Vehicle Improvement Programs	07	213,726	280,107	192,310	U
206	0203743A	155mm Self-Propelled Howitzer Improvements	07	217,959	175,076	136,680	U
207	0203744A	Aircraft Modifications/Product Improvement Programs	07	11,261	10,000		U
208	0203752A	Aircraft Engine Component Improvement Program	07	80	132	148	U
209	0203758A	Digitization	07	4,351	3,903	2,100	U
210	0203801A	Missile/Air Defense Product Improvement Program	07	1,241	127	3,109	U
211	0203802A	Other Missile Product Improvement Programs	07	15,268	10,265	9,027	U
212	0205412A	Environmental Quality Technology - Operational System Dev	07	250	262	793	U
213	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	72,817	60,733	20,180	U
214	0208053A	Joint Tactical Ground System	07	9,510	13,379	8,813	U

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FY 2023 President's Budget
Exhibit R-1 FY 2023 President's Budget
Total Obligational Authority   Apr 2022
(Dollars in Thousands)

Appropriation: 2040A Research, Development, Test & Eval, Army

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Enactment	FY 2023 Request	Sec
216	0303028A	Security and Intelligence Activities	07	23,367	24,531		U
217	0303140A	Information Systems Security Program	07	28,270	15,680	17,209	U
218	0303141A	Global Combat Support System	07	70,652	45,297	27,100	U
219	0303142A	SATCOM Ground Environment (SPACE)	07	18,002	15,222	18,321	U
222	0305179A	Integrated Broadcast Service (IBS)	07	382	5,430	9,926	U
223	0305204A	Tactical Unmanned Aerial Vehicles	07	38,151	8,410	4,500	U
224	0305206A	Airborne Reconnaissance Systems	07	28,858	24,460	17,165	U
225	0305208A	Distributed Common Ground/Surface Systems	07	40,771			U
226	0307665A	Biometrics Enabled Intelligence	07		2,066		U
227	0708045A	End Item Industrial Preparedness Activities	07	130,785	103,720	91,270	U
9999	9999999999	Classified Programs		3,983	2,993	6,664	U
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		Operational Systems Development		**1,719,691**	**1,466,180**	**1,188,403**	
228	0608041A	Defensive CYBER - Software Prototype Development	08	56,706	108,841	94,888	U
				----------	----------	----------	
		Software and Digital Technology Pilot Programs		**56,706**	**108,841**	**94,888**	
				----------	----------	----------	
Total Research, Development, Test & Eval, Army				**14,197,238**	**14,528,259**	**13,710,273**	

Program Element Table of Contents (by Budget Activity then Line Item Number)

Appropriation 2040: Research, Development, Test & Evaluation, Army

Program Element Table of Contents (Alphabetically by Program Element Title)

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Army											**Date:** April 2022	
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*							
COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
Total Program Element	-	344.031	368.751	279.328	-	279.328	283.521	289.022	291.270	291.296	0.000	2,147.219
AA1: *ILIR - AMC*	-	10.780	10.884	11.532	-	11.532	11.706	12.003	12.006	12.003	0.000	80.914
AA2: *ILIR - SMDC*	-	0.965	0.979	1.039	-	1.039	1.057	1.082	1.057	1.056	0.000	7.235
AA3: *Single Investigator Basic Research*	-	100.773	89.760	97.211	-	97.211	99.126	100.196	101.687	101.660	0.000	690.413
AA4: *Training and Human Science Research*	-	21.322	21.644	22.180	-	22.180	22.414	22.393	22.334	22.329	0.000	154.616
AA5: *Biotechnology and Systems Biology*	-	6.042	6.063	6.421	-	6.421	6.518	6.577	6.579	6.577	0.000	44.777
AA6: *Robotics and Mobile Energy*	-	22.353	20.616	21.854	-	21.854	22.173	24.323	24.331	24.324	0.000	159.974
AA7: *Mechanics and Ballistics*	-	35.368	33.331	35.234	-	35.234	35.760	36.184	36.195	36.186	0.000	248.258
AA8: *Sensing and Electromagnetics*	-	9.006	13.589	13.619	-	13.619	13.499	14.160	14.840	14.940	0.000	93.653
AA9: *Information and Networking*	-	40.376	40.435	42.839	-	42.839	43.480	43.875	43.889	43.877	0.000	298.771
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	31.957	36.910	4.405	-	4.405	4.465	4.607	4.580	4.578	0.000	91.502
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	17.089	17.967	19.201	-	19.201	19.478	19.749	19.897	19.892	0.000	133.273
CH9: *Advancing Concepts and Technology Forecasting*	-	-	3.573	3.793	-	3.793	3.845	3.873	3.875	3.874	0.000	22.833
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	48.000	73.000	-	-	-	-	-	-	-	0.000	121.000

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).

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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2023 Army		**Date:** April 2022
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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 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**
Previous President's Budget	344.031	297.241	0.000	-	0.000
Current President's Budget	344.031	368.751	279.328	-	279.328
Total Adjustments	0.000	71.510	279.328	-	279.328
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	73.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	279.328	-	279.328
• FFRDC Transfer	-	-1.490	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2021**	**FY 2022**
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Multi-fuel ignition, chemistry and control strategies for unmanned aircraft systems hybrid propulsion*	15.000	-
Congressional Add: *Program increase*	10.000	25.000
Congressional Add: *Program increase - explosives and opiods dual-use UV detection*	3.000	5.000
Congressional Add: *Program increase: Artificial intelligence complex multi?material composites processing*	10.000	-
Congressional Add: *Program Increase: Cell-Free Expression for Biomanufacturing*	10.000	10.000
Congressional Add: *Digital Thread for Advanced Manufacturing*	-	5.000

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2023 Army		**Date:** April 2022
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*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2021**	**FY 2022**
Congressional Add: *Joint Research Labratories*	-	20.000
Congressional Add: *Lightweight High Entropy Metallic Alloy Discovery*	-	3.000
Congressional Add: *Unmanned Aerial Systems Propulsion*	-	5.000
Congressional Add Subtotals for Project: T14	48.000	73.000
Congressional Add Totals for all Projects	48.000	73.000

Change Summary Explanation

Fiscal Year 2023 (FY23) funding increase reflects the fact that the FY22 President's Budget request did not include out-year funding.

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022	

| 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 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AA1: *ILIR - AMC*	-	10.780	10.884	11.532	-	11.532	11.706	12.003	12.006	12.003	0.000	80.914

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 2021	FY 2022	FY 2023
Title: Edgewood Chemical Biological Center (ECBC)	1.001	0.968	1.085

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 2022 Plans:
Will conduct basic research that informs Department of Defense Research Priorities and Army Modernization Priorities, focused on the areas of synthetic biology, machine learning for threat detection, novel physical and biological materials for future application of obscuration, protection, and detection, and expanded modeling and simulation in chemical and biological adsorption and deposition.

FY 2023 Plans:
Will 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. Will 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 2022 to FY 2023 Increase/Decrease Statement:

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Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022		
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 2021**	**FY 2022**	**FY 2023**
Funding change reflects planned lifecycle of this effort.			
Title: Armaments Research, Development and Engineering Center (ARDEC)	1.446	1.426	1.570
Description: Funds basic research in weapons component physics, explosives synthesis/detection, and the fundamental science base of area denial. *FY 2022 Plans:* Will conduct basic research investigations of airy beams, factors affecting and mechanisms of tube memory, rate constants for gas-phase energetic material decomposition, non-destructive methods for detecting hydrogen embrittlement in steels using plasmonic nanoparticles, thermally induced crack formation mechanisms, new and powerful insensitive explosives with enhanced performance, and novel composite structural materials for light weight armament systems. *FY 2023 Plans:* Will conduct research on methods to simulate breakup, ablation, and component connectivity change on novel composite structural materials for light weight armament systems. Will conduct research on methods to directly model surface texture and its modification to alter mechanical response. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Tank Automotive Research, Development and Engineering Center (TARDEC)	1.235	1.189	1.320
Description: This effort funds basic research in ground vehicle technologies that include power, mobility, autonomous systems, materials and manufacturing. *FY 2022 Plans:* Will competitively select in-house basic research topic areas to advance fundamental scientific understanding to support ground vehicle systems in: control systems for vehicles, optimal path planning for autonomous systems, advanced coatings, lightweight and composite materials, additive manufacturing, multi-physics battery modeling, hydrodynamic modeling, and internal combustion engine modeling. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:*			

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022	
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 2021	FY 2022	FY 2023
Funding change reflects planned lifecycle of this effort.			
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 2022 Plans:* Will explore techniques for tuning reconfigurability of metamaterials to control activation of multifunctional material properties and inform advancement of high-frequency rectifier materials platforms. Will produce knowledge to support improvements in antenna, communication, data storage, and electromagnetic interference (EMI) shielding technologies. *FY 2023 Plans:* Will 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. Will characterize optoelectronic and electronic properties of two-dimensional materials (MXenes) and investigate molecular structure-function relationships. Will interpret results to advance understanding related to the use of unique two-dimensional materials for controlling conductivity and EMI shielding efficiency. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	1.126	1.112	1.238
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts (AMRDEC-MI) *Description:* This effort funds the underlying fundamental science of Lethality and Protection Superiority for guided missile and rocket systems, directed energy weapons, unmanned vehicles, and related components. *FY 2022 Plans:* Will develop an experimental system using unclocked Boolean circuits to enable exploration of the fundamental nature of complex dynamics in networks of coupled identical oscillators for secure communications and device protection; will explore 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); will 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; will develop proof-of-concept experiments for entanglement generation on a quantum integrated circuit with investigations into quadrature methods for detection to enable quantum radar operation below classical noise limits. *FY 2023 Plans:* Will 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	2.394	2.310	2.509

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
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 2022 Plans:*** Will continue basic aerodynamic science research in the areas of vorticity dynamics, bluff body flow separation, and wake interactions; investigate advanced boundary layer flow control phenomenon including fluidic oscillators in the context of hub flows; will develop an uncertainty quantification and sensitivity analysis framework for rotorcraft aeromechanics simulations; will improve automation for setup and execution of rotorcraft aeromechanics simulation; develop high-fidelity surrogate models for rotorcraft aeromechanics simulations in order to dramatically reduce computational run times for these simulations. ***FY 2023 Plans:*** Will 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; will conduct experimental tests to better understand fundamental behavior of single and coaxial propeller over a range of configurations and operating conditions. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	1.344	1.327	1.466
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 2022 Plans:***	2.234	2.154	2.344

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will conduct research in structural excitation based conformal antenna design concepts; will study incoherent Fourier Ptychographic Photography (FPP) optimized with deep neural networks to Army imaging applications including Aided Target Recognition (AiTR) and target identification; will investigate the material properties of vanadium oxide (VOx) for Long-Wavelength Infrared (LWIR) sensor material; will investigate the incorporation and diffusion of Zinc into semiconductor alloys grown by molecular beam epitaxy (MBE); will investigate the reduction of interfacial resistance between cathode and solid electrolyte through conducting glass for solid state lithium ion batteries; will investigate safe polymer electrolytes for use with high voltage electrode materials in lithium-ion batteries. *FY 2023 Plans:* Will research unconventional vision-aided landmark navigation using spectral signature beacons; will investigate methods for wireless power transfer; will study thermal runaway inhibitors to reduce cell charge transfer at elevated temperatures in lithium-ion batteries; will investigate algorithms to fuse different aspects of Lidar and Radar data for improve target tracking; will characterize and analyze material inhomogeneity in type-II superlattice materials for infrared detectors; will investigate the use of electron channeling contrast imaging (ECCI) to identify and characterize crystalline defects in epitaxial materials grown for infrared detectors; will investigate atmospheric properties of the intraThermal Infrared (intraTIR) spectral band (4.5 ? 8.5 um). *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: FY2022 SBIR/STTR Transfer	-	0.398	-
Description: Funding transferred in accordance with Title 15 USC ?638 *FY 2022 Plans:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding transferred in accordance with Title 15 USC ?638			
Accomplishments/Planned Programs Subtotals	10.780	10.884	11.532

C. Other Program Funding Summary ($ in Millions)
 N/A

Remarks

D. Acquisition Strategy
 N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AA2: *ILIR - SMDC*	-	0.965	0.979	1.039	-	1.039	1.057	1.082	1.057	1.056	0.000	7.235

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 / AD2 (High Energy Laser (HEL) Enabling and Support Technologies.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: SMDC In-house Laboratory Independent Research (ILIR)	0.965	0.957	1.039
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 2022 Plans:* Will collect data using the advanced optical turbulence sensor developed in this effort. Will design a lab experiment and implement control algorithms for advanced atmospheric turbulence compensation techniques. Will design and conduct lab experiments for next generation laser technology. *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			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
data. Will collect data using the Ultra Short Pulsed Lasers (USPL) lab capability to investigate propagation and filamentation phenomenology and material interaction. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: SBIR/STTR Tax ***Description:*** ?Funding transferred in accordance with Title 15 USC ?638? ***FY 2022 Plans:*** ?Funding transferred in accordance with Title 15 USC ?638? ***FY 2022 to FY 2023 Increase/Decrease Statement:*** ?Funding transferred in accordance with Title 15 USC ?638?	-	0.022	-
Accomplishments/Planned Programs Subtotals	0.965	0.979	1.039

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AA3: Single Investigator Basic Research	-	100.773	89.760	97.211	-	97.211	99.126	100.196	101.687	101.660	0.000	690.413

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 2021	FY 2022	FY 2023
Title: Basic Research in Life Sciences	12.102	10.115	11.235

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 2022 Plans:
Will identity the biological molecules and mechanisms involved in the selective sequestration of strontium ions from seawater and the control over the single crystal growth of the mineral celestine that if successful, will be a key step toward designing biotechnological approaches to remove toxins to protect the Soldier, and for the use of synthetic biology to assemble structures with non-natural elements, thereby expanding the periodic table accessible to biology; will identify the regulatory mechanisms mediating expression variation in key genes involved in maintaining hydrogen sulfide homeostasis in tolerant and non-tolerant

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
eukaryotic populations that if successful, may lead to new therapeutic methods for combat casualty care and the treatment of traumatic injuries; will employ a machine learning approach wherein a computer vision algorithm is trained to identify bacteria in public-domain images of brain tissue to examine preliminary findings that the brain is not a sterile environment as traditionally thought, which if successful would validate initial findings that brain tissue co-exists with various bacterial species and would fundamentally change the scientific understanding of detecting and treating neurodegenerative diseases and mood disorders that may affect the active and retired Soldier; will conduct systems-level molecular studies on the physiology of slow growth with methanogenic Archaea using anaerobic chemostats with growth rates limited by either catabolic or anabolic substrates, to determine how cellular energy and ribosomal activity is allocated during slow growth, that if completed will provide new routes to harness microorganisms for the synthesis of future compounds of interest ranging from therapeutics to enzymes for inactivating toxic chemicals or warfare agents.			
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 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 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Basic Research in Chemical Sciences	14.664	10.950	10.607
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			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
for identification by the enemy, and advance warning of explosive, chemical, and biological weapons and dangerous industrial chemicals. *FY 2022 Plans:* Will assess a new hypothesis for how to design new classes of depolymerizable polymers that are capable of rapid depolymerization in the context of solid materials that if successful, will enable future protective layers for electronics devices and smart coatings for self-healing materials or the controlled release of specialized material layers to protect the Soldier and materiel; design, synthesize, and validate transient, responsive functional nanomaterials that autonomously respond to specific chemical stimuli that if successful will enable new classes of functional materials that can autonomously transform into a different functional configuration according to a preset schedule or stimuli, such as to resist or inactivate a toxic industrial chemical; perform parametric experimental studies as a function of the chemical functionality present at cation-exchange/anion-exchange membranes, coupled with multiscale modeling on length scales from nanometers to hundreds of microns to determine the transport and interfacial effects in bipolar membranes that if successful, will enable the next generation of polymer electrolyte fuel cells to reduce soldier-borne weight; determine the photochemical fate of saxitoxin (which can be from natural or synthetic sources) and its analogues in surface waters by assessing the degradation kinetics and pathways and identifying the major transformation products, that if successful will provide novel tracking and remediation practices to protect the Soldier and Army materiel. *FY 2023 Plans:* 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort			
Title: Basic Research in Physics *Description:* This effort fosters research in many subfields of physics, including condensed matter physics, optical physics, atomic and molecular physics, and quantum information, with an emphasis on discovering new realms of quantum and optical	11.607	11.522	12.784

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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 2022 Plans:*** Will perform two-photon electron bridge spectroscopy of the 229Th3+ nuclear isomer transition that if successful is expected to enable compact, fieldable, atomic clocks with significantly reduced environmental sensitivity to provide new capabilities in positioning, navigation, and timing; elucidate the nature of magnetic coupling across interfaces between topological materials and magnetic materials to the degree that device concepts based on those couplings can be pursued, 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; will generate and preserve multi-quantum bit entangled states via dynamically-corrected gate operations in silicon spin quantum bits that, if successful, should have a transformative impact on silicon based quantum computing by enabling the implementation of future quantum information processors that will provide new capabilities in command, control, computers, communications, cyber, intelligence, surveillance and reconnaissance; utilize non-Hermitian interaction coupled with quantum gauge theory for active control of chiral light with quantized orbital angular momentum that if successful would provide on-chip information processing and high-powered semiconductor microlaser sources for secure high-speed optical communications. ***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 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Basic Research in Electronics and Photonics	10.449	8.453	9.545

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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 2022 Plans:* Will develop bioelectric field imaging techniques and electronic material and device-based interfaces with single cells; will map the relationship between genetic responses and bioelectric networks within cell communities; will develop a hierarchy of simulation tools to analyze wave-propagation effects and electron-transport physics in active electromagnetic structures including the complex coupling of physical equations describing the nonlinear active phenomena with full-wave electromagnetic-wave modelling that captures interactions; will utilize two dimensional materials embedded in microcavities to induce band splitting with optical fields; will assess non-reciprocal effects that may be used in integrated photonic platforms; will explore large refractive index changes in inverted bandgap superlattices for long wavelength infrared optoelectronics including modulation and beam steering. *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 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects 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	11.760	10.809	13.631

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
provide support for the Army in firepower, mobility, communications, personnel protection, infrastructure and installations, and will directly affect virtually all mission areas. *FY 2022 Plans:* Will investigate novel driving forces that influence equilibrium and non-equilibrium self-assembly, including turbulence, light, mechanical stress, or chemical gradients, and use these forces to design self-assembling and reconfigurable soft materials that adapt to their environment and/or serve as artificial neural networks; develop the necessary computational, theoretical, and machine learning methods to enable new data-driven forward and inverse design paradigms for creating self-assembling and reconfigurable soft matter; investigate hetero-epitaxial thin-film growth methods to synthesize a new class of ternary transition metal perovskite chalcogenide in thin film form to understand the influence of strain and dimensionality on the physical properties of these materials; systematically investigate innovative synthesis routes and fundamental physical properties (electronic, optical, magnetic, superconducting as well as topological insulator behavior) of a novel class of crystalline two-dimensional metal-organic frameworks; will develop a computational method for calculating the ideal processing parameters for metallic additive manufacturing (AM) to address the challenges in formulating qualification procedures for AM parts; will explore new material phases in extreme mechanical and thermomechanical environments, to determine if they can actively respond to extreme events by becoming harder and tougher; design robust metamaterials capable of steering mechanical stress waves around critical areas within structures, which could eventually lead to lighter armor for Soldier and vehicle protection. *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 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 2022 to FY 2023 Increase/Decrease Statement:*			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding change reflects planned lifecycle of this effort.			
Title: Basic Research in Mechanical Sciences	11.188	8.421	9.340
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 2022 Plans:* Will develop information-theoretic control across different spatio-temporal scales and generalize uncertainties by combining tools from information theory with advances in nonequilibrium statistical mechanics and apply them to the problem of nonlinear stochastic optimal control; will explore the possibility that turbulent fluctuations can be harnessed to de-mix particles and assemble structures; will extend proof-of-concept work in the development of the Ultra-Short Pulse Off-Axis Digital Holography (USPODH) technique for imaging high pressure fuel sprays in the dense spray region; will determine the mechanisms which give rise to nonlinearity in geomaterials, will determine the influence of different periodic arrangements of the microstructures found in geomaterials on wave propagation, and will design meta-materials with controlled wave-propagation based on these microstructural features; will elucidate the role that surface roughness (topography) plays in modulating the spatial and temporal variability of wind, temperature, and passive gases inside the canopy/roughness layer, between and just above the buildings in urban terrain. *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; 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Basic Research in Computing Sciences	8.648	6.342	7.532

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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 2022 Plans:* Will develop new decentralized planning and learning methods for coordinating multiple agents in uncertain, unstructured domains that address three issues: planning in large continuous spaces, asynchronous learning, and adaptability. This will potentially enable efficient planning and learning methods to accomplish missions such as reconnaissance or resupply; investigate the robustness of existing machine learning systems and the ability to inject adaptively to the associated general methodologies in resource-limited scenarios with potential time-critical contexts, impacting areas such as Intelligence, Surveillance, Reconnaissance (ISR) and robotic perception; build a fully unified framework for Tractable Deep Probabilistic Models (TDPM) which will provided greater efficiency and interpretability compared to current deep neural network approach, benefitting future Army systems that will employ deep neural networks; explore understanding human behavior to be able to create generators and classifiers at the right level of fidelity in a virtual environment; better understand Generative Adversarial Networks (GANs) for data generation, compression, domain transfer, and security, resulting in the ability to design more robust implementations of secure, reliable, and efficient deep neural network artificial intelligence solutions. *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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects 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	10.807	10.453	11.742

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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 2022 Plans:* Will develop theory and system of network-wide radio context attestation that is capable of capturing the continuous dynamic change of radio contexts of individual devices while protecting the confidentiality of the operational parameters of those devices against untrusted network components, leading to the next generation of remote verification properties for military radios; develop a unified framework for geometric factorization for community mining, with particular focus on the challenges faced by homeland security and military intelligence operations such as network scenarios with many hidden links, small-footprint outliers, and outlying communities, that will address the current challenges associated with modeling the complexity of social networks; will develop an efficient computational method for the synthesis of optimal distributed controllers, particularly a new mathematical foundation for the design of optimal decentralized/distributed controllers that can be deployed for a wide range of real-world applications such as communication networks, electrical power systems, aerospace systems, large-space flexible structures, traffic systems, wireless sensor networks, and various multi-agent systems; will explore the use of online reinforcement learning across multiple concurrent agents to enable cross-layer optimization in tactical networks to support more efficient usage of resources in a dynamic and resource constrained environment. *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 2022 to FY 2023 Increase/Decrease Statement:*			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding change reflects planned lifecycle of this effort.			
Title: Basic Research in Mathematical Sciences	9.548	7.011	8.055

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 2022 Plans:
Will investigate and develop the increasing mathematical network of interlocking analogies between physics, topology, logic, and computer science, and their common overlap as the possible beginnings of a new science in the general science of mathematical systems and processes bringing together mathematical ideas within the context of Category theory, including in the contexts of algorithms, complexity, and error correction, such as are present in quantum information; gain an understanding of how electrical stimulation affects the behavior of active neuronal networks, focusing on creating and implementing new modeling techniques for simulations of large-scale biologically realistic cortical networks subjected to electrical stimulation, potentially leading to significantly improve the efficacy of existing electrical stimulation therapies across multiple domains and will be useful for future device/therapy design for neural dysfunctions such as movement disorders, tinnitus, traumatic brain injury, and pain and could potentially be used for restoration of motor function or sensation as well as for improvements in memory performance; will construct better optimization algorithms by uncovering the geometric structure of the model's landscape as a function of its parameters to better enable the fitting of statistical and probability models (i.e., finding good parameter values) which will lead to knowing the landscape's geometry aiding in finding a collection of nearly optimal points to allow analysts to see which features they agree (giving us more confidence in the inference) or disagree (giving us less confidence). This could enable more accurate modeling and simulation of future Army systems; develop an entirely new approach to Topological Data Analysis (TDA), bridging the important gap between traditional TDA output and practical applications of it using statistical inference and machine learning, and developing TDA output that is more stable with respect to initial data than the standard TDA output (e.g. persistence diagrams) which could enable the development of tools to search very large sets of data for anomalies and threats and to provide visualizations that may be used by humans to obtain actionable intelligence.

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,

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
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 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 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: HBCU/MI Single Investigator	-	2.388	2.740
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 2022 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/MI faculty are aligned with Research 1 (R-1) universities and Army research laboratories in order to contribute research in support of long-term Army modernization priority needs. **FY 2023 Plans:** Will 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; will 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 2022 to FY 2023 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.			
Title: FY2022 SBIR/STTR Transfer	-	3.296	-
Description: Funding transferred in accordance with Title 15 USC ?638 **FY 2022 Plans:** Funding transferred in accordance with Title 15 USC ?638 **FY 2022 to FY 2023 Increase/Decrease Statement:**			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding transferred in accordance with Title 15 USC ?638			
Accomplishments/Planned Programs Subtotals	100.773	89.760	97.211

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
AA4: *Training and Human Science Research*	-	21.322	21.644	22.180	-	22.180	22.414	22.393	22.334	22.329	0.000	154.616

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

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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 2021	FY 2022	FY 2023
Title: Translational Neuroscience **Description:** This effort integrates neuroscience with traditional approaches to understanding Soldier behavior to enable system designs that maximize Soldier performance. **FY 2022 Plans:** Will identify relationships between ocular and neural signals to understand visual search behavior in virtual and augmented environments; will investigate methods to augment the brain and predict neural behavior in real-world contexts including social interactions; will create initial neural models of the brain's spatial reasoning system. **FY 2023 Plans:** Will 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 2022 to FY 2023 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.	3.964	3.827	4.224
Title: Human System Integration **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 2022 Plans:** Will develop models to predict decisions by human users interacting with autonomous systems using multi-modal sensor measurements; generate initial, real-world physiological tracking of human state to drive optimal human-agent mutual adaptation;	5.200	5.063	4.740

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
will create models for optimizing individual decision making under uncertainty for future technology integration; will generate initial methodologies to analyze brain signals using topological data analysis. *FY 2023 Plans:* Will 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 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 2022 to FY 2023 Increase/Decrease Statement:* Funding decreased to support the creation of ?Hybridization of Team Thinking? task within this Program Element (PE) / Project.			
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 2022 Plans:* Will examine multi-modal and multi-timescale models of human dynamics to improve understanding of variability over unimodal or short timescale models; will conduct research to validate models predicting performance on military-relevant tasks, incorporating multi-timescale features; will explore adaptive algorithms using multi-timescale approaches for real-time prediction of task performance on specific, laboratory based tasks. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	4.162	4.207	4.639
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	1.336	1.285	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
performance similar to that in an operational environment. Characterize the appropriate use of different classes of simulated environments to ensure valid results. Develop guidelines for using mobility platforms in simulators to induce physical and cognitive stress representative of the operational environment. Implementation of these guidelines will enhance training effectiveness. ***FY 2022 Plans:*** Will identify training approaches that utilize immersive technologies and individual differences to improve decision-making and adaptability under complexity and uncertainty. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding decreased to support the creation of ?Hybridization of Team Thinking? task within this PE / Project.			
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 2022 Plans:*** Will develop techniques to incorporate multimodal sensing to improve autonomous system performance under dynamic environments to improve human/intelligent agent joint performance. ***FY 2023 Plans:*** Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	0.999	0.939	1.058
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:***	-	-	2.293

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funds increased as a result of funding realignments from the ?Human Systems Integration? and ?Training and Soldier Performance? tasks within this PE / Project.			
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 2022 Plans:* Will conduct research to develop new scoring approaches to improve measurement precision; will continue research to develop integrated frameworks of implicit-explicit personality; will continue research to identify individual contribution to team performance; develop collective and individual measures of performance. *FY 2023 Plans:* Will conduct research to advance psychometric theory and measurement of Soldiers and teams to improve selection and assignment. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	1.887	1.851	2.123
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. *FY 2022 Plans:* Will conduct research to develop integrative multi-disciplinary frameworks of organizational context; will conduct research to develop theory to understand cross-echelon influence of leadership on performance. *FY 2022 to FY 2023 Increase/Decrease Statement:*	0.899	0.932	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
This effort was completed in Fiscal Year 2022 (FY22) with the research maturing to higher Technical Readiness Levels (TRLs) earlier than expected.			
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 2022 Plans:* Will conduct research to develop computational approaches to model impact of organizational structure on team performance; will conduct research to develop frameworks to understand multi-team processes. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	1.888	1.771	2.076
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 2022 Plans:* Will conduct research to develop approaches to understand and model longitudinal developmental processes of personnel; will conduct research to develop frameworks for building constructive learning environments. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	0.987	0.987	1.027
Title: FY2022 SBIR/STTR Transfer *Description:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 Plans:*	-	0.782	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding transferred in accordance with Title 15 USC ?638			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding transferred in accordance with Title 15 USC ?638			
Accomplishments/Planned Programs Subtotals	21.322	21.644	22.180

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AA5: Biotechnology and Systems Biology	-	6.042	6.063	6.421	-	6.421	6.518	6.577	6.579	6.577	0.000	44.777

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 2021	FY 2022	FY 2023
Title: Engineered Biotechnology	2.572	2.478	2.746
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 2022 Plans: Will conduct targeted bioprospecting, bio-panning, and expand high throughput study of biological control mechanisms to identify material specific microbes and communities for material degradation; understand the behavior of micro-environment of degrading material through analytical and computational techniques to inform predictive community models; will investigate genetic engineering strategies to tune microbial interactions and adhesion to material interfaces for dynamic microbial/material interactions to identify candidates for degradation and assembly process. FY 2023 Plans: Will 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			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this 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 2022 Plans:*** Will explore new control strategies for harnessing indigenous biology in military environments; continue to examine materials and biologically derived assembly techniques for systems and materials performance; will develop high through-put technology for study of control mechanisms and/or parts in novel organisms; will identify orthogonal tools to allow for organism engineering agility to pivot for Army needs for material production and operational environment; will develop strategy to link high throughput data analysis of bioinformatics and material informatics to bulk material analytics. ***FY 2023 Plans:*** Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	3.470	3.364	3.675
Title: FY2022 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2022 Plans:***	-	0.221	-

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Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	**Project (Number/Name)** AA5 *I Biotechnology and Systems Biology*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding transferred in accordance with Title 15 USC ?638			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding transferred in accordance with Title 15 USC ?638			
Accomplishments/Planned Programs Subtotals	6.042	6.063	6.421

C. Other Program Funding Summary ($ in Millions)
 N/A

Remarks
 N/A

D. Acquisition Strategy
 N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AA6: *Robotics and Mobile Energy*	-	22.353	20.616	21.854	-	21.854	22.173	24.323	24.331	24.324	0.000	159.974

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 2021	FY 2022	FY 2023
Title: Vehicle Propulsion and Power Research *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 2022 Plans:* Will validate coupled fluid structure interaction models for dynamic contact angle for molten particulates in hot turbine components; assess emissivity characteristics of oxide/oxide ceramic matrix composites for engine applications; characterize thermo-mechanical behavior of ultra-high temperature composites. *FY 2023 Plans:*	1.225	1.332	1.633

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects 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 2022 Plans:* Will expand aviation fuel models for robust engine control to include gasoline and other highly volatile fuels; determine fuel property sensing method to differentiate fuel ignition quality; explore ignition behavior at cost start and altitude relight conditions in small gas turbine engine; investigate industrial processing conditions and alloying additions on microstructural evolution of advanced aluminum alloys for high thermomechanical applications; will produce and record lab scale mechanical properties of aluminum alloys with varying microstructures and at varying temperatures; will determine microstructural changes in novel tribological materials that lead to scuffing and coating delamination failures in fuel-lubricated mechanical interfaces in simple and complex geometries. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	3.696	3.203	3.177
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.	1.235	0.888	0.991

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
FY 2022 Plans: Will study isomer energy release utilizing nuclear excitation by electron capture or other processes, with the goal of testing a non-implantation approach to an isomer power source; will study charge and energy transfer pathways of light absorbing and catalytic electrochemical systems for energy storage chemical reactions using ultrafast spectroscopy and electrochemical characterization. ***FY 2023 Plans:*** Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Materials, Structures, and Analytics for Enduring Platform Operations *Description:* Basic research to establish fundamental understanding in structural damage tracking methods, novel material/structures, and prognostic and diagnostic techniques to improve vehicle performance and capability. This includes the advancement of machine learning algorithms for deep learning, and the exploration of novel lightweight, durable, self-sensing structures for improved maneuver and reduced maintenance.	1.538	-	-
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 2022 Plans:*** Will investigate reconfigurable platform mechanics (materials, structures, actuators, aeromechanics) and technologies to enable subsystem configuration concepts (mechanical, electrical, power, and information interfaces) for efficient high-speed, range, and payload VTOL aircraft; will explore interdisciplinary materials research to inform on the viability of engineering materials at the molecular level to achieve highly reconfigurable, mechanically relevant structures; will develop a sizing methodology and performance models for the assessment of advanced unmanned aerial system (UAS) concepts with adaptive structures. ***FY 2023 Plans:*** Will 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	0.999	0.937	1.046

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
morphing aircraft platform subsystems and incorporate them in the conceptual design framework to achieve extreme performance and agility attributes. **FY 2022 to FY 2023 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.			
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 planning, behaviors, energy efficient maneuver, and the interface of manipulation technologies to support manned-unmanned teaming constructs. **FY 2022 Plans:** Will investigate novel methods for energy prediction and energy awareness for heterogeneous unmanned systems; develop algorithms that enable autonomous power distribution between ground and air vehicles for sustained increase in operational duration; investigate optimized vehicle route planning among robot teams under constraints of energy availability and mission demands; develop methods for alternative energy in the form of heat engines for power distribution among robotic teams. **FY 2023 Plans:** Will 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 2022 to FY 2023 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.	1.513	1.559	1.844
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 2022 Plans:**	5.884	5.888	6.443

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B. Accomplishments/Planned Programs ($ in Millions)				**FY 2021**	**FY 2022**	**FY 2023**
Will conduct fundamental research on navigation algorithms capable of assessing route options using limited resources while assessing multiple courses of action over long planning horizons; develop algorithms that allow automated tuning of low level control parameters with limited human feedback; will extend shared representations techniques to enable planning across multiple platforms. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflect 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 2022 Plans:* Will combine aeromechanics models, artificial intelligence/machine learning, and classical mechanics to achieve embodied intelligence to creatively machine design platforms to enhance the performance and resilience of advanced air vehicle structures; develop computationally efficient methods and functional models of aerodynamic interactions for near real-time flight dynamics in virtual environments; acquire wind tunnel and experimental flight data on multi-rotor configurations to enable analytical and computational models for vehicle design methods, explore novel active flow control technologies and measurement methodologies, and assess novel numerical techniques; develop approaches for on-board sensing of airflow and vehicle orientation for automated flight transitions. *FY 2023 Plans:* Will 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,				2.997	2.883	3.199

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects 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 2022 Plans:*** Will conduct computational aerodynamics and structural dynamics research aimed to develop novel numerical methods to solve rotary-wing aeromechanics problems including hover and high-speed forward flight; continue to conduct experimental and computational investigations in order to identify, explain, and predict the interactional aerodynamics of multi-rotor configurations by developing pioneering flow measurement techniques and novel numerical algorithms/methods. ***FY 2023 Plans:*** Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	2.504	2.460	2.731
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 2022 Plans:***	0.762	0.707	0.790

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Appropriation/Budget Activity 2040 **I** 1	**R-1 Program Element (Number/Name)** PE 0601102A **I** *Defense Research Sciences*	**Project (Number/Name)** AA6 **I** *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will expand investigative research into quantum computing approaches for computationally expensive multi-scale algorithms for modeling a military ground vehicle interaction with terrain / soft soil; research assured mobility with cyber implications; research gaming engine algorithms for autonomous vehicle off-road mobility; conduct explorative research in intelligent autonomous mobility technologies integrating minimal sensor configurations; research deep learning based terrain identification; research and develop robust path planning and control, all on-board and in real time; continue researching the application of deep learning algorithms for generating Go/NoGo maps to other geographic regions. *FY 2023 Plans:* Will 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 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: FY2022 SBIR/STTR Transfer *Description:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 Plans:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding transferred in accordance with Title 15 USC ?638	-	0.759	-
Accomplishments/Planned Programs Subtotals	22.353	20.616	21.854

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AA7: *Mechanics and Ballistics*	-	35.368	33.331	35.234	-	35.234	35.760	36.184	36.195	36.186	0.000	248.258

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 2021	FY 2022	FY 2023
Title: Protection Sciences	5.000	5.193	5.574
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 2023 Army		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
mechanisms through increased understanding of wave propagation through tissue, and the resulting deformation and damage of tissue during ballistic and blast events. *FY 2022 Plans:* Will initiate micro-mechanical dynamic response experiments on heterogeneous ceramics and MAX phase material; conduct transverse indentation studies to establish the response of Tensylon to impact loading relevant to ballistic environments and use meso-scale validated computational models to obtain the evolution of the stress-state; perform macroscale fracture studies at quasi-static and dynamic strain rates using in-situ x-ray imaging and diffraction techniques to improve computational failure models; investigate a stable and accurate finite element model for ballistic impacts to the human thorax in order to improve personal protective equipment. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects 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 2022 Plans:* Will investigate the quasi-static and high-rate properties of nanostructured materials (iron-based and copper-based) determined to be important to the behavior needed in vehicle armor and lethality applications; investigate novel particulate consolidation methods that preserve the nanostructure at elevated processing temperatures and provide the unique properties needed to be successful; provide a correlation of the processing parameters to the properties observed; continued the development of high diamond content composite ceramic materials to include large enough specimens for sub-scale ballistic assessments for high-rate and resultant microstructural characterization. *FY 2023 Plans:*	3.245	3.183	3.506

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects 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 2022 Plans:*** Will integrate metals, ceramics, and polymers with unique high rate behaviors into prototype composite armor and composite weapon systems/sub-systems and investigate the influence on the composite response to extreme mechanical loading. ***FY 2023 Plans:*** Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	3.386	3.283	3.615
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 2022 Plans:*** Will identify alloy compositions which maximize response under a magnetic field for additive manufacturing alloy design and determine appropriate processing conditions which improve printability and carburization in aluminum and steel systems respectively through the application of descriptive models that incorporate magnetic field based diffusion mechanisms;	2.478	2.395	2.642

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
optimize processing methodology to produce samples large enough to conduct ballistic testing to assess if new material meets performance requirements. ***FY 2023 Plans:*** Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects 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 2022 Plans:*** Will explore expanding the palette of available 2D polymer chemistries to tune properties for a range of applications, guided in part by artificial intelligence and machine learning (AI/ML) design methodologies; identify processing science advances to enhance the quality, properties, and scalability of 2D polymer films. ***FY 2023 Plans:*** Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	1.690	1.601	1.779
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 2022 Plans:***	1.815	1.743	1.913

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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 2021**	**FY 2022**	**FY 2023**
Will down-select candidate materials, biopolymers, and composites and study functional behavior after scalable integration and processing; tune biopolymer properties for improvements to control meso-scale assembly and identify structure/function and/or sequence-defined function properties; investigate compatibility of biological materials and organisms and material scaffolds and uncover mechanisms for controlling precision placement and integration of biological and composite material behavior. *FY 2023 Plans:* Will 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 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of 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 2022 Plans:* Will perform studies to examine the aero-thermodynamics of Army-relevant shapes flying at hypersonic speeds and compare computational predictions, wind tunnel measurements, and ballistic free-flight experiments; extend theories of multi-agent perception and control for constrained, high-speed aerial systems. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	3.192	3.094	3.407
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.	3.648	3.486	3.838

Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022
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 2021**	**FY 2022**	**FY 2023**
FY 2022 Plans: Will synthesize, characterize, and explore novel high energy density nanometals and extended solids, building off of FY21 successes; transition grain scale dynamic modeling techniques and solid state kinetics methodologies developed in FY21 to large scale efforts for verification and validation; develop fundamental models to aide in the design of newly developed propulsion concepts.			
FY 2023 Plans: Will 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 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Theory in Atmospheric Characterization, Sensing, and Modeling *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 2022 Plans:** Will apply machine learning techniques to the Dense Urban Area Meteorological Sensor Array (MSA) data to identify previously unknown complex terrain and climatic processes building from research on complex land surface energy budget, water cycle processes, and radiative transfer processes using data collected at the MSA testbed; explore both short timeframe and longer timeframe environmental processes in urban domains; identify additional sensing modalities that could be integrated onto an unmanned aerial system (UAS) platform to facilitate environmental awareness essential for autonomous flight; continue research to quantify thermal and momentum flux of sloping surfaces under stratification to better treat physical processes in complex and urban terrain; study the application of lattice-Boltzmann methods to simulate radiative transfer in the urban environment; explore and devise new/improved methods to characterize and assess the impact of atmospheric environment on aerosols; explore methods of heterogeneous sensing modalities to both characterize the environment and assess the impact of the environment on electro-optic, radio frequency (RF), and acoustic signals. **FY 2023 Plans:** Will 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	3.900	4.007	4.411

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Multiscale Modeling for Novel Materials ***Description:*** Explore and develop multi-scale modeling techniques to support fundamental studies of electronic and structural material properties from the atomistic to the continuum. Resulting models will be used to design and develop materials for more efficient, longer lifetime sensors and power and energy devices, and lighter materials for vehicle and soldier protection. This effort includes coupled research with two 5-year Collaborative Research Alliances (CRAs): the Materials in Extreme Dynamic Environments CRA and the Multi-scale/Multidisciplinary Modeling of Electronic Materials CRA. These CRAs are funded under PE 0601104A (University and Industry Research Centers) / Project AB7 (Army Collaborative Research and Tech Alliances).	3.546	-	-
Title: Environmental Quality ***Description:*** This effort conducts research on innovative environmentally-friendly technologies that support the warfighter focusing on pollution prevention technologies. ***FY 2022 Plans:*** Will conduct innovative basic research in the systematic study of new innovative environmentally friendly energetics through the study of fundamental aspects of compounds and precursors and bench scale synthesis including experimental research; conduct modeling and simulation of various compounds and the study of alternative solvents and processes to reduce the hazards associated with the manufacturing of energetics; research new green coatings through the study of various shaped and sized nanoparticles to replace hazardous chemicals for a variety of armament and energetic materials, enhancing coloration while reducing toxicity; conduct research on innovative methods to replace toxic chemicals in the coating of metals for corrosion inhibition. ***FY 2023 Plans:*** Will 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	1.107	1.068	1.186

Exhibit R-2A, RDT&E Project Justification: PB 2023 Army			Date: April 2022		
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
replacement of hazardous solvents and alternative methods to process chemicals for energetics to reduce environmental, safety, and occupational health (ESOH) issues. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
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 2022 Plans:*** Will conduct research and studies focused on chemical and biological interactions on solid surfaces including interfaces between materials and the surface. Areas of interest include transport, deposition, reactivity, and removal of biological and chemical compounds of interest, material interactions and properties arising from physical or biological synthetic processes, and enabling models and theory of interfacial interactions or processes that may relate to bulk properties. ***FY 2023 Plans:*** Will 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 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	2.361	2.297	2.533
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 2022 Plans:***	-	0.764	0.830

Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will develop analysis methods for penetration mechanics of non-homogeneous materials for Army applications; develop a canonical experiment approach to relate lab-scale material properties to ballistic response. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: FY2022 SBIR/STTR Transfer *Description:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 Plans:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding transferred in accordance with Title 15 USC ?638	-	1.217	-
Accomplishments/Planned Programs Subtotals	35.368	33.331	35.234

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
AA8: *Sensing and Electromagnetics*	-	9.006	13.589	13.619	-	13.619	13.499	14.160	14.840	14.940	0.000	93.653

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 2021**	**FY 2022**	**FY 2023**
Title: Photonic Materials and Device Research *Description:* Conduct research into novel material and device structures operable throughout the electromagnetic spectrum from long wave infrared (LWIR) to ultraviolet (UV) including sources, detectors, and integrated photonic devices to increase situational awareness in open and complex terrains; allow assured communication, improved target detection, identification, and discrimination; and create new device functionalities while reducing size, weight, and power requirements.	0.999	-	-
Title: Advanced Materials Research *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 2022 Plans:* Will optimize topological insulator materials for use in topological enhanced devices for atta joule computing at the edge; develop methodologies and algorithms to demonstrate basic arithmetic operations based on specialized arrays needed for realizing	2.699	3.333	1.558

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
neuromorphic computing; study the electrical properties of silicon terminated diamond surfaces with the objective of operative transfer doping at higher temperatures. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding decreased in Fiscal Year 2023 (FY23) to support the creation of the ?Foundational Sensing? task within this Program Element (PE) / Project.			
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. *FY 2022 Plans:* Will investigate novel RF sensing modes for tactical Army applications; investigate and develop algorithms to enable the coherent integration of synthetic aperture radar (SAR) data across an aperture generated by sensor platform forward motion; research and develop low complexity signal processing for RF sensors detecting and tracking personnel in complex multi-path backgrounds; investigate cross-modality geophysical interactions and coupling between three-dimensional low-frequency electromagnetic fields, acoustic particle velocity, and torsional seismic waves. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding decreased in FY23 to support the creation of the ?Foundational Sensing? and ?Foundational Distributed Radar? tasks within this PE / Project.	1.716	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	1.664	1.132	1.268

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
power components. Materials, designs, and fabrication techniques will be studied for the future development of Micro-Electro-Mechanical Systems (MEMS) for RF)devices and sensors. *FY 2022 Plans:* Will validate previously developed models of impact ionization effects through experimental studies on appropriate structures; investigate how leakage currents are effected by lateral versus vertical structures; investigate interfacial interactions of adsorbed chemical species and excited states in plasmonic, electrocatalytic, and photoelectrocatalytic systems; identify causes of high leakage currents in wide band gap, silicon carbide (SiC) diode structures. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
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 2022 Plans:* Will investigate the optical properties and its environmental dependence of the permittivity near zero metamaterial based air-ring resonator; develop a new tuning method for the soliton based micro-optical-frequency-comb and explore the locking mechanism to lock the optical frequency comb to the environmental-insensitive resonator for long-term stability. *FY 2023 Plans:*	0.709	0.701	0.777

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
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 2022 Plans:* Will explore fabrication and characterization of novel materials with unique compositions and structures that result in tunable optical and electromagnetic properties; study human physiological responses to blue light exposure to understand the impact on sleep attributes and alertness. Knowledge gained will support optimization of Soldier performance, as well as inform design and usage of visual displays, such as in integrated headborne systems. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	1.219	1.186	1.311
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 2022 Plans:* Will explore new classes of passive and active phase change materials and processing methods to improve transient thermal management; investigate methods to tune and characterize thermal properties such as thermal conductivity and specific energy	-	1.241	1.047

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
storage; investigate innovative techniques of reliable measurement of thermal resistivity for novel gain materials and innovative fiber designs; conduct laser experiments utilizing improved transient thermal management based on new active phase change materials; investigate thermal interfaces and thermal transport in phase change materials; explore controlled crystallization of all-glass, low nonlinearity fibers as well as thermo-optic tailoring of novel, low-nonlinearity glasses. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Physics-Informed Machine Learning for Complex Phenomena *Description:* Existing machine-learning approaches are not guided by the laws governing physical systems and unable to provide predictions of a physical system response with quantifiable uncertainty. Research will explore and develop modeling techniques incorporating machine-learning approaches to support fundamental studies of physical systems. Resulting models will be used to design and develop novel physical systems, such as diamond for high power RF applications. *FY 2022 Plans:* Will investigate deficiencies of existing machine-learning approaches when applied to modeling of physical systems; validate the use of existing machine-learning techniques to construct models of physical systems; examine existing methods for incorporating physical constraints into machine-learning models of physical systems; conduct research into assimilation of multiple-fidelity data into machine-learning models of physical systems; explore techniques for uncertainty quantification of machine-learning models. *FY 2023 Plans:* Will 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 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	-	3.150	3.436
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	-	0.673	0.971

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
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 2022 Plans:* Will investigate recombination mechanisms in Type-II Long Wave Infrared (LWIR) and Medium Wave Infrared (MWIR) strained layer superlattices (SLS) to develop understanding for improving transport and efficiency in these materials for sensing; investigate methodologies for mitigation strategies for optimal device design for sensing; investigate the interface properties between a topological insulator (TI) and a ferromagnetic and antiferromagnetic layers, which is needed for realizing low power switching electronic devices. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* In FY 2023, funding increased to support additional research in transport and magnetic exchange characteristics.			
Title: Foundational Distributed Radar	-	-	1.231
Description: This research seeks to investigate novel signal processing techniques to develop distributed, GPS-independent, autonomous capabilities. This effort investigates tools and techniques for modeling, simulations, and emulation of distributed 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:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding realigned from the ?Distributed Sensor Research? task in this PE / Project to support the creation of this task in FY23.			
Title: Foundational Sensing	-	-	2.020

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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 E-field and Magnetic (H)- field signals in cluttered environments. *FY 2023 Plans:* Will 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 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 2022 to FY 2023 Increase/Decrease Statement:* Funding realigned from the ?Advanced Materials Research? and ?Distributed Sensor Research? tasks in this PE / Project to support the creation of this task in FY23.			
Title: FY2022 SBIR/STTR Transfer *Description:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 Plans:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding transferred in accordance with Title 15 USC ?638	-	0.497	-
Accomplishments/Planned Programs Subtotals	9.006	13.589	13.619

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
AA9: *Information and Networking*	-	40.376	40.435	42.839	-	42.839	43.480	43.875	43.889	43.877	0.000	298.771

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 2021	**FY 2022**	**FY 2023**
Title: Communications in Complex Dynamic Networks	5.475	5.128	5.655
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.			

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Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	**Project (Number/Name)** AA9 *I Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
FY 2022 Plans: Will conduct research on network models that jointly characterize combinations of the environment, network topology, communication technology diversity, computational resources, and/or mission objectives; develop and analyze multi-layer network protocols for optimizing network performance given technological, objective diversity, operational, and environmental constraints; explore novel network emulation approaches to support the development of future networks featuring vast scale and complexity; conduct emulation and physical experiments that characterize the performance of novel networking control protocols for intelligent, adaptive, and/or distributed operation. *FY 2023 Plans:* Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Data to Knowledge to Support Decision Making (Information Mediation) *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 2022 Plans:* Will investigate models and approaches to enable autonomous systems to transform information to facilitate increased comprehension, decreased ambiguity, and maintain effective op-tempo decision making and responsive situational awareness; explore human-in-the-loop and human-on-the-loop machine learning strategies for interoperability and rapid autonomous mediation of inter and cross-domain data from heterogeneous sources; investigate computational models, novel training corpora, and algorithms that enable automated computer systems to understand and interpret information content from multimedia data	5.221	4.063	4.486

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
and construct knowledge networks for concept recognition, explanation, and inferences for downstream analytics to support collaborative decision making. *FY 2023 Plans:* Will 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 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects 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 2022 Plans:* Will advance the use of machine learning in cyber security, with minimal need for subject matter experts, to counter swift attacks in a constrained environment; pursue innovative intelligent countermeasures against adversarial machine learning attacks that reduces burden on the defender and increases the cost to the adversary; investigate techniques to predict adversary tactics, techniques, and procedures (TTPs) for proactive network defense and to support honeynet generation which is situation-aware and realistic enough to attract and mislead an intelligent adversary; using machine learning and computational game theory, develop modeling approaches with the following features: (a) prediction of frequency and occurrence of network attacks by type for effectively implementing adaptive honeynets and (b) analysis of impact of software defined networks (SDN) for mobile network architectures; study and analyze the performance alternative methods of entanglement creation and distribution to mitigate entanglement degradation; explore and characterize the performance of fundamental quantum networking elements such as switches and interfaces. *FY 2023 Plans:*	4.742	4.887	5.395

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Naturalistic Behavior for Shared Understanding and Explanation with Intelligent Systems *Description:* Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of-the-art techniques in machine translation and natural language processing.	1.226	-	-
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 2022 Plans:*** Will study protocols and algorithms to enable sets of decentralized and distributed heterogeneous computing systems; research energy efficient algorithms for coordination and consensus; explore methodology and algorithms to enable information processing scaled across heterogeneous computing hardware; investigate both high performance processing capabilities, scalable to heterogeneous hardware platforms, and novel approaches to enable ingesting, extracting, translating, processing, and analyzing heterogeneous data. ***FY 2023 Plans:*** Will 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 2022 to FY 2023 Increase/Decrease Statement:***	3.891	3.757	4.149

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding change reflects planned lifecycle of this effort.			
Title: Assured Operations in the Physical, Social and Cyber Domain	6.000	6.084	6.544
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 techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. *FY 2022 Plans:* Will investigate and assess algorithms enabling intelligent intrusion detection and threat categorization; explore techniques for automated network forensics and analytics, and integrate with Machine Learning techniques to lay foundations for incorporating autonomous agents and decision making; conduct research on low-complexity, distributed, and/or robust cyber techniques based on machine learning for proactive evading, detecting, and responding to adversarial activity; develop rigorous mathematical frameworks and analyses of adaptive and responsive friendly and adversarial cyber protocols; continue to examine theories and algorithmic methods that measure information interoperability, quantify information/model uncertainty, and optimize information synthesis; investigate algorithmic approaches that quantifies the predictive uncertainty of automated decisions under adversarial computational-equivalency and conditions; validate algorithms which infer value of information characteristics from sensor and other information assets in information dissemination and mediation contexts; explore stochastic-process-based models of physical systems to incorporate random-field approaches; investigate methods for incorporating uncertainty into decision-making processes leveraging complex physical behaviors. *FY 2023 Plans:* Will 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			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
physical systems (inverse problems); assess performance of low-resource methods for aggregating and propagating uncertainty in physical systems.			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Machine Learning for Intelligent Agent and Human Decision Making *Description:* This effort researches methodologies and algorithms for machine learning with incomplete, unstructured, potentially deceptive, and heterogeneous information, enabling joint decision making for Intelligent Agent-Human teams which adapt to unknown environments and missions. Research includes methods for learning and decision making that occur under short time frames and constrained resources (e.g., computation, power, spectrum, and networks). *FY 2022 Plans:* Will develop models and algorithms for predicting impacts of diversification strategies on system assets, including network, applications and cybersecurity, to provide decision support to defenders, operators, and commanders on the battlefield; conduct empirical analysis of models and algorithms when pinned against malware and other intrusions; enable repeatable experimentation focused on systematic automation that will realize continuous model refinement; explore techniques that allow for reasoning over incomplete semantic data to draw inferences about semantic observations and introduce greater contextual richness into a shared world model; investigate multi-agent coordination techniques that facilitate the development of tactical behaviors across small teams of autonomous agents; extend distributed world model by investigating intelligent sharing of salient data streams based on operational context; identify, define, and explore computational models, novel training corpora, and machine learning approaches that enable intelligent systems to recognize shared and contrastive content in multiple forms of text, video, acoustic, and other modes of information sharing and multimodal communications; define algorithms, models, and machine learning techniques to enable intelligent systems to automatically identify context and intent to construct, generate, or transform relevant representations of information for enhanced situational awareness and decision-making. *FY 2023 Plans:* Will 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	3.981	5.533	6.103

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects 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 2022 Plans:* Will investigate artificial intelligence/machine learning methods for assessing value of targets in unstructured scenes; develop deep reinforcement learning approaches for scene understanding to feed rapid strategic decision making for Command and Control in complex Multi Domain Operation (MDO) environments; investigate domain transfer approaches for effective training of machine learning algorithms for scene understanding with synthetic data; investigate algorithm optimization approaches for scene understanding performance retention in resource constrained computation environments such as low size, weight, and power (SWaP) processors onboard unmanned air and ground vehicles. *FY 2023 Plans:* Will 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 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	2.231	2.148	2.380
Title: Fundamentals for Energy Efficient Electronic & Photonic Components *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.	1.947	1.872	2.077

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: Will investigate mechanism of energy deposition and transfer through ultra-wide bandgap materials through the use of time-dependent pulsed beam stimulation and repetitive photoluminescence (PL) and cathode luminescent (CL) measurement of charge carrier kinetics; investigate ferroelectric and anti-ferroelectric materials in nanoscale 3D scaffolding for high energy density capacitors for rapid recharge applications; explore materials and fabrication techniques for devices needed for through metal wireless power transfer and wearable, stretchable wireless power; research ultra-wide bandgap material structures based on Diamond/Boron Nitride technology for high efficiency RF components; investigate mechanisms for detection of circular polarized light in several topological materials through growth and characterization for efficient communications. ***FY 2023 Plans:*** Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects 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 2022 Plans:*** Will investigate optimal approaches for storing and manipulating quantum information in physical platforms of atoms, ions, and material systems for entanglement-enhanced sensing and communications; investigate multiplexed quantum memory in cold-atom systems; investigate schemes for efficient readout of Rydberg sensor information; extend atom-atom interaction distance through optical nanofibers for distributing entanglement; explore charge-state dynamics of solid-state defect materials for optimization of sensor capabilities and magnetometers; explore frequency conversion in ion trap systems for long-range entanglement through optical fiber. ***FY 2023 Plans:*** Will 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	5.662	5.484	6.050

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: FY2022 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2022 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	1.479	-
Accomplishments/Planned Programs Subtotals	40.376	40.435	42.839

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	31.957	36.910	4.405	-	4.405	4.465	4.607	4.580	4.578	0.000	91.502

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 2021	FY 2022	FY 2023
Title: Damage Control Resuscitation *Description:* This effort conducts studies to define and identify cellular processes and metabolic (biochemical activity) mechanisms associated with blood clotting to understand the relationships between the human immune processes and bleeding in trauma.	1.640	-	-
Title: Combat Trauma Therapies *Description:* This effort conducts studies of trauma to tissues and organs, including dental (facial and oral) injuries, extremity wounds and fractures, and burns, and ways to mitigate and/or repair this damage.	0.664	-	-
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. *FY 2022 Plans:* Will perform feasibility study to support development of an extremity tourniquet prototype able to provide guidance to operators of all skill levels on its proper application, optimal placement, and maximum time to be left on and management, and decrease complications associated with prolonged use. *FY 2022 to FY 2023 Increase/Decrease Statement:*	1.411	0.885	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
Title: Traumatic Brain Injury *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	1.356	-	-
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. *FY 2022 Plans:* Will perform In vitro and in vivo efficacy studies of medical treatments for burn in environments contaminated with nerve agent. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.	2.729	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 2022 Plans:* Will further the characterization of cellular and physiological pathways responsible for bone adaptation after strenuous exercise and characterize normal and abnormal pathways responsible when using non-steroidal anti-inflammatory drugs. Will develop scaling and correlations of bio mechanical and injury perturbations across multiple species to develop injury criteria for blast over pressure exposure resulting from improvised explosive devices. *FY 2022 to FY 2023 Increase/Decrease Statement:*	2.519	2.479	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
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 2022 Plans:*** Will continue to define the role of nutrition support for metabolic recovery from military activity. Will continue to understand field-based impact of sleep on operational performance. 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 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding decreased due to realignment of US Army Medical Research and Development Command to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.	4.926	3.861	2.555
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 2022 Plans:***	1.089	1.090	1.013

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Will research animal models for basic mechanisms of injuries from heat exposure and those factors that accelerate improved recovery; will establish screening methods to determine the underlying molecular mechanisms for degraded physical and behavioral performance of susceptible individuals in challenging dense urban and subterranean environments. *FY 2023 Plans:* 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 (CO_2) and low Oxygen (O_2) environments. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding decreased due to realignment of US Army Medical Research and Development Command to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
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. *FY 2022 Plans:* Will identify new candidate therapeutic targets to promote resilience to stressors using a novel evidence-synthetic receptor-based strategy, to speed the process of drug discovery. Will identify new compounds and pharmacologics for rapid recovery from acute stress reactions using preclinical experiments and will identify molecular markers of recovery from acute stress symptoms after intervention (pharmacological and non-pharmacological). Will research candidate pharmacological solutions for their ability to provide rapid recovery from acute stress symptoms by enhancing Soldier resilience to recover from high-stress events with minimal side effects using preclinical testing. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.	1.717	0.787	-
Title: Basic Research on Drugs and Vaccines Against Parasitic Diseases (previously titled: Basic Research to Prevent Parasitic Diseases)	5.835	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: Discover and identify new chemical compounds for further characterization and optimization as potential drug leads against malaria. Discover and identify new antigens, virulence factors and adjuvants that will lead to the development of effective malaria vaccines, develop approaches for multivalent vaccines that achieve protective efficacy across genetically diverse malaria parasites and identify correlates of protection in animal models and in humans.			
Title: Bacterial Disease Threats ***Description:*** Discover and identify new antigens, virulence factors and adjuvants that will lead to the development of effective diarrheal vaccines against Enterotoxigenic Escherichia Coli (ETEC), Shigella and Campylobacter. Identify approaches to develop multivalent vaccines that achieve protective efficacy across several bacterial serotypes and species, as well as identify correlates of protection from bacterial diarrheal disease in animal models and in humans.	1.721	-	-
Title: Viral Threats Research ***Description:*** Discover and identify new antigens, virulence factors and adjuvants that will lead to the development of effective vaccines against hemorrhagic fever viruses (e.g. dengue and Hantaviruses). Identify approaches to develop multivalent vaccines that achieve protective efficacy across all dengue serotypes, and discover and identify correlates of protection from viral diseases in animal models and in humans.	1.700	-	-
Title: Insect Vector Basic Research ***Description:*** Identify and characterize specific populations of vectors that may carry and transmit infectious disease, inform vector control countermeasures, and develop detection assays for vectors and vector-borne pathogens.	1.594	-	-
Title: Network Sciences Initiative ***Description:*** This effort uses mathematical models and 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 pose a threat to Warfighter readiness: e.g., musculoskeletal injury, PTSD, uncontrolled bleeding, infectious diseases, hard-to-diagnose pulmonary disease, and exposure to environmental stressors and hazards.	3.056	-	-
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. ***FY 2022 Plans:***	-	1.101	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Understand the mechanisms that contribute to the transition from acute to chronic pain and identifying novel drug therapy targets to alleviate pain. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
Title: Extremity Trauma ***Description:*** This effort performs basic research to support development of treatments to preserve tissues and function of severely mangled limbs. ***FY 2022 Plans:*** Will perform basic research of cellular metabolism in injured limb tissues to support identification of potential means to protect injured, viable tissues from further damage during the period from time of injury until definitive care is made available. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.	-	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. ***FY 2022 Plans:*** Will perform basic research to support development of new technologies to improve provision of critical care in forward, austere and logistically restricted areas of the battlefield). ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.	-	0.486	-
Title: Hemorrhage, Shock, Coagulopathy of Trauma	-	1.640	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
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. *FY 2022 Plans:* Will perform conceptual studies to support design, development, and optimization of a diagnostic tool that can predict overall hemostatic efficiency of an injured casualty. Will perform hemostatic functional assays of a novel dried whole blood product. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
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. *FY 2022 Plans:* Will conceptualize and evaluate synthetic and animal models in which to test feasibility of novel vascular access approaches. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.	-	0.467	-
Title: Burn Injury *Description:* This effort performs basic research to support development of treatment and clinical management tools for severe burns. *FY 2022 Plans:* Will perform In vitro and in vivo efficacy studies of medical treatments for burn in environments contaminated with nerve agent in order to examine the effects of the chemical agent and decontamination agents on the burn wound and surrounding viable tissues, and to examine the effects of acute burn wound treatment on decontamination. *FY 2022 to FY 2023 Increase/Decrease Statement:*	-	2.786	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
Title: TBI Neurotrauma/Brain Dysfunction	-	1.388	-
Description: This effort conducts basic research in poly-trauma (multiple injuries)/Traumatic Brain Injury (TBI) model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI. ***FY 2022 Plans:*** Will evaluate efficacy of Tactical Combat Casualty Care blood product resuscitation strategies in a swine model of penetrating TBI and polytrauma. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
Title: Soldier Performance Augmentation	-	1.871	0.837
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 2022 Plans:*** Will study relationship between underlying brain characteristics (e.g., density of neural synapses, glymphatic flow, and cortical thickness) to Soldier military performance. Will discover indices of brain dysfunction and repair related to Soldier job-related awakedness and recovery following sleep. Will investigate biomedical mechanisms of inter-individual differences in vulnerability to cognitive performance and attention related to time-on-task. ***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 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding decreased due to realignment of US Army Medical Research and Development Command to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
Title: Prolonged Field Care - Infectious Diseases	-	4.442	-
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. ***FY 2022 Plans:*** Will discover, identify, and characterize the following for prevention and treatment of combat wound infections and sepsis in a prolonged field care environment: new substances that induce an immune response in the body; molecules produced by microorganisms that help them attach, evade host responses and allow spread; and substances that enhance the body's immune response; generate, characterize, and evaluate proteins produced in response to and against combat wound infections; characterize combat wound infections to inform development of prophylactics and treatments. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
Title: Medical Readiness - Infectious Diseases	-	6.884	-
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. ***FY 2022 Plans:*** Will discover, identify, and characterize the following for the prevention and treatment of endemic bacterial and viral infectious diseases: new substances that induce an immune response in the body; molecules produced by microorganisms that help them attach, evade host responses and allow spread; and substances that enhance the body's immune response; generate, characterize, and evaluate proteins produced in response to and against endemic bacterial and viral infectious diseases; characterize endemic bacterial and viral infectious diseases to inform development of prophylactics and treatments. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022	
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
Title: Medical Computational Modeling	-	3.050	-
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. *FY 2022 Plans:* Will design algorithms to identify the impact of load carriage and stride-length on the risk of stress-related bone fracture in Warfighters during basic combat training. Will develop and refine computational strategies that allow us to use Artificial Neural Network and Machine Learning methods to solve military biomedical problems even when the sample sizes are small. Will quantitatively compare existing cooling strategies currently recommended by the United States Army and identify the most efficacious ones in reducing core body and organ temperatures following exposure to specific heat-stress conditions. Will identify genes and mechanisms of drug resistance in the malaria parasite, as a model organism, and validate their involvement in mitigating resistance against new antimalarial drugs. Will use a mathematical skeletal-muscle model based on biophysical principles to identify and assess interventions that delay muscle fatigue, reduce injury, and prolong optimal performance. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding and mission realigned as part of US Army Medical Research and Development Command transfer to the Defense Health Agency in order to meet Congressional intent as outlined in NDAA 2019 (Section 711) and NDAA 2020 (Section 737). Funding transferred to Program Element 601117DHA, Project Code 371F.			
Title: SBIR/STTR Tax	-	0.773	-
FY 2022 Plans: SBIR/STTR tax. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding transferred in accordance with Title 15 USC ?638.			
Accomplishments/Planned Programs Subtotals	31.957	36.910	4.405

C. Other Program Funding Summary ($ in Millions)

N/A

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C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

 N/A

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Appropriation/Budget Activity 2040 *I* 1					**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*				**Project (Number/Name)** AB2 *I Protection, Maneuver, Geospatial,* *Natural Sciences*		
COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	17.089	17.967	19.201	-	19.201	19.478	19.749	19.897	19.892	0.000	133.273

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 2021**	**FY 2022**	**FY 2023**
Title: Mapping, remote sensing, signature physics and terrain state	3.868	3.819	4.277
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 2022 Plans:*** Investigate signal processing algorithms for automatic target recognition. Basic research characterizes urban noise fields at ground level, for both acoustic and electromagnetic waves, relevant to military operations. ***FY 2023 Plans:*** Will investigate parameterized anomalous sound propagation effects derived from ground turbulence blocking to localize and track elevated acoustic sources. Will investigate if a link exists between mechanical properties of snow permeability, elastic modulus, and acoustic response. Will quantify thin snow absorption, emission, and scattering processes influencing radiative transfer. Will use this fundamental research to inform deep learning models for a forest canopy that predicts understory parameters. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Fundamental Adaptive Protection and Projection Research	4.700	4.639	4.782

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Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	**Project (Number/Name)** AB2 *I Protection, Maneuver, Geospatial, Natural Sciences*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
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 2022 Plans:* Investigate physical drivers of currents in the littoral swash zone to inform the geo-environmental conditions of autonomous vehicles; study thermal conductivity in cold environments to understand the electrical performance limitations of crystalline materials; determine the mechanisms that enable tunability of specific materials for novel unconventional countermeasures and survivability applications. *FY 2023 Plans:* Will determine if density class interactions in multiple density mixtures lead to nonlinear sediment transport curves based on the proportion of dense material. Will use parallel treatment of grains and bonds to understand how microscale snow parameters, particularly sintered bonds, impact the macroscale compressive strength. Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
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 2022 Plans:* Explore the potential of resonance energy transfer as a light harvesting mechanism to inform future development of advanced materials; investigate the structure-function relationship in compartmentalized nanoreactors for future application in on-demand chemical reactions and real time monitoring. *FY 2023 Plans:* Will investigate the protein responsible for the durable, water resistant and thermally regulated mud dauber wasp nest. Will investigate characterizations of liquid Gallium diffusion in Aluminum to potentially inform future infrastructure engineering	1.817	1.796	2.012

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
advancements. Will use dynamic hyperbolic data projection to reveal knowledge from hyperdimensional datasets that existing methods are incapable of exposing. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects 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 2022 Plans:* Investigate mechanisms in cold-dwelling bacteria (psychrophiles) and frozen media to support future development of cold-specific Army technologies; explore how synthetic biology can be combined with new materials to allow manipulation of materials on demand. *FY 2023 Plans:* Will investigate soil disturbance and emissions using volatile compounds. Will explore the relationship between atmospheric phenomena and natural processes. Will explore synthetic engineering of bacteria to function as a non-model synthetic biology chassis. Will investigate fundamental principles of cryptobiosis by engineering mechanisms into cells. Explorative research will investigate current and signal propagation dynamics in fungal melanin. New research into genetic adaptations of lichens will be conducted to exploit biological engineering functionalities. Will 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 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort, the increase provides for adequate investigation and experimentation to explore the relationship between atmospheric phenomena and natural processes, and also for further investigation into bacteria manipulation.	6.704	7.057	8.130
Title: FY 2022 SBIR/STTR Transfer *Description:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 Plans:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 to FY 2023 Increase/Decrease Statement:*	-	0.656	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding transferred in accordance with Title 15 USC ?638			
Accomplishments/Planned Programs Subtotals	17.089	17.967	19.201

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks
 N/A

D. Acquisition Strategy
 N/A

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Appropriation/Budget Activity 2040 *I* 1				**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*					**Project (Number/Name)** CH9 *I Advancing Concepts and Technology Forecasting*		

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CH9: *Advancing Concepts and Technology Forecasting*	-	-	3.573	3.793	-	3.793	3.845	3.873	3.875	3.874	0.000	22.833

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 2021	FY 2022	FY 2023
Title: Advancing Concepts and Technology Forecasting	-	3.443	3.793
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 2022 Plans:* Will perform initial integration of basic scientific research outcomes with a priority focus on far-term Maneuver, Fires, and Mission Command Army Warfighting Concepts; perform long-range technology forecasts of Army Priority Basic Research Areas, including Synthetic Biology, Artificial Intelligence, and Disruptive Energetics. *FY 2023 Plans:*			

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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 2021	FY 2022	FY 2023
Will 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 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: FY2022 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2022 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.130	-
Accomplishments/Planned Programs Subtotals	-	3.573	3.793

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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Appropriation/Budget Activity 2040 *I* 1				**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*					**Project (Number/Name)** T14 *I BASIC RESEARCH INITIATIVES - AMC (CA)*		

COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	48.000	73.000	-	-	-	-	-	-	-	0.000	121.000

Note

Congressional Interest Item funding provided for Defense Research Sciences.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Defense Research Sciences.

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 2021**	**FY 2022**
Congressional Add: Multi-fuel ignition, chemistry and control strategies for unmanned aircraft systems hybrid propulsion	15.000	-
FY 2021 Accomplishments: Program Increase supported basic research on Multi-Fuel Ignition, Chemistry, and Control Strategies for Unmanned Aircraft Systems Hybrid Propulsion. Work executed by Army Futures Command.		
Congressional Add: Program increase	10.000	25.000
FY 2021 Accomplishments: Program Increase supported basic research on Defense Research Services. Work executed by Army Futures Command. *FY 2022 Plans:* Congressional Interest Item funding provided for Basic Research		
Congressional Add: Program increase - explosives and opiods dual-use UV detection	3.000	5.000
FY 2021 Accomplishments: Program Increase supported basic research on Explosives and Opiods Dual-Use UV Detection.		

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**
Work executed by Army Futures Command. *FY 2022 Plans:* Congressional Interest Item funding provided for Explosives and Opiods Dual-Use UV Detection		
Congressional Add: Program increase: Artificial intelligence complex multi?material composites processing *FY 2021 Accomplishments:* Program Increase supported basic research on Artificial Intelligence Complex Multi-Material Composites Processing. Work executed by Army Futures Command.	10.000	-
Congressional Add: Program Increase: Cell-Free Expression for Biomanufacturing *FY 2021 Accomplishments:* Program Increase supported basic research on Cell-Free Expression for Biomanufacturing. Work executed by Army Futures Command. *FY 2022 Plans:* Congressional Interest Item funding provided for Cell-Free Expression for Biomanufacturing	10.000	10.000
Congressional Add: Digital Thread for Advanced Manufacturing *FY 2022 Plans:* Congressional Interest Item funding provided for Digital Thread for Advanced Manufacturing	-	5.000
Congressional Add: Joint Research Labratories *FY 2022 Plans:* Congressional Interest Item funding provided for Joint Research Labratories	-	20.000
Congressional Add: Lightweight High Entropy Metallic Alloy Discovery *FY 2022 Plans:* Congressional Interest Item funding provided for Lightweight High Entropy Metallic Alloy Discovery	-	3.000
Congressional Add: Unmanned Aerial Systems Propulsion *FY 2022 Plans:* Congressional Interest Item funding provided for Unmanned Aerial Systems Propulsion	-	5.000
Congressional Adds Subtotals	48.000	73.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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D. Acquisition Strategy
 N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Army											Date: April 2022	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					**R-1 Program Element (Number/Name)** PE 0601103A *I University Research Initiatives*							
COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
Total Program Element	-	84.697	91.241	70.775	-	70.775	71.842	72.491	72.516	72.496	0.000	536.058
AB3: *MURI/PECASE/DURIP*	-	64.697	66.241	70.775	-	70.775	71.842	72.491	72.516	72.496	0.000	491.058
D58: *URI ACTIVITIES (CA)*	-	20.000	25.000	-	-	-	-	-	-	-	0.000	45.000

A. Mission Description and Budget Item Justification

This Program Element (PE) supports the Multidisciplinary University Research Initiative (MURI), the Defense University Research Instrumentation Program (DURIP), and the Presidential Early Career Awards for Scientists and Engineers (PECASE) program. The MURI program funds university based basic research in a wide range of scientific and engineering disciplines pertinent to maintaining land combat technology superiority. Army MURI efforts involve teams of researchers investigating high-priority, transformational topics that intersect more than one traditional technical discipline (e.g., Intelligent Luminescence for Communication, Display, and Identification). For many complex problems, this multidisciplinary approach serves to accelerate research progress and expedite transition of results to application. The DURIP provides funds to acquire major research equipment to augment current, or devise new, research capabilities in support of Army transformational research. The PECASE program funds single-investigator research efforts performed by outstanding academic scientists and engineers early in their independent research careers.

Work in this PE 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.

B. Program Change Summary ($ in Millions)

	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	84.697	66.981	0.000	-	0.000
Current President's Budget	84.697	91.241	70.775	-	70.775
Total Adjustments	0.000	24.260	70.775	-	70.775
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	25.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	70.775	-	70.775
• FFRDC Transfer	-	-0.740	-	-	-

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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103A *I University Research Initiatives*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2021**	**FY 2022**
Project: D58: *URI ACTIVITIES (CA)*		
Congressional Add: *Program increase*	20.000	-
Congressional Add: *Defense University Research Instrumentation Program*	-	25.000
Congressional Add Subtotals for Project: D58	20.000	25.000
Congressional Add Totals for all Projects	20.000	25.000

Change Summary Explanation

Fiscal Year 2023 (FY23) funding increase reflects the fact that the FY22 President's Budget request did not include out-year funding.

| Exhibit R-2A, RDT&E Project Justification: PB 2023 Army | | | | | | | | | | Date: April 2022 | |

Appropriation/Budget Activity 2040 / 1				R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*						Project (Number/Name) AB3 / *MURI/PECASE/DURIP*	
COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
AB3: *MURI/PECASE/DURIP*	-	64.697	66.241	70.775	-	70.775	71.842	72.491	72.516	72.496	0.000	491.058

A. Mission Description and Budget Item Justification

This Project supports the Multidisciplinary University Research Initiative (MURI), the Defense University Research Instrumentation Program (DURIP), and the Presidential Early Career Awards for Scientists and Engineers (PECASE) program. The MURI program funds university based basic research in a wide range of scientific and engineering disciplines pertinent to maintaining land combat technology superiority. Army MURI efforts involve teams of researchers investigating high-priority, transformational topics that intersect more than one traditional technical discipline. For many complex problems, this multidisciplinary approach serves to accelerate research progress and expedite transition of results to application. The DURIP provides funds to acquire major research equipment to augment current, or devise new, research capabilities in support of Army transformational research. The PECASE program funds single-investigator research efforts performed by outstanding academic scientists and engineers early in their research careers. Work in this Project provides a foundation for applied research initiatives at the Army laboratories and centers.

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 2021	FY 2022	FY 2023
Title: Multidisciplinary University Research Initiative	52.117	51.762	57.506
Description: The Multidisciplinary University Research Initiative (MURI) program is a tri-service Department of Defense (DoD) program that supports extra-mural teams whose basic research efforts intersect more than one traditional science and engineering discipline. A multidisciplinary team effort, usually from several collaborating universities, can accelerate research progress in areas particularly suited to this approach by cross- fertilization of ideas, hasten the transition of basic research findings to practical applications, and help to train students in science, technology and/or engineering in areas of importance to DoD. MURI programs are typically five years in length at a cost of $1.25 million each per year. *FY 2022 Plans:* Will provide support for MURI awards made in prior years and assess and initiate six to eight Fiscal Year 2022 (FY22) MURI new starts to enable advances in select interdisciplinary basic science and/or engineering research areas determined to be of critical importance to national defense. *FY 2023 Plans:* Will provide support for MURI awards made in prior years and initiate six to eight FY23 MURI new starts to enable advances in select interdisciplinary basic science and/or engineering research areas determined to be of critical importance to national defense *FY 2022 to FY 2023 Increase/Decrease Statement:*			

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Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022	
Appropriation/Budget Activity 2040 **/** 1	**R-1 Program Element (Number/Name)** PE 0601103A **/** *University Research Initiatives*	**Project (Number/Name)** AB3 **/** *MURI/PECASE/DURIP*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding change reflects planned lifecycle of this effort.			
Title: Presidential Early Career Awards for Scientists and Engineers	4.686	4.510	4.986
Description: Supports Presidential Early Career Awards for Scientists and Engineers (PECASE) investigators started in prior years as well as new award recipients. *FY 2022 Plans:* Will support prior year awardees and assess and recommend four new PECASE candidates. *FY 2023 Plans:* Will support prior year awardees and assess and recommend four new PECASE candidates in FY23. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Defense University Research Instrumentation Program	7.894	7.525	8.283
Description: Supports basic research through competitive grants for research instrumentation. *FY 2022 Plans:* Will assess and award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research and enhance educational capabilities critical to Army transformation and modernization. *FY 2023 Plans:* Will assess and award competitive grants for research instrumentation to enhance universities' capabilities to conduct world-class research and enhance educational capabilities critical to Army transformation and modernization. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: FY2022 SBIR/STTR Transfer	-	2.444	-
Description: Funding transferred in accordance with Title 15 USC ?638 *FY 2022 Plans:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 to FY 2023 Increase/Decrease Statement:*			

Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601103A *I University Research Initiatives*	**Project (Number/Name)** AB3 *I MURI/PECASE/DURIP*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding transferred in accordance with Title 15 USC ?638			
Accomplishments/Planned Programs Subtotals	64.697	66.241	70.775

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army											**Date:** April 2022	
Appropriation/Budget Activity 2040 / 1					**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*				**Project (Number/Name)** D58 / *URI ACTIVITIES (CA)*			
COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
D58: *URI ACTIVITIES (CA)*	-	20.000	25.000	-	-	-	-	-	-	-	0.000	45.000

Note

Congressional Interest Item.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for University Research Initiatives.

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 2021**	**FY 2022**
Congressional Add: Program increase	20.000	-
FY 2021 Accomplishments: Congressional Increase. Basic research to support University Research Initiatives.		
Congressional Add: Defense University Research Instrumentation Program	-	25.000
FY 2022 Plans: Congressional Interest Item funding provided for Defense University Research Instrumentation Program		
Congressional Adds Subtotals	20.000	25.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Army											**Date:** April 2022	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*						**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*						
COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
Total Program Element	-	118.716	126.267	100.909	-	100.909	103.414	101.736	107.292	122.411	0.000	780.745
AB4: *Army Research Centers*	-	22.425	22.686	24.586	-	24.586	25.331	25.504	25.928	25.921	0.000	172.381
AB7: *Army Collaborative Research and Tech Alliances*	-	45.147	52.364	57.673	-	57.673	58.132	55.787	60.911	76.043	0.000	406.057
AB8: *Army Educational Outreach Program*	-	10.275	10.641	11.244	-	11.244	12.430	12.659	12.664	12.661	0.000	82.574
AC6: *International Science and Technology*	-	6.869	6.951	7.406	-	7.406	7.521	7.786	7.789	7.786	0.000	52.108
CI9: *Strategic University Basic Research Alliance*	-	-	0.375	-	-	-	-	-	-	-	0.000	0.375
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	34.000	33.250	-	-	-	-	-	-	-	0.000	67.250

A. Mission Description and Budget Item Justification

This Program Element (PE) fosters university and industry based research to provide a scientific foundation for enabling technologies for future force capabilities. Broadly, the work in this PE falls into the categories of Collaborative Technology Alliances / Collaborative Research Alliances (CTAs/CRAs), University Centers of Excellence (COE), University Affiliated Research Centers (UARCs), Army-sponsored educational outreach, and Army investments at international academic and industrial partners. The Army formed CTAs to leverage large investments by the commercial sector in basic research areas that are of great interest to the Army. CTAs are industry-led partnerships between industry, academia, and the Army Futures Command to incorporate the practicality of industry, the expansion of the boundaries of knowledge from universities, and Army scientists to shape, mature, and transition technology relevant to the Army mission. CRAs are academia-led partnerships, which leverage the cutting-edge innovation found in the academic environment. The COEs focus on expanding the frontiers of knowledge in research areas where the Army has enduring needs, and couples state-of-the-art research programs at academic institutions with broad-based graduate education programs to increase the supply of scientists and engineers in automotive and rotary wing technology. Also included are Army Educational Outreach Program (AEOP) and activities to stimulate interest in science, math, and technology among middle and high school students. This PE includes support for basic research at three Army UARCs, which have been created to exploit opportunities to advance new capabilities through a sustained long- term multidisciplinary effort. The Institute for Soldier Nanotechnologies focuses on Soldier protection by emphasizing revolutionary materials research for advanced Soldier protection and survivability. The Institute for Collaborative Biotechnologies focuses on enabling network centric-technologies, and broadening the Army's use of biotechnology for the development of bio-inspired materials, sensors, and information processing. The Institute for Creative Technologies is a partnership with academia and the entertainment and gaming industries to leverage innovative research and concepts for training and simulation. Examples of specific research of mutual interest to the entertainment industry and the Army are technologies for realistic immersion in synthetic environments, networked simulation, standards for interoperability, and tools for creating simulated environments. This PE also includes the Historically Black Colleges and Universities and Minority Institution (HBCU/MI) Centers of Excellence that address critical research areas for Army Transformation.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2023 Army	**Date:** April 2022
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*

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 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**
Previous President's Budget	118.716	94.003	0.000	-	0.000
Current President's Budget	118.716	126.267	100.909	-	100.909
Total Adjustments	0.000	32.264	100.909	-	100.909
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	33.250			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	100.909	-	100.909
• FFRDC Transfer	-	-0.986	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2021**	**FY 2022**
Project: J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*		
Congressional Add: *Congressional Program increase - Materials in Extreme Dynamic Environments*	10.000	5.000
Congressional Add: *Program increase - biotechnology development*	4.000	4.000
Congressional Add: *Program increase - Army artificial intelligence innovation*	20.000	20.000
Congressional Add: *Soldier Protection Materials*	-	1.000
Congressional Add: *Hypervelocity Testing*	-	3.000
Congressional Add: *The Discovery Center at Waters Edge*	-	0.250
Congressional Add Subtotals for Project: J13	34.000	33.250
Congressional Add Totals for all Projects	34.000	33.250

Change Summary Explanation

Fiscal Year 2023 (FY23) funding increase reflects the fact that the FY22 President's Budget request did not include out-year funding.

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Appropriation/Budget Activity 2040 *I* 1				R-1 Program Element (Number/Name) PE 0601104A *I University and Industry Research Centers*						Project (Number/Name) AB4 *I Army Research Centers*	

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AB4: *Army Research Centers*	-	22.425	22.686	24.586	-	24.586	25.331	25.504	25.928	25.921	0.000	172.381

A. Mission Description and Budget Item Justification

This Project encompasses three types of Centers. The first is the Partnered Research Initiative (PRI) which supports Army's research partnerships with Historically Black Colleges and Universities and Minority Institutions (HBCU/MI). The PRI Program was established as the next phase of what was previously known as Partnership in Research Transition (PIRT) Program that ended in Fiscal Year 2016 (FY16). The focus of the PRI Program is to advance innovative basic research leading to potential technology development in areas of strategic importance to the Army by bringing competitively selected HBCUs and Minority-Serving Institutions (MIs) research teams into existing Army Futures Command Collaborative Research Alliances (CRAs) and Collaborative Technology Alliances (CTAs). The CTAs and CRAs are large collaborative centers focused on developing and transitioning research in Army critical areas.

The second is the University Affiliated Research Centers (UARCs). Army UARCs have been created to exploit opportunities to advance new capabilities through a sustained long-term multidisciplinary effort. The Institute for Soldier Nanotechnologies focuses on Soldier protection by emphasizing revolutionary materials research for advanced Soldier protection and survivability. The Institute for Collaborative Biotechnologies focuses on enabling network centric-technologies, and broadening the Army's use of biotechnology for the development of bio-inspired materials, sensors, and information processing. The Institute for Creative Technologies is a partnership with academia and the entertainment and gaming industries to leverage innovative research and concepts for training and simulation. Examples of specific research of mutual interest to the entertainment industry and the Army are technologies for realistic immersion in synthetic environments, networked simulation, standards for interoperability, and tools for creating simulated environments.

The third is the Army Centers of Excellence (COEs). The COEs focus on expanding the frontiers of knowledge in research areas where the Army has enduring needs, and couples state-of-the-art research programs at academic institutions with broad-based graduate education programs to increase the supply of scientists and engineers in automotive and rotary wing 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 2021	FY 2022	FY 2023
Title: Centers of Excellence for Battlefield Capability Enhancements (BCE)	1.669	1.586	1.774
Description: The focus of the HBCU/MI Research Centers of Excellence Program is to advance innovative basic research leading to potential technology development in areas of strategic importance to the Army by competitively selecting HBCU and MI research teams for grants or cooperative agreements. Awards have five-year periods of performance, with one each awarded in the areas of information, engineering, and physical science in order to support Army goals and broaden the performer base and diversify the research ecosystem. **FY 2022 Plans:**			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Army			Date: April 2022
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*		Project (Number/Name) AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Will support three competitively-selected HBCU/MI-led collaborative research centers in the areas of information, engineering, and physical sciences that were competitively-selected and awarded in FY21. *FY 2023 Plans:* Will advance digital forensic investigative capabilities and improve operational decision-making capabilities, while advancing education and training of minority and underrepresented students in research targeted towards Army modernization needs; focus on developing new models and tools to understand and extract high-value, actionable information from digital data and devices across operational theaters. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Institute for Collaborative Biotechnologies *Description:* This effort performs sustained multidisciplinary discovery-based research that combines state-of-the-art methods in synthetic biology with novel techniques for biologically-enabled material synthesis and characterization. This fundamental research program provides a firm foundation of biotechnological knowledge that serves as a robust platform for design and development of biologically-enabled materials and technologies for Army-relevant applications and priorities. *FY 2022 Plans:* Will develop innovative platforms by using the tools of synthetic and systems biology, genetic circuitry, biocatalytic enzymes, and directed evolution to design and engineer new types of multi-functional materials with novel properties; design and assess enabled functionalities that include optical signature management, solar-to-electrochemical energy conversion, mechanical and thermal robustness, self-assembly and healing, highly selective chemical reactivity, sense-and-respond properties, and logging of environmental signals and events. These basic research efforts will combine state-of-the-art methods in synthetic and systems biology with advanced materials synthesis and characterization to provide unique biologically-derived material solutions for the Army?s future challenges. *FY 2023 Plans:* Will develop material-by-design platforms using synthetic biology, genetic circuitry, biocatalytic enzymes, and directed evolution to synthesize, characterize, and engineer novel biologically-enabled materials, including biocatalytically-synthesized heterocyclic strained-ring compounds for use as energetic materials, additive manufacturing strategies for synthetic biological materials and composites, synthetic protein complexes that react to environmental inputs, responsive protein-based materials for optical signature management, solar-to-electrochemical energy conversion, or lenses with refractive-index gradients, and engineered	4.565	4.502	5.009

Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** AB4 *I Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
microbial consortia with dynamic properties for modular and programmable biological behaviors, such as event logging or syntheses of reactive materials. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Institute for Creative Technologies *Description:* This effort focuses on basic research of Immersive Environments and spans a number of key areas to include virtual humans, three-dimensional (3D) sound and visual media to achieve more efficient and affordable training, modeling, simulation, and application solutions and tools. Research includes: investigation of techniques and methods to address the rapid development of synthetic environments and the study of perception and cognition to help direct the development of new technologies and techniques that evoke more realistic responses from users; auditory aspects of immersion to provide the sound stimulus for increasing the realism for military training and simulation devices; new computational techniques in graphics for achieving real-time photo-realistic rendering of physical and synthetic environments for training and simulations; innovative methods for automatically generating animations and gestures for virtual humans based on what is being communicated; new technologies for scanning real people and rapidly generating virtual humans which look like these people significantly reducing the time, expense, and effort required to develop virtual humans and virtual environments; methods and techniques for creating autonomous virtual human computer-generated characters that look, communicate, and behave like real people, use verbal and non-verbal communication, exhibit emotions, model their own beliefs, desires, and intentions as well as those of others, and reason using advanced artificial intelligence; and methods and techniques for improving the perception, communication, understanding, and responsiveness of virtual humans when interacting with live humans and explore how people relate to virtual humans. *FY 2022 Plans:* Will explore understanding human behavior to be able to create generators and classifiers at the right level of fidelity in a virtual environment; research Artificial Intelligence-based systems that make it easy to author Army training systems; advance scientific understanding on how technology can assist the performance of individuals within tasks that are assumed to require social and emotional intelligence within a virtual environment; assess whether the effect of the virtual environment itself (e.g., poor vs. affluent neighborhood) on responses during the training or simulation (e.g., training outcomes, stress, impressions of virtual human (VH) characters in the environment, etc.) is significant (i.e., reliable) for simulations with different content (e.g., wayfinding, active shooter simulation, negotiation); build a theoretical and end-to-end framework based on 3D deep learning to enable AI-driven synthesis of dynamic 3D objects from two-dimensional (2D) views. *FY 2023 Plans:*	4.506	4.458	5.029

Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Will explore human behavior in small groups and teams, made up of a mixture of software and human agents, to understand conversational patterns as well as use of non-verbal behavior to disambiguate multiple threads of interaction in groups; continue to develop theoretical and end-to-end framework based on 3D deep learning to enable artificial intelligence (AI)-driven synthesis of dynamic 3D objects from 2D view generalizations will be extended to outdoor settings, where topographical information changes very quickly, to drive synthetic training environments that are not restricted to indoor spaces and dyadic relationships; advance scientific and technical support for simulation, for studying emerging sentiments in societies under biased sources of information; advance Learning sciences, in particular, the role of environment in training as well as feedback to trainee in guiding them towards strategies consistent with military rules and culture. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Institute for Soldier Nanotechnologies *Description:* This effort investigates Nanomaterials and Nanotechnologies for Soldier applications focused on light-weight, multifunctional nanostructured fibers and materials. *FY 2022 Plans:* Will design a novel, durable, shape-stable metamaterial composite for future high-temperature high Mach Number hypersonic applications; design superelastic granular materials to enable novel ductile (as opposed to current brittle) ceramic plates for greatly improved Soldier armor; design low-power on-chip beam-steering capabilities by exploiting a Luneburg lens design in a nanophotonic platform, to enable efficient directed Soldier comms that cannot be adversary-detected; design rapid and effective treatment of incompressible and internal wounds by systemically injectable hemostasis, based on nanoparticles crosslinked through bio-orthogonal click chemistry, designed to hone-in to location of bleeding even if location cannot be identified. *FY 2023 Plans:* Will research key areas including: advanced materials for challenging operational environments (e.g., strong, lightweight protective and structural materials for Soldiers, their devices, and platforms); battlefield care to increase Soldier survivability; and innovative optoelectronic, quantum, high-functionality materials and devices for novel sensing, communications, computing devices and systems, and electric power generation capabilities. The work will be in collaboration with Army strategic partners to address critical capability needs in Soldier protection, battlefield care, and sensing, augmenting situational awareness, and transformational nano-optoelectronic Soldier capabilities. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	5.196	4.662	5.173
Title: Vertical Lift Research Center of Excellence (VLRCOE)	3.190	3.152	3.527

Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022	
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** AB4 *I Army Research Centers*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Description: VLRCOE agreements with Penn State University, University of Maryland, and Georgia Institute of Technology to supplement a robust experimental and analytic basic research program in rotorcraft technologies including: Aeromechanics, Structures, Flight Dynamics and Control, Rotorcraft Design and Concepts, Vibration and Noise Control, Propulsion, Affordability, Safety and Survivability, and Naval Operations. *FY 2022 Plans:* Will kick-off a new, five year program combining graduate education and university research to explore frontier areas relevant to Future Vertical Lift; assess proposals based on a combination of criteria that requires a critical mass of expertise to form an inter-disciplinary research and education center; individual research tasks will be selected predominantly based on their scientific merit and relevance to Army Science and Technology (S&T) goals; conduct multi-disciplinary experimental, computational, and analytical basic research tasks in vertical lift technology disciplines spanning aeromechanics, structures and materials, flight dynamics and control, Vertical Take-Off and Landing (VTOL) concepts and design, vibration and noise control, propulsion, affordability, and safety and survivability. *FY 2023 Plans:* Will execute the second year of the five-year VLRCOE cooperative agreements with Georgia Tech, Penn State University, and University of Maryland. Will focus on fundamental research with long-term relevance to Future Vertical Lift such as aeromechanics of high-speed compound and coaxial configurations, interactional aerodynamics of low drag hubs and pylon flows, stability analysis of advanced VTOL configurations and whirl-flutter for tilt-rotor configurations. Will ensure research is highly collaborative with government subject matter experts (SMEs) closely involved in technical interchanges with academia throughout the program to ensure continued relevance. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Automotive Research Center (ARC) *Description:* The ARC is an United States Army Center of Excellence for Modeling and Simulation of ground vehicles. The Center relies on the collaboration of researchers from multiple universities and disciplines to bridge fundamental technology gaps in five research thrust areas of strategic importance to the Army: mobility, human factors and man-machine integration, lightweight structure and materials, power and energy, and design integration. A major integrative focus of these five areas are autonomy and manned-unmanned teaming. *FY 2022 Plans:* Will enhance modeling and simulation (M&S) capabilities for ground systems with a concerted effort in autonomous vehicle off-road mobility M&S in harsh terrains and contested environments; other major ground system M&S focus areas for enhancements	3.299	3.479	4.074

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
include: Vehicle-Level Sensing, Perception and Acting for autonomous vehicles in different situational and teaming environments; Communication, Trust and Cognition between humans and conventional/autonomous vehicles; Intelligence, Off-Road, Resilience for vehicle structures and large-scale computational methods; Adaptability and Self-Awareness for power systems; Fleet Dynamics, Decision-Making, and System of Systems. Will research usage of operational data-driven techniques to analytics models to improve prediction accuracy and efficiency. *FY 2023 Plans:* Will enhance M&S capabilities for ground systems with a concerted effort in heterogeneous multi-vehicle teams of humans and autonomous vehicles capable of adapting in adversarial environments using advanced materials, structures, and intelligent power systems. Major ground system M&S focus areas for enhancements include: (a) Algorithms for Autonomous Off-road Mobility near vehicle performance limits using planning, perception, and control algorithms scalable to complex off-road environments, tolerant to partial information, uncertainty, and failures, (b) Human-Autonomy Interactions, Collaboration and Control for teams including context-accurate, real-time communication that considers cognitive loads, active information gathering, system anomalies and recovery, and bi-directional transparency of state, (c) Materials and Structures for autonomous vehicles with advanced adaptability, structural perception and multi-functional capabilities, including M&S for Off-road Terramechanics, (d) Intelligent Power Systems with heterogeneous energy sources for management of operational energy and decision-making support, and (e) Dynamic Management, requirements development, and performance evaluations of multiple heterogeneous vehicles in teams to exploit their collective, evolving operational capabilities including System of Systems Integration accounting for design, development, manufacturing, deployment and logistics. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: FY2022 SBIR/STTR Transfer	-	0.847	-
FY 2022 Plans: Funding transferred in accordance with Title 15 USC ?638 *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding transferred in accordance with Title 15 USC ?638			
Accomplishments/Planned Programs Subtotals	22.425	22.686	24.586

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

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D. Acquisition Strategy
 N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AB7: *Army Collaborative Research and Tech Alliances*	-	45.147	52.364	57.673	-	57.673	58.132	55.787	60.911	76.043	0.000	406.057

A. Mission Description and Budget Item Justification

This Project supports the Army Collaborative Research Alliances (CRAs) and Collaborative Technology Alliances (CTAs). CTAs and CRAs are partnerships between Army laboratories and centers, private industry, and academia that focus on the rapid transition of innovative technologies to the Warfighter to enable the Army's Future Force. The collaboration between industry, academia, and the government is a key element of the alliance concept as each member brings with it a distinctly different approach to research. Academia is known for its cutting-edge innovation; the industrial partners are able to leverage existing research results for transition and to deal with technology bottlenecks; the Army Futures Command researchers keep the program oriented toward solving complex Army technology problems. This approach enables an Alliance to bring together world class research and development talent and focus it on Army-specific technology objectives for application to Army needs. The topics covered by CRAs and CTAs include cyber security (funded in PE 0601121A (Cyber Collaborative Research Alliance)), the internet of battlefield things, distributed and collaborative intelligent systems technology, neuroergonomics and neuroscience, advanced materials, exploitation of quantum effects, semiconductor modeling, convergent manufacturing, autonomous maneuver and machine learning and artificial intelligence.

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 2021	FY 2022	FY 2023
Title: Internet of Battlefield Things CTA (IoBT CTA)	5.856	2.789	3.119

Description: The IoBT CTA seeks to gain fundamental understanding of Internet of Things (IoT) phenomena and its performance in tactical environments, ranging from sparse, remote settings to complex, dense urban environments. Research will address intelligent resourcing and influence in complex, constrained, and uncertain networks (demand from massive numbers of dynamically connected devices, limited and unpredictable connectivity, shared civilian networks, computation at or near the device), heterogeneous sensing and actuation devices (efficient, smart devices with self-organizing/preservation/directing capabilities), and variable and unreliable provenance and dynamisms of information and device signals.

FY 2022 Plans:
Will explore foundational theories and methods for quantifying uncertainty in data and predictive or classifying algorithms given highly heterogeneous and pervasive intelligent systems; create approaches that quantitatively improve the overall dependability/stability of complex, smart command and control systems-of-systems; investigate algorithms that capitalize on ubiquitous sensor/actuators and the ability to derive information outside of their intended/advertised use; investigate theories and algorithms that

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
enable agile composite systems to have self-awareness and autonomy to reconfigure/react to adversarial battlefield environment and information dynamics. *FY 2023 Plans:* Will continue to explore foundational theories and methods for quantifying the amount of uncertainty or error in machine learning (ML) algorithms and overall dependability/stability of intelligent systems-of-systems; explore approaches that investigate atypical use of sensing modalities that capitalizes on ubiquitous sensor/actuators and the ability to derive information outside of their intended/advertised use; investigate theories and methods for efficient distributed learning that provides lightweight and/or information-theoretic compression methods and resource provisioning across Command and Control information-networks. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Distributed Analytics and Information Science International Technology Alliance (ITA) *Description:* This research will address the fundamental science underpinning the complex information network issues that are vital to future United States (US) / United Kingdom (UK) coalition military operations and to fully exploit the joint development of emerging technologies necessary to enable coalition operations. These efforts provide enhanced ability to perform adaptive, goal-driven, semantically-aware, distributed analytics for situational understanding in coalition operations. *FY 2022 Plans:* Will investigate theories, models, and techniques for distributed control of policy-enabled dynamic infrastructures, federated policy learning and management, federated learning for coalition analytics, interpretability of neural networks in distributed and contested coalition environments, understanding internal group behavior and dynamics in complex multi-domain environments, and learning and inferencing for uncertainty-aware human-machine situational understanding, in the context of ad-hoc coalition operations at the tactical-edge. *FY 2023 Plans:* Will investigate theories, models, and techniques for distributed resource awareness, resource allocation optimizations, and joint orchestration of network slices and analytics microservices to improve the capacity, resilience, and speed of decision of distributed analytics at the tactical edge. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	4.074	2.610	2.950
Title: Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Material CRA *Description:* Research will focus on two-way multiscale modeling for predicting performance and designing materials; investigating analytical and theoretical analyses to effectively define the interface physics across length scales; advancing	8.363	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
experimental capabilities for verification and validation of multiscale physics; and modeling and strategies for the synthesis of high loading rate tolerant materials. The multiscale modeling capability will be applied across multiple disciplines to facilitate revolutionary advances in materials for coupled environments (electromagnetic, high rate, high pressure, and other extreme environments).			
Title: Distributed Collaborative Intelligent Systems Technology CTA **Description:** Establish the underpinning science to extend the reach, situational awareness, and operational effectiveness of intelligent system and Soldier teams against dynamic threats in complex and contested environments and provide technical and operational superiority through fast, intelligent, resilient, and collaborative behaviors. Research efforts will enable distributed systems to engage in complex, time-varying, and contested environments to accomplish Army missions by leveraging a mix of online adaptation and system-wide resilience. **FY 2022 Plans:** Will conduct fundamental research in heterogeneous multi-agent situational awareness to explore how a heterogeneous team can collaborate to build shared situational awareness while moving through a contested environment and perform collaborative decision making over long timescales with high operational tempo in complex, dynamic environments; explore dynamic teaming operations, heterogeneous team control and strategy, and synthesis and adaptation of team behaviors with high operational tempo; establish resource aware communication required for coordination and collaboration amongst team members and increase distributed resilience in the team response. **FY 2023 Plans:** Will conduct fundamental research to explore how heterogeneous teams of humans and autonomous systems collaborate, share large amounts of information, learn, and adapt in complex and dynamic situations and environments; research how teams of autonomous systems efficiently and effectively communicate, tactically engage, and plan against dynamic adversaries; investigate how multi-agent systems collectively understand and exploit terrain and the environment in planning; explore how individual agents, heterogeneous teams, and sub-teams adaptively task and re-task over long duration missions; explore methods to provide resilient multi-agent behaviors in the presence of adversaries. **FY 2022 to FY 2023 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.	6.059	6.009	6.599
Title: Neurosciences CRA **Description:** This effort performs multidisciplinary basic research in the area of neuroscience through collaboration with the University of California at Santa Barbara.	0.629	0.598	0.680

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
FY 2022 Plans: Will employ state-of-the-art techniques in neuroscience to develop and test neural biomarkers associated with human cognition that track with directed attention, modes of planning and problem solving, memory-guided decision-making, and visual search; characterize the influence of arousal, fatigue, stress, and other demands on cognitive states and their neural biomarkers; assess the potential for biomarkers to inform human-machine interfaces, to accelerate learning, and to enhance integrated human-artificial intelligence system performance. *FY 2023 Plans:* Will conduct fundamental neuroscientific studies aimed at understanding the basic mechanisms that support situational awareness, including cognitive priority control, and how those mechanisms are impacted by changes in physical and cognitive workloads; characterize human neural systems that integrate motor skill learning, route planning, and choice behavior during adaptive planning in complex physical scenarios; uncover the cognitive and neural mechanisms underlying individual decision-making conducted under uncertainty; develop models of visual information processing and neural systems under covert and overt attention. If successful, these basic research studies will support Army efforts to augment Soldier performance, increase situational awareness, lighten cognitive workloads, and integrate humans with autonomous systems employing artificial intelligence. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Center for Exploitation of Quantum Effects *Description:* This work supports needed quantum information science basic research for next generation capabilities in security, decision aids, sensing, and position, navigation, and timing (PNT) for Army dominance on the future battlefield. *FY 2022 Plans:* Will investigate approaches to solid-state sensing of magnetic fields using Nitrogen-Vacancy (NV) diamond and Silicon Carbide (SiC) defects in solids; investigate long-range atom-atom interactions through optical fiber and solid-state emitters near integrated waveguides; investigate topological light sources for low-loss routing of entangled photon pairs; explore distributed sensing using ion traps; explore methods for using telecom-compatible energy levels in ytterbium (Yb) ions for long-range entanglement distribution. *FY 2022 to FY 2023 Increase/Decrease Statement:*	2.888	2.793	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
In FY23, funding administratively realigned within this Project to support the creation of the ?Fundamentals for Quantum Technologies? task.			
Title: Identification and characterization of team-level processes for enhancing performance of heterogeneous Soldier-Agent teams CRA *Description:* By developing and validating theoretical principles of human-agent team states and processes, this effort defines methods for exploiting individual dynamics and variability to improve team-level properties and performance. *FY 2022 Plans:* Will characterize and model critical individual processes and dynamics in relation to team-level emergence in military-relevant team tasks involving multiple humans and multiple intelligent agents; extend and validate human-based theories of team effectiveness incorporating micro, meso, and macro signatures of emergence to human-agent teams; explore team emergent responses to perturbations; incorporate agent-based learning from humans to improve dynamic teaming. *FY 2023 Plans:* Will create and validate algorithms to measure how rank and competency status of humans and agents predict emergent multiple human multiple agent team states; measure how stress and the reconfiguration of teammates in a hierarchy impacts predictions of successful team performance; determine the physiological and telemetric processes that predict desirable versus undesirable team states and how changes in the world perturb these processes; measure the emergence of team level trust based on team composition, and develop practices to build teams with strong trust characteristics; create real-time, individualized, and adaptive intervention to improve performance of teams composed of multiple humans and multiple agents in a complex task. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	4.758	4.707	5.253
Title: Army Artificial Intelligence Innovation Institute (A2I2) *Description:* This effort coordinates, conducts, and accelerates basic research to address Army-specific challenges, with a focus on advancing artificial intelligence (AI) and machine learning (ML) capabilities for autonomous maneuver in multi-domain operations (MDO). A broad-spectrum of AI capabilities are critical to the integration of operations in the contested environment including human-agent teaming for faster and more informed decisions, multi-domain Command, Control, Communications, and Computers (C4) that is resilient to Cyber Electromagnetic Activities (CEMA), and AI enabled cyber security that is robust to enemy deception. The Army Futures Command (AFC) will leverage existing High Performance Computing (HPC) and network infrastructure, along with regional laboratory extensions to enable basic research on AI that is open, with top-tier universities, commercial businesses, and established Department of Defense industrial partners. The A2I2 creates an accessible database of heterogeneous data, a repository of AI and ML algorithms and software tools, and military-relevant challenge problems.	7.202	7.195	7.667

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
FY 2022 Plans: Will assess current research and combine, re-direct, or initiate efforts to meet progressively harder challenge problems through experimentation and physics based criteria; transition most promising results and models to Army specific applications enabling rapid improvement of ML techniques; increase database accessibility and tools to provide an array of software and processing capabilities to academic, industry, and other Department of Defense partners; provide access to curated, labeled dataset covering a large variety of applications to meet Army requirements. *FY 2023 Plans:* Will develop methods for increased situation awareness between agents in multi-agent scenarios; enhance learning algorithms to increase the functionality of robots powered by artificial intelligence; create robust and safe planning methods for autonomous mobile robots; increase the use of domain-knowledge use in artificial intelligence; establish human-accessible and understandable machine plan of action; design secure algorithms that can provide probabilistic guarantees on security and latency. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Artificial Intelligence Hub *Description:* The AI Hub is located at Carnegie Mellon University as a consortium of industry, government, and academia focused on building and optimizing the Army's AI and ML initiatives with the goal of accelerating the fielding of capability. The AI Hub will utilize the A2I2 data and AI/ML algorithms and software tools to investigate AI and ML capabilities to address the Army's unique problems. The AI Hub will focus on research into AI technologies for future application to Army-relevant areas such as predictive maintenance, operations for intelligence in support of Long Range Precision Fires, human relations/talent management; and autonomous threat recognition.	5.318	-	-
Title: Army Radio-Frequency (RF) Electronics Center *Description:* The Army RF Electronics Center will develop ultra-wide bandgap (UWBG) materials and device concepts designed to enable next generation RF semiconductor technology for the Army. This research will enable advanced, robust, high-power RF electronics for radars, comms, directed energy, and electronic warfare (EW). The resulting robust high power operation will provide longer ranges for sensing and effect-on-target under adverse conditions and improved sized, weight, and power (SWaP) will give small systems (Unmanned Aerial Vehicles, countermeasures, etc.) new capabilities. *FY 2022 Plans:* Will implement a combination of approaches designed to create a basic research paradigm in UWBG semiconductor materials using data-driven physics informed computer science approaches; undertake research that will understand materials/device	-	4.670	5.110

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
physics and performance limits under extreme conditions; create innovative device concepts and circuit architectures to realize or overcome these limits. *FY 2023 Plans:* Will synthesize high Aluminum composition devices through theory and modeling, device engineering, and characterization techniques that if successful, will enable devices with performance far exceeding current state-of-the-art wide-bandgap devices in terms of large signal gain, output power density, and power added efficiency at operating frequencies greater than 90 GigaHertz (GHz); create a new paradigm for heat transfer from UWBG materials, surfaces, and interfaces through ballistic thermal injection (BTI) that if successful, will enhance thermal transport across and near UWBG interfaces and mitigate thermal degradation of device performance. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Army Advanced Biological Control Center *Description:* The Army Advanced Biological Control Center will develop a fundamental knowledge base for precise, reliable control of engineered biological systems for functional effect during military operations. By exploiting fundamental relationships governing the functions and properties of biological systems, the Center will develop advanced control schemes using synthetic biology targeting two key areas: 1) Genetic Control of Material Properties and 2) Biological Control in Competitive Environments. *FY 2022 Plans:* Will initiate concepts for a comprehensive information pipeline for the creation of new algorithms and scalable computational models that extract the critical genetic parameters driving material properties; develop robust predictive models to inform genetic manipulation using synthetic biology for precision material synthesis with targeted properties across scales; design and assess experimental approaches to measure interactions of engineered microorganisms with the biological, chemical, and physical parameters of the microenvironment and bulk environment compared to naturally occurring microorganisms. *FY 2023 Plans:* Will determine the parameters required for development of robust predictive tools that enable informed design using synthetic biology to produce biological materials with targeted multifunctional properties; initiate experimentation using high-throughput analytical methods for characterization, screening, and selection of engineered variants with targeted multifunctional material properties; devise relevant surrogate laboratory environment(s) for cellular consortia and methods to effectively target specific organisms within a consortium for genetic modification; analyze the fate of engineered deoxyribonucleic acid (DNA) within a consortium, including gene transfer, persistence, and mutation that if successful, will provide key elements of a synthetic biology	-	4.670	5.110

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
research pipeline enabling the rapid and effective exploration and validation of novel material and cellular systems to protect the Soldier.			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Army Advanced Energetics Center	-	4.670	5.110
Description: The Army Advanced Energetics Center will develop a fundamental knowledge base for greater than 5x lethality and range of guns and projectiles through the discovery of disruptive energetic materials and exceeding the strategic objectives of current programs. This research focuses on high through-put synthesis and rapid characterization to accelerate discovery of next, next generation materials to enable Army domination of the future battlefield. *FY 2022 Plans:* Will develop concepts around future energetic materials for tailorable effects which enable increased lethality of warhead fragments and enable new concepts for shape charge weapons; develop energetic materials with higher energy density and enable lighter, smaller, more lethal warheads for smart munitions; design materials for high specific impulse propellants, enable increased range of munition systems, and enable reduced time-of-flight, increased munitions survivability, and end-game maneuverability to avoid threat countermeasures. *FY 2023 Plans:* Will devise pathways to novel energetic materials, both organic and inorganic, and synthesis methods for increased energy density and improved insensitivity; establish methodologies to focus energy through deliberate design of energetic materials microstructure to enable enhanced effects on target; develop enhanced diagnostics methods that allow testing of minute quantities of novel materials to feed back to synthesis efforts and increase development cycle speed to enable faster future novel energetic materials development; create novel modeling frameworks to enable future virtual assessments of energetic materials, munitions, and propellants.			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Tactical Behaviors for Autonomous Maneuver	-	2.315	2.620
Description: This effort focuses on development of the algorithmic underpinnings of adaptive, resilient, and tactically relevant behaviors for teams of autonomous ground and aerial vehicles, which will enable multi-domain autonomous maneuver. *FY 2022 Plans:*			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Will conduct fundamental research on planning algorithms that can passively learn tactics from observed data in constrained terrains using limited resources, and predict positions of advantage for area reconnaissance based on external observations. *FY 2023 Plans:* Will explore foundation theories and methods for autonomous systems that can maneuver and adapt in a tactically relevant manner with limited Soldier intervention, and adapt to changing conditions and adversarial actions; create algorithms and techniques to passively learn tactics from observed data in constrained terrains using limited resources; investigate techniques to predict positions of advantage for area reconnaissance based on external observations. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Materials Discovery for Extreme Environments *Description:* Research will focus on material discovery for next-generation ballistic materials by using accelerated material-by-design approach to include consideration of nonhomogeneous, anisotropic, and hierarchical material systems. A data-driven material design approach will be developed utilizing high-throughput material processing and characterization, multi-scale modeling, and machine intelligence to produce leap-ahead material solutions. *FY 2022 Plans:* Will conduct research in data-driven and machine intelligence approaches to correlate material structure, property, and requirements for multiple harsh military environments such as launch and flight, high-temperature and high ablation, and impacts at unprecedented velocity; enable rapid screening of high dimensional material datasets; establish parameter space and methods for synthesis and high-throughput characterization of material classes suitable for high rate applications to produce large variations in properties. *FY 2023 Plans:* Will continue collaborative research on data-driven and machine intelligence approaches to correlate material structure, property, and requirements for multiple harsh military environments such as launch and flight, high-temperature and high ablation, and impacts at unprecedented velocity; mature rapid screening methods for high dimensional material datasets; continue to mature parameter space and methods for synthesis and high-throughput characterization of material classes suitable for high rate applications to produce large variations in properties; down select most promising seedling efforts for continuation to Army Centers (multi-year, comprehensive anchor programs). *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	-	5.971	6.530
Title: Fundamentals for Quantum Technologies	-	0.483	4.916

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Description: This work supports quantum information science basic research for next generation capabilities in entanglement-enhanced novel sensors and communications for Army dominance on the future battlefield. *FY 2022 Plans:* Will investigate foundational approaches to light-matter interfaces to understand how to efficiently store, retrieve, and distribute quantum information between atoms and ions. *FY 2023 Plans:* Will investigate increased spin coherence in a nanophotonic cavity; explore optimization of charge state ratios in solid-state defect materials for improved sensors; research waveguide-based Faraday rotation for on-chip optical isolation; investigate spin-squeezing protocols for quantum metrology; explore methods for controlling motional states of trapped ion; research arrays of Rydberg atoms for controllable phased array photon emission from atoms. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding administratively realigned from the ?Center for Exploitation of Quantum Effects? task within this Project and from Program Element (PE) 0601104A (University and Industry Research Centers) / Project CI9 (Strategic University Basic Research Alliance) to support the increased focus for this task.			
Title: Convergent Manufacturing for High Performance Material Interfaces *Description:* This research will address novel additive deposition, high fidelity subtractive methods, and high resolution directed energy processes to investigate complex, non-discrete, high performance, multi-material interfaces with improved adhesion, gradual coefficient of thermal expansion changes, and gradual wavespeed changes to enable high performance under extreme ballistic and thermal conditions. *FY 2022 Plans:* Will develop a basic convergent manufacturing platform that is capable of depositing two classes of materials (i.e., polymers, metals, or ceramics) and transform those materials into their desired morphology independently; investigate a complex interface, such as a gradient, composed of two classes of materials using convergent processing. *FY 2023 Plans:* Develop a more complex convergent manufacturing platform to manufacture a material interface with superior properties/performance relative to existing interfaces (e.g., adhesives or fasteners); develop basic capabilities to concurrently manufacture and transform other classes of dissimilar materials. *FY 2022 to FY 2023 Increase/Decrease Statement:*	-	0.955	1.036

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding change reflects planned life cycle of effort.			
Title: Semi-Conductor Modeling Consortium	-	-	0.973
Description: As a result of the Army?s investment in electronic material modeling and simulation, tools are now available to predict semiconductor material and device performance with high fidelity. Through modeling and simulation, the Center for Semiconductor Modeling of Materials and Devices (CSM) assesses performance, guides improvements, and reduces technology risk for niche Department of Defense (DoD) semiconductor applications before large investment is committed. The intent of the CSM is to simulate real materials and devices in real environments, understand the limits of the technology, understand the parameters that control the performance, eliminate variances to the maximum extent possible, and arrive at a materials and device design which will reproducibly yield the required performance. Doing so at an early stage of innovation will undoubtedly lead to acceleration toward the next disruptive innovation. This acceleration is becoming increasingly important because the environment is changing rapidly and to stay ahead we must innovate faster. *FY 2023 Plans:* Will investigate the physics of blinking pixels and noise that limit the ultimate performance of imagers; support the development of transformational electro-optical devices that use emerging semiconductors; enhance initiatives in new applied materials such as topological insulator; investigate photonic devices for infrared imaging; explore advanced wide band gap devices that address the unique DoD applications challenges in RF and power management. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding realigned from Program Element (PE) 0601104A (University and Industry Research Centers) / Project CI9 (Strategic University Basic Research Alliance) to support the creation of this task in FY23.			
Title: FY2022 SBIR/STTR Transfer	-	1.929	-
Description: Funding transferred in accordance with Title 15 USC ?638 *FY 2022 Plans:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding transferred in accordance with Title 15 USC ?638			
Accomplishments/Planned Programs Subtotals	45.147	52.364	57.673

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** AB7 *I Army Collaborative Research and Tech Alliances*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

 N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										**Date:** April 2022	
Appropriation/Budget Activity 2040 *I* 1				**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*					**Project (Number/Name)** AB8 *I Army Educational Outreach Program*		

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AB8: *Army Educational Outreach Program*	-	10.275	10.641	11.244	-	11.244	12.430	12.659	12.664	12.661	0.000	82.574

A. Mission Description and Budget Item Justification

This Project supports science, technology, engineering, and mathematics (STEM) activities that encourage elementary/middle/high school and undergraduate youths to develop an interest in and pursue education in the STEM fields to support the Army, and the nation's growing dependence on STEM skills. These activities are coordinated within the Army Educational Outreach Program (AEOP) that links and networks appropriate components to derive the best synergies to present the Army to a larger pool of technical talent and to provide students with Army-unique practical experiences at Army laboratories, centers, and institutes and expose them to Department of Defense (DoD) careers. AEOP increases interest and involvement of students and teachers across the nation in STEM at all proficiency levels and backgrounds to include underserved and economically disadvantaged groups, and military affiliated communities, through exposure to Army sponsored research, education, competitions, internships, and practical experiences. This Project utilizes Army STEM assets to contribute to a STEM literate citizenry as well as enhances the national pool of science and engineering personnel that in turn supports defense industry and Army laboratory and research, development, and engineering center needs.

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 2021	FY 2022	FY 2023
Title: AEOP Coop Agreement	9.975	10.252	11.244

Description: The Army Educational Outreach Program Cooperative Agreement encompasses a cohesive and coordinated portfolio of STEM education experiences to develop, enhance, and reward students in pursuit of STEM education. This activity supports a strong partnership with government, academia and industry to leverage assets and provide a broader and deeper STEM experience for students and teachers to address the Department's, and the nation's, challenge of acquiring clearable STEM literate talent in positions throughout the workforce and in the industrial base. These activities include Army-sponsored research, education, competitions, apprenticeships, internships, and practical experiences designed to engage and guide students and teachers in Army sponsored STEM programs. AEOP has targeted efforts to reach and engage underserved and military affiliated communities in STEM initiatives to build the pool of diverse STEM competitive talent. The West Point Cadet Research Program provides West Point Cadets an opportunity to work on Army research projects alongside Army and industry scientists and engineers during the summer.

FY 2022 Plans:
Will continue Army sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive reviews and educational

Exhibit R-2A, RDT&E Project Justification: PB 2023 Army			Date: April 2022
Appropriation/Budget Activity 2040 I 1	R-1 Program Element (Number/Name) PE 0601104A I *University and Industry Re search Centers*	Project (Number/Name) AB8 I *Army Educational Outreach Program*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
assessments to support future decisions and best practices. Continue career development opportunities that support agile human capital needs within laboratories with a concentration on continued STEM education development. Will increase partnerships with like-minded organizations in an effort to increase participation from underserved students and military affiliated communities. Will conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and engineering centers ***FY 2023 Plans:*** Will continue Army sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive reviews and educational assessments to support future decisions and best practices. Will continue career development opportunities that support agile human capital needs within laboratories with a concentration on continued STEM education development. Will increase partnerships with like-minded organizations in an effort to increase participation from underserved students and military affiliated communities. Will conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and engineering centers. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: West Point Cadet Program ***Description:*** The West Point Cadet Research Program provides West Point Cadets an opportunity to work on Army research projects alongside Army and industry scientists and engineers during the summer.	0.300	-	-
Title: FY2022 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2022 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.389	-
Accomplishments/Planned Programs Subtotals	10.275	10.641	11.244

C. Other Program Funding Summary ($ in Millions)
 N/A

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Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** AB8 *I Army Educational Outreach Program*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

  N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										**Date:** April 2022	
Appropriation/Budget Activity 2040 *I* 1				**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*					**Project (Number/Name)** AC6 *I International Science and Technology*		

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
AC6: *International Science and Technology*	-	6.869	6.951	7.406	-	7.406	7.521	7.786	7.789	7.786	0.000	52.108

A. Mission Description and Budget Item Justification

This Project funds: 1) the Combat Capabilities Development Command's (DEVCOM) International Basic Research Mission, 2) the DEVCOM International Technology Centers (ITCs), and 3) the Foreign Technology (and Science) Assessment Support (FTAS) program. The International Basic Research Mission seeks to discover highly promising basic research from the universities of our foreign partners and awards seed funding to discoveries that support the United States Army's Science and Technology (S&T) strategy. The ten ITCs located in North America, South America, Asia, and Europe support the Army's goals of providing the best technology in the world to our Warfighters by leveraging the international S&T investments of our international partners, thereby increasing our ability to use limited S&T funds on promising research opportunities. The DEVCOM ITCs and DEVCOM's Army Research Laboratory / Army Research Office (ARL / ARO) will identify and assess international technology programs, 'technology finds', to assess their potential impact on the Army's S&T investment strategy and modernization priorities. These 'technology finds' are submitted to various Army S&T organizations for assessment and consideration for further research and development. Highly promising research will be awarded seed funding by ARO and/or the ITC through a grant, contract, or cooperative agreement. The FTAS program also builds upon the 'technology finds' submitted by ARO and the ITCs. In some cases the find is truly unique and may well meet an Army requirement or potentially support ongoing Army S&T investments or modernization priorities. In such cases, the FTAS program can provide initial resources (seed money) to determine the appropriateness of these technology areas identified as having potential relevance to the Army. These efforts will provide information useful in making early assessments of the technology's potential contributions to the Army's S&T strategy and modernization priorities.

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 2021	FY 2022	FY 2023
Title: International Technology Centers	4.469	4.397	1.716
Description: The ten ITCs located in North America, South America, Asia, and Europe support the Army's goals of providing the best technology in the world to our Warfighters by leveraging the research investments in Science and Technology (S&T) of our international partners. The ITCs perform identification and assessment of international technology programs to assess their potential impact on the Army's S&T investment strategy and modernization priorities. ITC 'technology finds' are submitted to various Army S&T organizations for assessment and consideration for further research and development through avenues such as the Foreign Technology (and Science) Assessment Support (FTAS) Program. Highly promising research is awarded seed funding by the ITC through a grant, contract, or cooperative agreement - typically to a foreign researcher. *FY 2022 Plans:* Will continue to continue to seek out promising foreign S&T basic research within geographic areas of responsibility that may have interest and applicability to the United States Army?s research and development efforts in support of the Army?s Modernization			

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Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 **I** 1	**R-1 Program Element (Number/Name)** PE 0601104A **I** *University and Industry Research Centers*	**Project (Number/Name)** AC6 **I** *International Science and Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Priorities;. In accordance with the Army S&T Strategy and the Combat Capabilities Development Command (CCDC) Global Engagement Plan (GEP), continue to seek -out and connect foreign researchers with United States Army scientists and engineers, with the explicit intent to fund promising and relevant research through a contract or cooperative agreement; continue to enhance and refine technology search capabilities using customer feedback to focus on mid- and long-term capabilities. *FY 2023 Plans:* Will scout for foreign S&T within geographic areas of responsibility on behalf of AFC and the United States Army DEVCOM Lab and Centers to identify early emerging technologies of interest to the United States Army's research and development efforts in support of the Army's Modernization Priorities. In accordance with the Army S&T Strategy and the DEVCOM GEP; seek and connect foreign technology developers with United States Army science and technology enterprise. The ITCs will support funding of promising and relevant research through grants, contracts, cooperative agreements, or other existing funding mechanisms (e.g., Coalition Warfare Program, Foreign Technology and Science Assessment Support, Foreign Comparative Testing, etc.); will continue to enhance and refine technology search capabilities using customer feedback to focus on mid- and long-term capabilities for the Army enterprise. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding decrease to administratively separate the "International Basic Research" task mission from the "International Technology Center" task mission, both in this same Project.			
Title: Foreign Technology (& Science) Assessment Support *Description:* The FTAS program serves as a catalyst for the Army Futures Command to assess potentially game-changing technologies discovered in friendly foreign nations by the Army International ITCs which may meet future Army needs. The technology finds can often times be truly unique and may well meet an Army requirement or potentially support ongoing Army S&T investments. These efforts will provide information useful in making early assessments of a technology's potential contributions to the Army's S&T strategy. *FY 2022 Plans:* Will solicit proposals and assess scientific quality of candidate projects by utilizing United States Army scientific expertise; continue to provide funding for approved proposals to United States Army S&T centers and laboratories to develop and/or assess technology areas identified by the ITCs and S&T community and ARO personnel. *FY 2023 Plans:* Will continue to solicit proposals, assess scientific quality/alignment to Army priorities of candidate proposals, and fund highly relevant and rigorous projects for potential contribution to the Army?s S&T programs. Funds will be used to support research grants, innovation challenges, procurement of foreign technology, partnering with international allies and partners to include non-traditional entities, and enabling efforts for international research and technology collaboration with the Army Modernization	2.400	2.348	2.591

Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 I 1	**R-1 Program Element (Number/Name)** PE 0601104A I *University and Industry Research Centers*	**Project (Number/Name)** AC6 I *International Science and Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Enterprise. Will provide funding for approved proposals to support development and/or assessment of foreign technologies by U.S. Army laboratories and foreign partners in topical areas supporting Army priorities. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: International Basic Research Mission *Description:* ARL/ARO will execute the international basic research mission in support of the ITCs. ARO will create and exploit new international scientific discoveries and technology breakthroughs with foreign universities to improve the Army?s transformational capabilities. Highly promising fundamental research finds will be awarded seed funding through a grant, contract, or cooperative agreement. 'Technology finds' are submitted to various Army S&T organizations for assessment and consideration for further research and development. *FY 2023 Plans:* Will continue to seek promising foreign S&T basic research within geographic areas of responsibility that may have interest and applicability to the United States Army's research and development efforts in support of the Army's Modernization Priorities. In accordance with the Army S&T Strategy and the Army international basic research strategy within the DEVCOM GEP, continue to seek and connect foreign researchers with United States Army scientists and engineers, with the explicit intent to fund promising and relevant research through grants; continue to enhance and refine technology search capabilities using customer feedback to focus on long-term capabilities. *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding increase to administratively separate the "International Basic Research" task mission from the "International Technology Center" task mission, both in this same Project.	-	-	3.099
Title: FY2022 SBIR/STTR Transfer *Description:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 Plans:* Funding transferred in accordance with Title 15 USC ?638 *FY 2022 to FY 2023 Increase/Decrease Statement:* Funding transferred in accordance with Title 15 USC ?638	-	0.206	-
Accomplishments/Planned Programs Subtotals	6.869	6.951	7.406

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Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** AC6 *I International Science and Technology*

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022	
Appropriation/Budget Activity 2040 / 1				R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*						Project (Number/Name) CI9 / *Strategic University Basic Research Alliance*	

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CI9: *Strategic University Basic Research Alliance*	-	-	0.375	-	-	-	-	-	-	-	0.000	0.375

Note

In Fiscal Year 2023 (FY23), this Project is Terminated and all funding is realigned to Project AB7 (Army Collaborative Research and Tech Alliances) within the same Program Element.

A. Mission Description and Budget Item Justification

The Strategic University Basic Research Alliance, coordinated by the Army Future Command's University Technology Development Division (UTDD), enables enduring strategic academic partnerships focused on providing academia a gateway to identify, propose, and pursue basic research efforts that may lead to unique solutions for Warfighter problems. This Project supports basic research originating in academia in areas with the potential to impact future Army modernization including, but not limited to, autonomy, artificial intelligence and machine learning (AI/ML), robotics, network integration, decisive lethality, soldier performance, resulting in high-value, shared-risk partnerships for the enterprise to influence, leverage, and accelerate Army priorities. The Strategic University Basic Research Alliance exploits state-of-the-art research programs at academic institutions to increase the supply of scientists and engineers to advance and enhance research within Army laboratories. This effort conducts basic research leading to potential emerging technologies in sister Projects of applied research and advanced technology areas of strategic importance pertinent to Army prioritization, by bringing competitively selected Universities into strategic Alliances. This approach enables persistent, competitive partnerships fostering deep awareness, knowledge, and expertise for Warfighter modernization efforts.

This Project is fully coordinated with PE 0602144A (Ground Technology), PE 0602141A (Lethality Technology), PE 0602182A (C3I Applied Research), PE 0602183A (Air Platform Applied Research), and PE 0602184A (Soldier Applied Research).

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: University Basic Research Strategic Partnerships	-	0.361	-
Description: Conducts basic research leading to potential emerging technologies in areas of strategic importance to the Army by bringing competitively selected Universities with research teams into strategic alliances. Investigates novel principles, ideas, and theories potentially leading to novel technologies in collaboration with academic entities that might not otherwise collaborate with the DoD, with the end goal of accelerating the adoption of cutting-edge technology for the warfighter.			
FY 2022 Plans:			

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Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** CI9 *I Strategic University Basic Research Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will conduct fundamental research employing a multidisciplinary research strategy to advance new capabilities in such areas as autonomy, artificial intelligence, machine learning, robotics, all terrain navigation/routing, and novel materials and sensing modalities; discover novel methods for seamless cooperation between intelligent agents and humans; and investigate network resiliency. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** In Fiscal Year 2023, all funding is realigned to project AB7 (Army Collaborative Research and Tech Alliances) within the same program element.			
Title: SBIR/STTR Transfer ***FY 2022 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.014	-
Accomplishments/Planned Programs Subtotals	-	0.375	-

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army											Date: April 2022	
Appropriation/Budget Activity 2040 / 1				**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*					**Project (Number/Name)** J13 / *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*			
COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	34.000	33.250	-	-	-	-	-	-	-	0.000	67.250

Note
 Congressional Increase

A. Mission Description and Budget Item Justification
 Congressional Interest Item funding provided for University and Industry Initiatives.

 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 2021**	**FY 2022**
Congressional Add: Congressional Program increase - Materials in Extreme Dynamic Environments	10.000	5.000
FY 2021 Accomplishments: Congressional increase: Accelerated basic research on materials in extreme dynamic environments.		
FY 2022 Plans: Congressional Interest Item funding provided for Materials in Extreme Dynamic Environments		
Congressional Add: Program increase - biotechnology development	4.000	4.000
FY 2021 Accomplishments: Congressional increase: Accelerated basic research on biotechnology development.		
FY 2022 Plans: Congressional Interest Item funding provided for Biotechnology Advancements		
Congressional Add: Program increase - Army artificial intelligence innovation	20.000	20.000
FY 2021 Accomplishments: Congressional Increase: Basic Research supported Army Artificial Intelligence Innovation.		
FY 2022 Plans: Congressional Interest Item funding provided for Army Artificial Intelligence Innovation		
Congressional Add: Soldier Protection Materials	-	1.000
FY 2022 Plans: Congressional Interest Item funding provided for Soldier Protection Materials		
Congressional Add: Hypervelocity Testing	-	3.000

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Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J13 / *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**
FY 2022 Plans: Congressional Interest Item funding provided for Hypervelocity Testing		
Congressional Add: The Discovery Center at Waters Edge	-	0.250
FY 2022 Plans: Congressional Interest Item funding provided for The Discovery Center at Waters Edge		
Congressional Adds Subtotals	34.000	33.250

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Army											Date: April 2022	

Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*						R-1 Program Element (Number/Name) PE 0601121A *I Cyber Collaborative Research Alliance*						

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
Total Program Element	-	5.077	5.067	5.355	-	5.355	5.435	5.483	5.485	5.484	0.000	37.386
CB5: *Cyber Collaborative Research Alliance*	-	5.077	5.067	5.355	-	5.355	5.435	5.483	5.485	5.484	0.000	37.386

A. Mission Description and Budget Item Justification

This Program Element (PE) fosters research performed through the Cyber Security Collaborative Research Alliance (CSEC CRA), a competitively selected consortium, formed to advance the theoretical foundations of cyber science in the context of Army networks. This CRA consists of academia, industry and government researchers working jointly with the objective of developing a fundamental understanding of cyber phenomena so that fundamental laws, theories, and theoretically grounded and empirically validated models can be applied to a broad range of Army domains, applications, and environments. This research focuses on three interrelated aspects of cyber security and is conducted using a trans-disciplinary approach that takes into account the human element of the network. The three aspects of cyber that are addressed are: 1) vulnerabilities and risks of cyber networks to malicious activities, 2) anticipating, detecting, and analyzing malicious activities, and 3) agile cyber maneuver to thwart and defeat malicious activities. Overarching goals of cyber security are to significantly decrease the adversary's return on investment when considering cyber attack on Army networks, and minimizing the impact on (Army) network performance related to implementing cyber security. The CRA research creates a framework that effectively integrates the knowledge of cyber assets and potential adversary capabilities and approaches, and provides defense mechanisms that dynamically adjust to changes related to mission, assets, vulnerability state, and defense mechanisms.

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 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	5.077	5.067	0.000	-	0.000
Current President's Budget	5.077	5.067	5.355	-	5.355
Total Adjustments	0.000	0.000	5.355	-	5.355
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	5.355	-	5.355

Change Summary Explanation

Fiscal Year 2023 (FY23) funding increase reflects the fact that the FY22 President's Budget request did not include out-year funding.

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022	

| Appropriation/Budget Activity
2040 / 1 | | | | R-1 Program Element (Number/Name)
PE 0601121A / Cyber Collaborative Research Alliance | | | | Project (Number/Name)
CB5 / Cyber Collaborative Research Alliance | | | |

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CB5: *Cyber Collaborative Research Alliance*	-	5.077	5.067	5.355	-	5.355	5.435	5.483	5.485	5.484	0.000	37.386

A. Mission Description and Budget Item Justification

This Project fosters research performed through the Cyber Security Collaborative Research Alliance (CSEC CRA), a competitively selected consortium, formed to advance the theoretical foundations of cyber science in the context of Army networks. This CRA consists of academia, industry, and government researchers working jointly to develop a fundamental understanding of cyber phenomena so that fundamental laws, theories, and theoretically grounded and empirically validated models can be applied to a broad range of Army domains, applications, and environments. This research focuses on three interrelated aspects of cyber security and is conducted using a trans-disciplinary approach that takes into account the human element of the network. The three aspects of cyber that are addressed are: 1) adaptive reasoning for deception, 2) anticipating, detecting, and analyzing malicious activities, and 3) agile cyber maneuver to thwart and defeat malicious activities. Overarching goals of cyber security are to significantly decrease the adversary's return on investment when considering cyber attack on Army networks, and minimizing the impact on (Army) network performance related to implementing cyber security. The CRA research creates a framework that effectively integrates the knowledge of cyber assets and potential adversary capabilities and approaches, and provides defense mechanisms that dynamically adjust to changes related to mission, assets, vulnerability state, and defense mechanisms.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Cyber Security Collaborative Research Alliance *Description:* The CSEC CRA supports basic research to enable capabilities for rapid development and adaptation of cyber tools for dynamically assessing cyber risks, detecting hostile activities on friendly networks, and supporting agile maneuver in cyber space in spite of the emergence of novel threats. *FY 2022 Plans:* Will investigate theories and models that study fundamental properties and capabilities of adaptive, scalable, and robust cyber threat detection techniques; investigate methods for planning, assessing, and directing autonomous cyber maneuvers; research fundamental properties and capabilities of adaptive deception techniques for cyber defense, mission resilience, and counter-adversarial machine learning, in congested and contested tactical environments. *FY 2023 Plans:*	5.077	5.067	5.355

PE 0601121A: *Cyber Collaborative Research Alliance*
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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601121A *I Cyber Collaborative Research Alliance*	**Project (Number/Name)** CB5 *I Cyber Collaborative Research Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will investigate fundamental theories and models for intelligent and resilient cyber security intrusion monitoring and detection in uncertain and resource constrained environments; conduct foundational research to understand adversarial machine learning techniques and defenses; investigate generalized game-theoretic models, and intelligent network-system techniques to enable adaptive cyber maneuvers and misdirection strategies against dynamic cyber threats.			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	5.077	5.067	5.355

C. Other Program Funding Summary ($ in Millions)
 N/A

Remarks

D. Acquisition Strategy
 N/A

PE 0601121A: *Cyber Collaborative Research Alliance*
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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Army										**Date:** April 2022	

Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601601A *I Artificial Intelligence and Machine Learning Basic Research*

COST ($ in Millions)	**Prior Years**	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**	**Cost To Complete**	**Total Cost**
Total Program Element	-	-	15.183	10.456	-	10.456	10.661	10.230	12.293	12.290	0.000	71.113
CL3: *AI/ML Basic Research Hub*	-	-	15.183	10.456	-	10.456	10.661	10.230	12.293	12.290	0.000	71.113

A. Mission Description and Budget Item Justification

This Program Element (PE) executes intramural and extramural basic research in artificial intelligence (AI) and machine learning (ML) to support an AI-enabled Multi-Domain Operations (MDO) Force. The PE includes Projects that perform basic research in AI/ML with the potential to impact areas such as: Target Detection using Multiple Cooperative Autonomous Sensors (MCAS); more effective and quicker leader decision-making through use of AI-enhanced Common Operating Procedure (COP); replication of tactical behaviors to enable autonomous capabilities for maneuver; predictive maintenance; Intel support for Operations (specifically in support of long range precision fires); AI-enabled network/cybersecurity; intelligent business and process automation; and medical support. The Army's Artificial Intelligence Integration Center (AI2C) will provide strategic guidance and coordination of these basic research efforts in AI/ML across the Army Modernization enterprise.

Work in this PE contributes to the Army Science and Technology (S&T) portfolio and is fully coordinated with efforts in PE 0602180A Artificial Intelligence Technologies and PE 0603040A Artificial Intelligence Advanced Technologies.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering S&T focus areas, the Army Modernization Strategy and the Joint Artificial Intelligence Center (JAIC).

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

B. Program Change Summary ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023 Base**	**FY 2023 OCO**	**FY 2023 Total**
Previous President's Budget	0.000	10.183	0.000	-	0.000
Current President's Budget	0.000	15.183	10.456	-	10.456
Total Adjustments	0.000	5.000	10.456	-	10.456
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	5.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	10.456	-	10.456

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Army		Date: April 2022
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601601A *I Artificial Intelligence and Machine Learning Basic Research*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: CL3: *AI/ML Basic Research Hub*		
Congressional Add: *Extreme Events in Structurally Evolving Materials (CA)*	-	5.000
Congressional Add Subtotals for Project: CL3	-	5.000
Congressional Add Totals for all Projects	-	5.000

Change Summary Explanation

Fiscal Year 2023 (FY23) funding increase reflects the fact that the FY22 President's Budget request did not include out-year funding.

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| Exhibit R-2A, RDT&E Project Justification: PB 2023 Army | | | | | | | | | | **Date:** April 2022 | |

| Appropriation/Budget Activity
2040 / 1 | | | | R-1 Program Element (Number/Name)
PE 0601601A / *Artificial Intelligence and Machine Learning Basic Research* | | | | | | Project (Number/Name)
CL3 / *AI/ML Basic Research Hub* | |

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CL3: *AI/ML Basic Research Hub*	-	-	15.183	10.456	-	10.456	10.661	10.230	12.293	12.290	0.000	71.113

A. Mission Description and Budget Item Justification

The Artificial Intelligence / Machine Learning (AI/ML) Basic Research Hub is a consortium of industry, government, and academia focused on AI basic research originating from world leaders in academic research pertaining to AI/ML breakthrough technologies for future application to Army-relevant areas such as object recognition using Multiple Cooperative Autonomous Sensors, leader decision-making, replication of tactical behaviors to enable autonomous capabilities for maneuver, predictive maintenance, Intel support for Operations, network and cybersecurity, AI-enhanced common operating picture, intelligent business and process automation, and medical support. Collaboration between academia, industry, and government is a key element of the Hub concept as each member brings with it a distinctly different approach to research. Academia is known for its cutting-edge innovation; the industrial partners are able to leverage existing research results for transition and to deal with technology bottlenecks; and Army AI researchers keep the program oriented toward solving complex Army technology problems.

Work in this PE contributes to the Army Science and Technology (S&T) portfolio and is fully coordinated with efforts in PE 0602180A Artificial Intelligence Technologies and PE 0603040A Artificial Intelligence Advanced Technologies.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering S&T focus areas, the Army Modernization Strategy and the Joint Artificial Intelligence Center (JAIC) mission initiatives.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Intelligence support to Operations	-	1.450	1.600

Description: Research AI / ML methodologies to perform object detection on imagery to augment operations. Investigate meeting the challenge of recognition of surrogate targets in S&T test ranges that are not absolute visual representations, using AI capabilities trained on real operational objects. Perform basic research in the area of intelligence support for operations in support of long range precision fires.

FY 2022 Plans:
Will research the ability to model, animate, and render synthetic data to train algorithms using a high-altitude electro-optical (EO) imagery training set comprised of synthetic data created from open source imagery and limited real-world data. Will also research new low-shot object detection and recognition techniques for small sample learning, and unsupervised computer vision approaches to improve battlespace awareness.

FY 2023 Plans:

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Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601601A *I Artificial Intelligence and Machine Learning Basic Research*	**Project (Number/Name)** CL3 *I AI/ML Basic Research Hub*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Will continue research in methodologies and technologies to advance artificial intelligence (AI) for situational awareness and its connection to command and coordination in support to operations. Will investigate approaches for novel detection and recognition algorithm training to realize rapid, reliable computer vision and informed decision making. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Funding change reflects planned life cycle of effort.			
Title: Artificial Intelligence Hub *Description:* The AI Hub is located at Carnegie Mellon University as a consortium of industry, government, and academia focused on building and optimizing the Army's AI and ML initiatives with the goal of accelerating the fielding of capability. The AI Hub will utilize the Army Artificial Intelligence Innovation Institute (A2I2) data and AI/ML algorithms and software tools to investigate AI and ML capabilities to address the Army's unique problems. The AI Hub will focus on research into AI technologies for future application to Army-relevant areas such as, but not limited to, replication of tactical behaviors to enable autonomous capabilities for maneuver, robotics, predictive maintenance, multi-domain Command, Control, Communications, and Computers (C4), network resiliency and cybersecurity, AI-enhanced common operating picture (CoP), intelligent business and process automation, decision support, AI-enabled collaborative data infrastructure platform, medical support and force protection. *FY 2022 Plans:* Will investigate new ways of streamlining collaborative AI development with approaches that improve developer productivity and application robustness; research AI-enabled cyber security methodologies in adversarial AI/counter AI, cyber intrusion, and ML-based anomaly detection with counter-actions that are robust to enemy deception; research into safe manned-unmanned vehicle teaming to improve system performance; research to improve the understanding and use of reinforcement learning for studying strategic and cooperative interactions in multi-agent systems and improve decision support. *FY 2023 Plans:* Will continue investigation to streamline collaborative AI development that can scale to enterprise level. Will research AI-enabled cyber security methodologies in adversarial AI/counter AI, cyber intrusion, and ML-based anomaly detection with counter-actions that are robust to enemy deception. Research into safe manned-unmanned vehicle teaming to improve system performance. Will conduct research to improve the understanding and use of reinforcement learning for studying strategic and cooperative interactions in multi-agent systems and improve decision support. Will conduct research in other novel artificial intelligence (AI) enabling technologies across multiple capability areas, to include, but are not limited to, computing, data management, machine learning, modeling, decision support, and ethics. *FY 2022 to FY 2023 Increase/Decrease Statement:*	-	5.361	5.547

Exhibit R-2A, **RDT&E Project Justification:** PB 2023 Army		**Date:** April 2022
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601601A *I Artificial Intelligence and Machine Learning Basic Research*	**Project (Number/Name)** CL3 *I AI/ML Basic Research Hub*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2021**	**FY 2022**	**FY 2023**
Funding change reflects planned lifecycle of this effort.			
Title: ATR-MCAS	-	3.000	3.309
Description: Combat Formations require the ability to autonomously maneuver to identify threats and enable friendly forces to disintegrate and exploit enemy forces in the close and deep maneuver areas. This effort researches AI-based, multi-system approaches to aided threat recognition (ATR) using a combination of autonomous air & ground sensors to build a more accurate operating picture when given zone recon missions. ATR and situational awareness is improved through the direct cooperation & autonomous mobility of the sensors.			
FY 2022 Plans: Will research emerging AI-based, multi-system ground and air vehicle-based object recognition strategies based on autonomous collection, integration, and analysis of information from myriad sensors/systems; will further investigate AI methods that raise the level and number of tasks that can be executed autonomously or semi-autonomously by vehicles in the fleet; will perform research into advanced algorithms for autonomous ground and air platform movement with obstacle detection/avoidance in GPS-denied, dense urban and low/no- light environments; will research AI-enabled tactical maneuver of ground platforms by using terrain and vegetation to avoid enemy detection.			
FY 2023 Plans: Will continue foundational research in emerging artificial intelligence (AI)-based autonomy that scale and connect sensors/ systems for shared perception and communication to maneuver in complex environments to include, but not limited to, varied terrain, dense urban, low-no light, and GPS-denied environments. Will investigate novel approaches in AI/human teaming for maneuver and force application in multi-domain operations.			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: SBIR/STTR Transfer	-	0.372	-
FY 2022 Plans: Funding transferred in accordance with Title 15 USC ?638			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding transferred in accordance with Title 15 USC ?638			
Accomplishments/Planned Programs Subtotals	-	10.183	10.456

	FY 2021	**FY 2022**
Congressional Add: Extreme Events in Structurally Evolving Materials (CA)	-	5.000

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	FY 2021	**FY 2022**
FY 2022 Plans: Congressional Interest Item funding provided for Extreme Events in Structurally Evolving Materials. Congressional Add to be executed by Army Futures Command.		
Congressional Adds Subtotals	-	5.000

C. Other Program Funding Summary ($ in Millions)
 N/A
Remarks

D. Acquisition Strategy
 N/A

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