Department of Defense
Fiscal Year (FY) 2024 Budget Estimates

March 2023

Army

Justification Book Volume 1a of 1

Research, Development, Test & Evaluation, Army

RDT&E − Volume I, Budget Activity 1

Volume 1a Table of Contents

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, $15,772,215,000.00 to remain available for obligation until September 30, 2025.

The FY 2024 Overseas Operations accounted for in the base budget are as follows:

In-theater and in-CONUS expenses that remain after combat operations cease and have been previously funded in Overseas Operations $3,166,000.00.

COST STATEMENT

The following Justification Books were prepared at a cost of $365,839.52: 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 2024 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 2024.

2. Relationship of the FY 2024 Budget Submitted to Congress to the FY 2023 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	0602146A / AM6	Modular RF Communications Technology
02	0602148A / CI4	Adaptive Avionics Technologies
02	0602141A / CIC	Fire Control Lethality Technology
02	0602182A / DA8	Quantum PNT & Radio Frequency Sensing
02	0602182A / DB4	Enabling Long Standoff 3D (ELS3D) Tech
02	0602002A / DC6	Sci & Analysis for Autonomous Sys & Counter-Auton
02	0602183A / DE2	Airborne Threat Defeat
02	0602150A / DE3	Adv Beam Control Component Development for C-CM
02	0602182A / DE6	Understanding Environment as a Threat Tech
03	0603044A / CW1	Technical-SAVVY Soldier Advanced Research
03	0603116A / DB2	Future Armaments Scalable Technologies
03	0603042A / DB5	Enabling Long Standoff 3D (ELS3D) Adv Tech
03	0603463A / DB6	Pathfinder 3D Advanced Technology
04	0604103A / DG4	NAVWAR SA
04	0603779A / DH6	Installation Resilience
05	0604802A / DC9	30mm MMPA M-SHORAD INC 3

05	0604818A / DD1	Unified Network Technology Trans & Integ (UNTTI)
05	0605206A / DG3	CI and HUMINT Equipment Program-Army (CIHEP-A)
05	0605013A / DH1	Operational Medicine Information System
05	0605216A / EFA	Joint Target Integrated Cmd & Coordination Suite
05	0605036A / EQ5	Combating Weapons of Mass Destruction (CWMD)
05	0605049A / XT4	Advanced Threat Detection System (ATDS)
06	0605601A / WD1	West Desert Test Center
07	0203735A / DD4	AMPV Improvement Program
07	0607315A / DD5	Army Power Systems Modernization

Program Element/Project Restructures:

Budget Activity	***Old OSDPE / Project: Title***	***New OSDPE / Project***
02	0602145A / CU5: Next Generation Combat Vehicle Technolog	0602141A / CIA
02	0602181A / CM7: All Domain Convergence Applied Research	0602141A / CIB
02	0602143A / AZ9: Soldier Lethality Technology	0602143A / BB4
02	0602143A / BBG: Soldier Lethality Technology	0602143A / BC2
02	0602145A / BG8: Next Generation Combat Vehicle Technology	0602144A / DG1
02	0602180A / CL7: Artificial Intelligence and Machine Learning Technologies	0602180A / DE8
03	0603040A / CL6: Artificial Intelligence and Machine Learning Technologies	0603040A / DE9
03	0603463A / AR6: Network C3I Advanced Technology	0603042A / DE7
03	0603041A / CM8: All Domain Convergence Advanced Technology	0603116A / CID
03	0603462A / BH6: Next Generation Combat Vehicle Advanced Technology	0603118A / BD9
03	0603462A / BG9: Next Generation Combat Vehicle Advanced Technology	0603119A / DG2
03	0603464A / CZ8: Long Range Precision Fires Advanced Technology	0603464A / AF2
04	0604036A / BY9: Multi-Domain Sensing System (MDSS) Adv Dev	0604036A / DD6
04	0604036A / BY9: Multi-Domain Sensing System (MDSS) Adv Dev	0604036A / DD6

05	0604818A / EJ5: Family of Heavy Vehicles	0604622A / DG7
05	0605224A / CK4: Long-Range Hypersonic Weapon	0604182A / HX2
05	0605224A / CK4: All Up Round and Canister (AUR+C)	0604182A / HX2
05	0605457A / S40: Common Hypersonic Glide Body (CHGB)	0604182A / HX2
05	0605601A / F30: Ground Support Equipment (GSE)	0604182A / HX2
05	0203744A / EB6: HX6: Test and Evaluation	0604182A / HX2
05	0605224A / CK4: Multi-Domain Intelligence	0604805A / 593
05	0605224A / CK4: Multi-Domain Intelligence	0605224A / DD8
05	0605457A / S40: Multi-Domain Intelligence	0605224A / DD9
05	0605601A / F30: Army Integrated Air and Missile Defense (AIAMD)	0605457A / SS1
06	0605601A / F30: Army Integrated Air and Missile Defense (AIAMD)	0605702A / 128
07	0203744A / EB6: Army Test Ranges and Facilities	0305219A / MQ2

Program Terminations (including transfers to Procurement and Sustainment):

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Budget Activity	***OSDPE / Project***	***Project Title***
03	0603465A / AI8	Future Vertical Lift Advanced Technology / Alternative Concept Engine Advanced Technology
03	0603463A / AV4	Network C3I Advanced Technology / Foundational S&T for Network C3I Advanced Tech
04	0305251A / DD3	Cyberspace Operations Forces and Force Support / Joint Cyber Warfighting Architecture Cyber Train
04	0604115A / AX8	Technology Maturation Initiatives / Adv Leth and Accuracy Sys for Med Calber (ALAS-MC)
04	0604115A / AX9	Technology Maturation Initiatives / Adv Mobility Experimental Prototype Adv Tech
05	0604802A / CE3	Weapons and Munitions - Eng Dev / Precision Munition (Sniper)
05	0604802A / EU4	Weapons and Munitions - Eng Dev / 40mm HV Improved High Explosive Dual Purpose
05	0604804A / FG4	Logistics and Engineer Equipment - Eng Dev / Ultra-Lightweight Camouflage Net System (ULCANS)
05	0604822A / DV6	General Fund Enterprise Business System (GFEBS) / General Fund Enterprise Business System
05	0604854A / HB6	Artillery Systems - EMD / Mobile 155MM Howitzer
05	0605013A / 184	Information Technology Development / Installation Support Modules
07	0305204A / 11A	Tactical Unmanned Aerial Vehicles / Advanced Payload Develop & Spt

07	0305206A / EH2	Airborne Reconnaissance Systems / EMARSS ADV DEV
07	0305206A / EH3	Airborne Reconnaissance Systems / EMARSS Payloads ADV DEV
08	0608041A / DD2	Defensive CYBER - Software Prototype Development / Joint Cyber Warfighting Architecture Software

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 Defense
FY 2024 President's Budget
Exhibit R-1 FY 2024 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Mar 2023

Appropriation	FY 2022 Actuals	FY 2023 Less Supplementals Enactment	FY 2023 Supplementals Enactment*	FY 2023 Total Enactment	FY 2024 Request
Research, Development, Test and Evaluation, Army	14,660,654	17,142,121	9,100	17,151,221	15,775,381
Total Research, Development, Test, & Evaluation	**14,660,654**	**17,142,121**	**9,100**	**17,151,221**	**15,775,381**

*Includes enacted funding in the Ukraine Supplemental Appropriation Act, 2023 (Division B of Public Law 117-180) and Additional Ukraine Supplemental Appropriation Act, 2023 (Division M of Public Law 117-328).

Department of Defense
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(Dollars in Thousands)

Mar 2023

	FY 2022 Actuals	FY 2023 Less Supplementals Enactment	FY 2023 Supplementals Enactment*	FY 2023 Total Enactment	FY 2024 Request
Summary Recap of Budget Activities					
Basic Research	590,078	635,395		635,395	497,455
Applied Research	1,521,472	1,823,330		1,823,330	948,358
Advanced Technology Development	2,145,309	2,532,690		2,532,690	1,455,986
Advanced Component Development & Prototypes	3,799,417	4,631,111	6,000	4,637,111	4,420,315
System Development & Demonstration	3,178,005	4,317,752	600	4,318,352	5,639,364
Management Support	1,901,655	1,820,502		1,820,502	1,624,585
Operational Systems Development	1,416,677	1,286,510	2,500	1,289,010	1,105,748
Software And Digital Technology Pilot Programs	108,041	94,831		94,831	83,570
Total Research, Development, Test, & Evaluation	**14,660,654**	**17,142,121**	**9,100**	**17,151,221**	**15,775,381**
Summary Recap of FYDP Programs					
General Purpose Forces	559,789	372,120		372,120	404,375
Intelligence and Communications	262,480	248,995		248,995	212,694
Research and Development	13,733,825	16,382,072	9,100	16,391,172	15,055,009
Central Supply and Maintenance	101,466	132,270		132,270	75,317
Administration and Associated Activities	101				
Classified Programs	2,993	6,664		6,664	27,986
Total Research, Development, Test, & Evaluation	**14,660,654**	**17,142,121**	**9,100**	**17,151,221**	**15,775,381**

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Department of the Army
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(Dollars in Thousands)

Mar 2023

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Advanced Technology Development	2,145,309	2,532,690		2,532,690	1,455,986
Advanced Component Development & Prototypes	3,799,417	4,631,111	6,000	4,637,111	4,420,315
System Development & Demonstration	3,178,005	4,317,752	600	4,318,352	5,639,364
Management Support	1,901,655	1,820,502		1,820,502	1,624,585
Operational Systems Development	1,416,677	1,286,510	2,500	1,289,010	1,105,748
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Department of the Army
FY 2024 President's Budget
Exhibit R-1 FY 2024 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Mar 2023

Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2022 Actuals	FY 2023 Less Supplementals Enactment	FY 2023 Supplementals Enactment*	FY 2023 Total Enactment
1	0601102A	Defense Research Sciences	01	U	358,521	391,642		391,642
2	0601103A	University Research Initiatives	01	U	88,797	107,160		107,160
3	0601104A	University and Industry Research Centers	01	U	122,521	121,160		121,160
4	0601121A	Cyber Collaborative Research Alliance	01	U	5,067	5,355		5,355
5	0601601A	Artificial Intelligence and Machine Learning Basic Research	01	U	15,172	10,078		10,078
	Basic Research				**590,078**	**635,395**		**635,395**
6	0602002A	Army Agile Innovation and Development-Applied Research	02	U		1,000		1,000
7	0602115A	Biomedical Technology	02	U	11,489			
8	0602134A	Counter Improvised-Threat Advanced Studies	02	U	1,904	6,192		6,192
9	0602141A	Lethality Technology	02	U	89,285	194,717		194,717
10	0602142A	Army Applied Research	02	U	28,654	27,833		27,833
11	0602143A	Soldier Lethality Technology	02	U	201,221	253,539		253,539
12	0602144A	Ground Technology	02	U	214,489	264,523		264,523
13	0602145A	Next Generation Combat Vehicle Technology	02	U	239,284	277,445		277,445
14	0602146A	Network C3I Technology	02	U	161,759	212,115		212,115
15	0602147A	Long Range Precision Fires Technology	02	U	107,454	128,529		128,529
16	0602148A	Future Verticle Lift Technology	02	U	130,108	104,348		104,348
17	0602150A	Air and Missile Defense Technology	02	U	92,926	88,768		88,768
18	0602180A	Artificial Intelligence and Machine Learning Technologies	02	U	14,486	16,068		16,068

*Includes enacted funding in the Ukraine Supplemental Appropriation Act, 2023 (Division B of Public Law 117-180) and Additional Ukraine Supplemental Appropriation Act, 2023 (Division M of Public Law 117-328).

Department of the Army
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(Dollars in Thousands)

Mar 2023

Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2024 Request
1	0601102A	Defense Research Sciences	01	U	296,670
2	0601103A	University Research Initiatives	01	U	75,672
3	0601104A	University and Industry Research Centers	01	U	108,946
4	0601121A	Cyber Collaborative Research Alliance	01	U	5,459
5	0601601A	Artificial Intelligence and Machine Learning Basic Research	01	U	10,708
	Basic Research				**497,455**
6	0602002A	Army Agile Innovation and Development-Applied Research	02	U	5,613
7	0602115A	Biomedical Technology	02	U	
8	0602134A	Counter Improvised-Threat Advanced Studies	02	U	6,242
9	0602141A	Lethality Technology	02	U	85,578
10	0602142A	Army Applied Research	02	U	34,572
11	0602143A	Soldier Lethality Technology	02	U	104,470
12	0602144A	Ground Technology	02	U	60,005
13	0602145A	Next Generation Combat Vehicle Technology	02	U	166,500
14	0602146A	Network C3I Technology	02	U	81,618
15	0602147A	Long Range Precision Fires Technology	02	U	34,683
16	0602148A	Future Verticle Lift Technology	02	U	73,844
17	0602150A	Air and Missile Defense Technology	02	U	33,301
18	0602180A	Artificial Intelligence and Machine Learning Technologies	02	U	24,142

Department of the Army
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Line No	Program Element Number	Item	Act	Sec	FY 2022 Actuals	FY 2023 Less Supplementals Enactment	FY 2023 Supplementals Enactment*	FY 2023 Total Enactment
19	0602181A	All Domain Convergence Applied Research	02	U	25,019	27,360		27,360
20	0602182A	C3I Applied Research	02	U	11,954	27,868		27,868
21	0602183A	Air Platform Applied Research	02	U	6,356	41,588		41,588
22	0602184A	Soldier Applied Research	02	U	10,660	15,716		15,716
23	0602213A	C3I Applied Cyber	02	U	12,119	13,605		13,605
24	0602386A	Biotechnology for Materials - Applied Research	02	U	19,889	21,811		21,811
25	0602785A	Manpower/Personnel/Training Technology	02	U	18,414	19,649		19,649
26	0602787A	Medical Technology	02	U	124,002	80,656		80,656
	Applied Research				**1,521,472**	**1,823,330**		**1,823,330**
27	0603002A	Medical Advanced Technology	03	U	147,287	31,588		31,588
28	0603007A	Manpower, Personnel and Training Advanced Technology	03	U	13,865	15,598		15,598
29	0603025A	Army Agile Innovation and Demonstration	03	U	21,420	20,900		20,900
30	0603040A	Artificial Intelligence and Machine Learning Advanced Technologies	03	U	876	6,395		6,395
31	0603041A	All Domain Convergence Advanced Technology	03	U	20,095	45,377		45,377
32	0603042A	C3I Advanced Technology	03	U	3,036	12,716		12,716
33	0603043A	Air Platform Advanced Technology	03	U	727	17,946		17,946
34	0603044A	Soldier Advanced Technology	03	U	858	479		479
35	0603115A	Medical Development	03	U	25,540			
36	0603116A	Lethality Advanced Technology	03	U	7,772	9,796		9,796
37	0603117A	Army Advanced Technology Development	03	U	76,815	134,874		134,874

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Department of the Army
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Mar 2023

Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2024 Request
19	0602181A	All Domain Convergence Applied Research	02	U	14,297
20	0602182A	C3I Applied Research	02	U	30,659
21	0602183A	Air Platform Applied Research	02	U	48,163
22	0602184A	Soldier Applied Research	02	U	18,986
23	0602213A	C3I Applied Cyber	02	U	22,714
24	0602386A	Biotechnology for Materials - Applied Research	02	U	16,736
25	0602785A	Manpower/Personnel/Training Technology	02	U	19,969
26	0602787A	Medical Technology	02	U	66,266
	Applied Research				**948,358**
27	0603002A	Medical Advanced Technology	03	U	4,147
28	0603007A	Manpower, Personnel and Training Advanced Technology	03	U	16,316
29	0603025A	Army Agile Innovation and Demonstration	03	U	23,156
30	0603040A	Artificial Intelligence and Machine Learning Advanced Technologies	03	U	13,187
31	0603041A	All Domain Convergence Advanced Technology	03	U	33,332
32	0603042A	C3I Advanced Technology	03	U	19,225
33	0603043A	Air Platform Advanced Technology	03	U	14,165
34	0603044A	Soldier Advanced Technology	03	U	1,214
35	0603115A	Medical Development	03	U	
36	0603116A	Lethality Advanced Technology	03	U	20,582
37	0603117A	Army Advanced Technology Development	03	U	136,280

Department of the Army
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Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2022 Actuals	FY 2023 Less Supplementals Enactment	FY 2023 Supplementals Enactment*	FY 2023 Total Enactment
38	0603118A	Soldier Lethality Advanced Technology	03	U	148,458	154,639		154,639
39	0603119A	Ground Advanced Technology	03	U	281,637	415,846		415,846
40	0603134A	Counter Improvised-Threat Simulation	03	U	23,920	21,486		21,486
41	0603386A	Biotechnology for Materials - Advanced Research	03	U	51,774	56,853		56,853
42	0603457A	C3I Cyber Advanced Development	03	U	61,426	41,354		41,354
43	0603461A	High Performance Computing Modernization Program	03	U	222,220	301,964		301,964
44	0603462A	Next Generation Combat Vehicle Advanced Technology	03	U	294,491	471,434		471,434
45	0603463A	Network C3I Advanced Technology	03	U	205,576	177,917		177,917
46	0603464A	Long Range Precision Fires Advanced Technology	03	U	138,482	202,830		202,830
47	0603465A	Future Vertical Lift Advanced Technology	03	U	255,323	272,551		272,551
48	0603466A	Air and Missile Defense Advanced Technology	03	U	125,027	99,147		99,147
49	0603920A	Humanitarian Demining	03	U	18,684	21,000		21,000
	Advanced Technology Development				**2,145,309**	**2,532,690**		**2,532,690**
51	0603305A	Army Missle Defense Systems Integration	04	U	56,579	118,001		118,001
52	0603308A	Army Space Systems Integration	04	U	25,401	30,945		30,945
53	0603327A	Air and Missile Defense Systems Engineering	04	U	15,000	15,000		15,000
54	0603619A	Landmine Warfare and Barrier - Adv Dev	04	U	44,933	55,953	6,000	61,953
55	0603639A	Tank and Medium Caliber Ammunition	04	U	61,641	51,488		51,488
56	0603645A	Armored System Modernization - Adv Dev	04	U	154,010	135,122		135,122
57	0603747A	Soldier Support and Survivability	04	U	2,791	4,060		4,060
58	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	U	113,365	72,314		72,314

*Includes enacted funding in the Ukraine Supplemental Appropriation Act, 2023 (Division B of Public Law 117-180) and Additional Ukraine Supplemental Appropriation Act, 2023 (Division M of Public Law 117-328).

Department of the Army
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Mar 2023

Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2024 Request
38	0603118A	Soldier Lethality Advanced Technology	03	U	102,778
39	0603119A	Ground Advanced Technology	03	U	40,597
40	0603134A	Counter Improvised-Threat Simulation	03	U	21,672
41	0603386A	Biotechnology for Materials - Advanced Research	03	U	59,871
42	0603457A	C3I Cyber Advanced Development	03	U	28,847
43	0603461A	High Performance Computing Modernization Program	03	U	255,772
44	0603462A	Next Generation Combat Vehicle Advanced Technology	03	U	217,394
45	0603463A	Network C3I Advanced Technology	03	U	105,549
46	0603464A	Long Range Precision Fires Advanced Technology	03	U	153,024
47	0603465A	Future Vertical Lift Advanced Technology	03	U	158,795
48	0603466A	Air and Missile Defense Advanced Technology	03	U	21,015
49	0603920A	Humanitarian Demining	03	U	9,068
	Advanced Technology Development				**1,455,986**
51	0603305A	Army Missle Defense Systems Integration	04	U	12,904
52	0603308A	Army Space Systems Integration	04	U	19,120
53	0603327A	Air and Missile Defense Systems Engineering	04	U	
54	0603619A	Landmine Warfare and Barrier - Adv Dev	04	U	47,537
55	0603639A	Tank and Medium Caliber Ammunition	04	U	91,323
56	0603645A	Armored System Modernization - Adv Dev	04	U	43,026
57	0603747A	Soldier Support and Survivability	04	U	3,550
58	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	U	65,567

Department of the Army
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Line No	Program Element Number	Item	Act	Sec	FY 2022 Actuals	FY 2023 Less Supplementals Enactment	FY 2023 Supplementals Enactment*	FY 2023 Total Enactment
59	0603774A	Night Vision Systems Advanced Development	04	U	62,534	97,478		97,478
60	0603779A	Environmental Quality Technology - Dem/Val	04	U	22,491	76,749		76,749
61	0603790A	NATO Research and Development	04	U	3,639	3,805		3,805
62	0603801A	Aviation - Adv Dev	04	U	1,138,457	1,157,472		1,157,472
63	0603804A	Logistics and Engineer Equipment - Adv Dev	04	U	10,797	24,638		24,638
64	0603807A	Medical Systems - Adv Dev	04	U	27,768	5,598		5,598
65	0603827A	Soldier Systems - Advanced Development	04	U	25,288	23,444		23,444
66	0604017A	Robotics Development	04	U	78,309	26,555		26,555
67	0604019A	Expanded Mission Area Missile (EMAM)	04	U	26,855	258,320		258,320
68	0604020A	Cross Functional Team (CFT) Advanced Development & Prototyping	04	U		77,000		77,000
69	0604035A	Low Earth Orbit (LEO) Satellite Capability	04	U	18,922	35,509		35,509
70	0604036A	Multi-Domain Sensing System (MDSS) Adv Dev	04	U	50,548	47,915		47,915
71	0604037A	Tactical Intel Targeting Access Node (TITAN) Adv Dev	04	U	28,347	863		863
72	0604100A	Analysis Of Alternatives	04	U	9,723	10,659		10,659
73	0604101A	Small Unmanned Aerial Vehicle (SUAV) (6.4)	04	U	892	1,425		1,425
74	0604103A	Electronic Warfare Planning and Management Tool (EWPMT)	04	U				
75	0604113A	Future Tactical Unmanned Aircraft System (FTUAS)	04	U	76,349	134,719		134,719
76	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04	U	408,766	380,147		380,147
77	0604115A	Technology Maturation Initiatives	04	U	127,725	219,742		219,742
78	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04	U	37,939	274,838		274,838

*Includes enacted funding in the Ukraine Supplemental Appropriation Act, 2023 (Division B of Public Law 117-180) and Additional Ukraine Supplemental Appropriation Act, 2023 (Division M of Public Law 117-328).

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59	0603774A	Night Vision Systems Advanced Development	04	U	73,675
60	0603779A	Environmental Quality Technology - Dem/Val	04	U	31,720
61	0603790A	NATO Research and Development	04	U	4,143
62	0603801A	Aviation - Adv Dev	04	U	1,502,160
63	0603804A	Logistics and Engineer Equipment - Adv Dev	04	U	7,604
64	0603807A	Medical Systems - Adv Dev	04	U	1,602
65	0603827A	Soldier Systems - Advanced Development	04	U	27,681
66	0604017A	Robotics Development	04	U	3,024
67	0604019A	Expanded Mission Area Missile (EMAM)	04	U	97,018
68	0604020A	Cross Functional Team (CFT) Advanced Development & Prototyping	04	U	117,557
69	0604035A	Low Earth Orbit (LEO) Satellite Capability	04	U	38,851
70	0604036A	Multi-Domain Sensing System (MDSS) Adv Dev	04	U	191,394
71	0604037A	Tactical Intel Targeting Access Node (TITAN) Adv Dev	04	U	10,626
72	0604100A	Analysis Of Alternatives	04	U	11,095
73	0604101A	Small Unmanned Aerial Vehicle (SUAV) (6.4)	04	U	5,144
74	0604103A	Electronic Warfare Planning and Management Tool (EWPMT)	04	U	2,260
75	0604113A	Future Tactical Unmanned Aircraft System (FTUAS)	04	U	53,143
76	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04	U	816,663
77	0604115A	Technology Maturation Initiatives	04	U	281,314
78	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04	U	281,239

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79	0604119A	Army Advanced Component Development & Prototyping	04	U	179,483	198,111		198,111
80	0604120A	Assured Positioning, Navigation and Timing (PNT)	04	U	80,858	57,620		57,620
81	0604121A	Synthetic Training Environment Refinement & Prototyping	04	U	198,815	242,468		242,468
82	0604134A	Counter Improvised-Threat Demonstration, Prototype Development, and Testing	04	U	12,891	14,840		14,840
83	0604135A	Strategic Mid-Range Fires	04	U		404,291		404,291
84	0604182A	Hypersonics	04	U	305,406	238,168		238,168
85	0604403A	Future Interceptor	04	U	6,643	8,179		8,179
86	0604531A	Counter - Small Unmanned Aircraft Systems Advanced Development	04	U	18,449	35,110		35,110
87	0604541A	Unified Network Transport	04	U	33,879	36,966		36,966
88	0604644A	Mobile Medium Range Missile	04	U	275,989			
89	0604785A	Integrated Base Defense (Budget Activity 4)	04	U	2,040			
90	0305251A	Cyberspace Operations Forces and Force Support	04	U	55,895	55,599		55,599
999	999999999	Classified Programs	04	U				
	Advanced Component Development & Prototypes				**3,799,417**	**4,631,111**	**6,000**	**4,637,111**
91	0604201A	Aircraft Avionics	05	U	6,411	3,335		3,335
92	0604270A	Electronic Warfare Development	05	U	29,683	4,140		4,140
93	0604601A	Infantry Support Weapons	05	U	77,027	83,329		83,329
94	0604604A	Medium Tactical Vehicles	05	U	9,177	22,163		22,163
95	0604611A	JAVELIN	05	U	8,202	16,186		16,186

*Includes enacted funding in the Ukraine Supplemental Appropriation Act, 2023 (Division B of Public Law 117-180) and Additional Ukraine Supplemental Appropriation Act, 2023 (Division M of Public Law 117-328).

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79	0604119A	Army Advanced Component Development & Prototyping	04	U	204,914
80	0604120A	Assured Positioning, Navigation and Timing (PNT)	04	U	40,930
81	0604121A	Synthetic Training Environment Refinement & Prototyping	04	U	109,714
82	0604134A	Counter Improvised-Threat Demonstration, Prototype Development, and Testing	04	U	16,426
83	0604135A	Strategic Mid-Range Fires	04	U	31,559
84	0604182A	Hypersonics	04	U	43,435
85	0604403A	Future Interceptor	04	U	8,040
86	0604531A	Counter - Small Unmanned Aircraft Systems Advanced Development	04	U	64,242
87	0604541A	Unified Network Transport	04	U	40,915
88	0604644A	Mobile Medium Range Missile	04	U	
89	0604785A	Integrated Base Defense (Budget Activity 4)	04	U	
90	0305251A	Cyberspace Operations Forces and Force Support	04	U	
999	999999999	Classified Programs	04	U	19,200
	Advanced Component Development & Prototypes				**4,420,315**
91	0604201A	Aircraft Avionics	05	U	13,673
92	0604270A	Electronic Warfare Development	05	U	12,789
93	0604601A	Infantry Support Weapons	05	U	64,076
94	0604604A	Medium Tactical Vehicles	05	U	28,226
95	0604611A	JAVELIN	05	U	7,827

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96	0604622A	Family of Heavy Tactical Vehicles	05	U	27,406	53,014		53,014
97	0604633A	Air Traffic Control	05	U	4,244	2,623		2,623
98	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05	U		109,849		109,849
99	0604642A	Light Tactical Wheeled Vehicles	05	U	1,980			
100	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05	U	118,296	63,131		63,131
101	0604710A	Night Vision Systems - Eng Dev	05	U	41,831	92,951		92,951
102	0604713A	Combat Feeding, Clothing, and Equipment	05	U	1,598	1,566		1,566
103	0604715A	Non-System Training Devices - Eng Dev	05	U	28,605	18,588		18,588
104	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	U	58,633	55,541		55,541
105	0604742A	Constructive Simulation Systems Development	05	U	21,424	29,481		29,481
106	0604746A	Automatic Test Equipment Development	05	U	8,486	5,178		5,178
107	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	U	12,182	8,189		8,189
108	0604798A	Brigade Analysis, Integration and Evaluation	05	U	20,976	21,086		21,086
109	0604802A	Weapons and Munitions - Eng Dev	05	U	287,787	285,778	600	286,378
110	0604804A	Logistics and Engineer Equipment - Eng Dev	05	U	49,201	75,669		75,669
111	0604805A	Command, Control, Communications Systems - Eng Dev	05	U	19,372	44,993		44,993
112	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	U	43,023	5,513		5,513
113	0604808A	Landmine Warfare/Barrier - Eng Dev	05	U	28,622	37,150		37,150
114	0604818A	Army Tactical Command & Control Hardware & Software	05	U	146,291	131,190		131,190
115	0604820A	Radar Development	05	U	124,832	71,259		71,259

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96	0604622A	Family of Heavy Tactical Vehicles	05	U	44,197
97	0604633A	Air Traffic Control	05	U	1,134
98	0604641A	Tactical Unmanned Ground Vehicle (TUGV)	05	U	142,125
99	0604642A	Light Tactical Wheeled Vehicles	05	U	53,564
100	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05	U	102,201
101	0604710A	Night Vision Systems - Eng Dev	05	U	48,720
102	0604713A	Combat Feeding, Clothing, and Equipment	05	U	2,223
103	0604715A	Non-System Training Devices - Eng Dev	05	U	21,441
104	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	U	74,738
105	0604742A	Constructive Simulation Systems Development	05	U	30,985
106	0604746A	Automatic Test Equipment Development	05	U	13,626
107	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	U	8,802
108	0604798A	Brigade Analysis, Integration and Evaluation	05	U	20,828
109	0604802A	Weapons and Munitions - Eng Dev	05	U	243,851
110	0604804A	Logistics and Engineer Equipment - Eng Dev	05	U	37,420
111	0604805A	Command, Control, Communications Systems - Eng Dev	05	U	34,214
112	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	U	6,496
113	0604808A	Landmine Warfare/Barrier - Eng Dev	05	U	13,581
114	0604818A	Army Tactical Command & Control Hardware & Software	05	U	168,574
115	0604820A	Radar Development	05	U	94,944

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116	0604822A	General Fund Enterprise Business System (GFEBS)	05	U	15,395	10,402		10,402
117	0604827A	Soldier Systems - Warrior Dem/Val	05	U	6,219	19,408		19,408
118	0604852A	Suite of Survivability Enhancement Systems - EMD	05	U	93,207	100,384		100,384
119	0604854A	Artillery Systems - EMD	05	U	25,000	48,106		48,106
120	0605013A	Information Technology Development	05	U	125,109	104,134		104,134
121	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	U	65,230	67,519		67,519
122	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	U	34,262			
123	0605030A	Joint Tactical Network Center (JTNC)	05	U	15,752	17,936		17,936
124	0605031A	Joint Tactical Network (JTN)	05	U	27,849	30,150		30,150
125	0605035A	Common Infrared Countermeasures (CIRCM)	05	U	15,982	11,523		11,523
126	0605036A	Combating Weapons of Mass Destruction (CWMD)	05	U				
127	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05	U	7,340			
128	0605041A	Defensive CYBER Tool Development	05	U	18,811	39,029		39,029
129	0605042A	Tactical Network Radio Systems (Low-Tier)	05	U	27,688	4,426		4,426
130	0605047A	Contract Writing System	05	U	20,195	13,742		13,742
131	0605049A	Missile Warning System Modernization (MWSM)	05	U				
132	0605051A	Aircraft Survivability Development	05	U	60,127	19,123		19,123
133	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05	U	175,604	131,093		131,093
134	0605053A	Ground Robotics	05	U	15,763	26,809		26,809
135	0605054A	Emerging Technology Initiatives	05	U	219,284	244,047		244,047

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116	0604822A	General Fund Enterprise Business System (GFEBS)	05	U	2,965
117	0604827A	Soldier Systems - Warrior Dem/Val	05	U	11,333
118	0604852A	Suite of Survivability Enhancement Systems - EMD	05	U	79,250
119	0604854A	Artillery Systems - EMD	05	U	42,490
120	0605013A	Information Technology Development	05	U	104,024
121	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	U	102,084
122	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	U	
123	0605030A	Joint Tactical Network Center (JTNC)	05	U	18,662
124	0605031A	Joint Tactical Network (JTN)	05	U	30,328
125	0605035A	Common Infrared Countermeasures (CIRCM)	05	U	11,509
126	0605036A	Combating Weapons of Mass Destruction (CWMD)	05	U	1,050
127	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05	U	
128	0605041A	Defensive CYBER Tool Development	05	U	27,714
129	0605042A	Tactical Network Radio Systems (Low-Tier)	05	U	4,318
130	0605047A	Contract Writing System	05	U	16,355
131	0605049A	Missile Warning System Modernization (MWSM)	05	U	27,571
132	0605051A	Aircraft Survivability Development	05	U	24,900
133	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05	U	196,248
134	0605053A	Ground Robotics	05	U	35,319
135	0605054A	Emerging Technology Initiatives	05	U	201,274

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136	0605143A	Biometrics Enabling Capability (BEC)	05	U	4,326	11,091		11,091
137	0605144A	Next Generation Load Device - Medium	05	U	14,835	22,439		22,439
138	0605145A	Medical Products and Support Systems Development	05	U	927			
139	0605148A	Tactical Intel Targeting Access Node (TITAN) EMD	05	U	54,972	108,987		108,987
140	0605203A	Army System Development & Demonstration	05	U	122,175	143,616		143,616
141	0605205A	Small Unmanned Aerial Vehicle (SUAV) (6.5)	05	U	2,192	6,530		6,530
142	0605206A	CI and HUMINT Equipment Program-Army (CIHEP-A)	05	U				
143	0605216A	Joint Targeting Integrated Command and Coordination Suite (JTIC2S)	05	U				
144	0605224A	Multi-Domain Intelligence	05	U	9,313	6,008		6,008
145	0605225A	SIO Capability Development	05	U	22,713			
146	0605231A	Precision Strike Missile (PrSM)	05	U	181,574	259,506		259,506
147	0605232A	Hypersonics EMD	05	U	107,404	633,499		633,499
148	0605233A	Accessions Information Environment (AIE)	05	U	16,177	10,088		10,088
149	0605235A	Strategic Mid-Range Capability	05	U		5,016		5,016
150	0605236A	Integrated Tactical Communications	05	U		12,447		12,447
151	0605450A	Joint Air-to-Ground Missile (JAGM)	05	U	2,467	2,366		2,366
152	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	U	154,257	263,545		263,545
153	0605531A	Counter - Small Unmanned Aircraft Systems Sys Dev & Demonstration	05	U	49,667	14,892		14,892
154	0605625A	Manned Ground Vehicle	05	U	194,936	554,925		554,925
155	0605766A	National Capabilities Integration (MIP)	05	U	13,454	17,030		17,030

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136	0605143A	Biometrics Enabling Capability (BEC)	05	U	
137	0605144A	Next Generation Load Device - Medium	05	U	36,970
138	0605145A	Medical Products and Support Systems Development	05	U	
139	0605148A	Tactical Intel Targeting Access Node (TITAN) EMD	05	U	132,136
140	0605203A	Army System Development & Demonstration	05	U	81,657
141	0605205A	Small Unmanned Aerial Vehicle (SUAV) (6.5)	05	U	31,284
142	0605206A	CI and HUMINT Equipment Program-Army (CIHEP-A)	05	U	2,170
143	0605216A	Joint Targeting Integrated Command and Coordination Suite (JTIC2S)	05	U	9,290
144	0605224A	Multi-Domain Intelligence	05	U	41,003
145	0605225A	SIO Capability Development	05	U	
146	0605231A	Precision Strike Missile (PrSM)	05	U	272,786
147	0605232A	Hypersonics EMD	05	U	900,920
148	0605233A	Accessions Information Environment (AIE)	05	U	27,361
149	0605235A	Strategic Mid-Range Capability	05	U	348,855
150	0605236A	Integrated Tactical Communications	05	U	22,901
151	0605450A	Joint Air-to-Ground Missile (JAGM)	05	U	3,014
152	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	U	284,095
153	0605531A	Counter - Small Unmanned Aircraft Systems Sys Dev & Demonstration	05	U	36,016
154	0605625A	Manned Ground Vehicle	05	U	996,653
155	0605766A	National Capabilities Integration (MIP)	05	U	15,129

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156	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	U	2,470	9,376		9,376
157	0605830A	Aviation Ground Support Equipment	05	U	1,158	2,959		2,959
158	0303032A	TROJAN - RH12	05	U	3,362	3,761		3,761
159	0304270A	Electronic Warfare Development	05	U	75,520	99,938		99,938
	System Development & Demonstration				**3,178,005**	**4,317,752**	**600**	**4,318,352**
160	0604256A	Threat Simulator Development	06	U	60,749	138,937		138,937
161	0604258A	Target Systems Development	06	U	41,769	64,132		64,132
162	0604759A	Major T&E Investment	06	U	91,130	142,031		142,031
163	0605103A	Rand Arroyo Center	06	U	31,087	33,631		33,631
164	0605301A	Army Kwajalein Atoll	06	U	242,279	309,005		309,005
165	0605326A	Concepts Experimentation Program	06	U	80,386	86,824		86,824
166	0605502A	Small Business Innovative Research	06	U	374,118			
167	0605601A	Army Test Ranges and Facilities	06	U	362,223	417,567		417,567
168	0605602A	Army Technical Test Instrumentation and Targets	06	U	57,584	67,962		67,962
169	0605604A	Survivability/Lethality Analysis	06	U	35,042	36,500		36,500
170	0605606A	Aircraft Certification	06	U	2,398	4,777		4,777
171	0605702A	Meteorological Support to RDT&E Activities	06	U	6,389	6,958		6,958
172	0605706A	Materiel Systems Analysis	06	U	20,771	22,004		22,004
173	0605709A	Exploitation of Foreign Items	06	U	13,631	6,186		6,186
174	0605712A	Support of Operational Testing	06	U	54,797	70,718		70,718

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156	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	U	27,243
157	0605830A	Aviation Ground Support Equipment	05	U	1,167
158	0303032A	TROJAN - RH12	05	U	3,879
159	0304270A	Electronic Warfare Development	05	U	137,186
	System Development & Demonstration				**5,639,364**
160	0604256A	Threat Simulator Development	06	U	38,492
161	0604258A	Target Systems Development	06	U	11,873
162	0604759A	Major T&E Investment	06	U	76,167
163	0605103A	Rand Arroyo Center	06	U	37,078
164	0605301A	Army Kwajalein Atoll	06	U	314,872
165	0605326A	Concepts Experimentation Program	06	U	95,551
166	0605502A	Small Business Innovative Research	06	U	
167	0605601A	Army Test Ranges and Facilities	06	U	439,118
168	0605602A	Army Technical Test Instrumentation and Targets	06	U	42,220
169	0605604A	Survivability/Lethality Analysis	06	U	37,518
170	0605606A	Aircraft Certification	06	U	2,718
171	0605702A	Meteorological Support to RDT&E Activities	06	U	
172	0605706A	Materiel Systems Analysis	06	U	26,902
173	0605709A	Exploitation of Foreign Items	06	U	7,805
174	0605712A	Support of Operational Testing	06	U	75,133

Department of the Army
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Exhibit R-1 FY 2024 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Mar 2023

Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2022 Actuals	FY 2023 Less Supplementals Enactment	FY 2023 Supplementals Enactment*	FY 2023 Total Enactment
175	0605716A	Army Evaluation Center	06	U	65,693	67,058		67,058
176	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	U	2,537	6,097		6,097
177	0605801A	Programwide Activities	06	U	90,443	89,793		89,793
178	0605803A	Technical Information Activities	06	U	31,174	37,652		37,652
179	0605805A	Munitions Standardization, Effectiveness and Safety	06	U	54,922	60,645		60,645
180	0605857A	Environmental Quality Technology Mgmt Support	06	U	1,724	1,912		1,912
181	0605898A	Army Direct Report Headquarters - R&D - MHA	06	U	48,798	53,271		53,271
182	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06	U	78,187	89,602		89,602
183	0606003A	CounterIntel and Human Intel Modernization	06	U	10,641	1,424		1,424
184	0606105A	Medical Program-Wide Activities	06	U	37,616			
185	0606942A	Assessments and Evaluations Cyber Vulnerabilities	06	U	5,466	5,816		5,816
186	0909999A	Financing for Cancelled Account Adjustments	06	U	101			
	Management Support				**1,901,655**	**1,820,502**		**1,820,502**
187	0603778A	MLRS Product Improvement Program	07	U	11,865	18,463		18,463
188	0605024A	Anti-Tamper Technology Support	07	U	8,544	9,284		9,284
189	0607131A	Weapons and Munitions Product Improvement Programs	07	U	39,994	54,674	2,500	57,174
190	0607136A	Blackhawk Product Improvement Program	07	U	14,599			
191	0607137A	Chinook Product Improvement Program	07	U	65,960	67,513		67,513
192	0607139A	Improved Turbine Engine Program	07	U	250,533	228,036		228,036
193	0607142A	Aviation Rocket System Product Improvement and Development	07	U	8,831	11,312		11,312

*Includes enacted funding in the Ukraine Supplemental Appropriation Act, 2023 (Division B of Public Law 117-180) and Additional Ukraine Supplemental Appropriation Act, 2023 (Division M of Public Law 117-328).

Department of the Army
FY 2024 President's Budget
Exhibit R-1 FY 2024 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Mar 2023

Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2024 Request
175	0605716A	Army Evaluation Center	06	U	71,118
176	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	U	11,204
177	0605801A	Programwide Activities	06	U	93,895
178	0605803A	Technical Information Activities	06	U	31,327
179	0605805A	Munitions Standardization, Effectiveness and Safety	06	U	50,409
180	0605857A	Environmental Quality Technology Mgmt Support	06	U	1,629
181	0605898A	Army Direct Report Headquarters - R&D - MHA	06	U	55,843
182	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06	U	91,340
183	0606003A	CounterIntel and Human Intel Modernization	06	U	6,348
184	0606105A	Medical Program-Wide Activities	06	U	
185	0606942A	Assessments and Evaluations Cyber Vulnerabilities	06	U	6,025
186	0909999A	Financing for Cancelled Account Adjustments	06	U	
	Management Support				**1,624,585**
187	0603778A	MLRS Product Improvement Program	07	U	14,465
188	0605024A	Anti-Tamper Technology Support	07	U	7,472
189	0607131A	Weapons and Munitions Product Improvement Programs	07	U	8,425
190	0607136A	Blackhawk Product Improvement Program	07	U	1,507
191	0607137A	Chinook Product Improvement Program	07	U	9,265
192	0607139A	Improved Turbine Engine Program	07	U	201,247
193	0607142A	Aviation Rocket System Product Improvement and Development	07	U	3,014

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(Dollars in Thousands)

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Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2022 Actuals	FY 2023 Less Supplementals Enactment	FY 2023 Supplementals Enactment*	FY 2023 Total Enactment
194	0607143A	Unmanned Aircraft System Universal Products	07	U	4,426	10,512		10,512
195	0607145A	Apache Future Development	07	U	9,700	25,074		25,074
196	0607148A	AN/TPQ-53 Counterfire Target Acquisition Radar System	07	U	46,009	61,559		61,559
197	0607150A	Intel Cyber Development	07	U	3,611	13,343		13,343
198	0607312A	Army Operational Systems Development	07	U	28,029	26,131		26,131
199	0607313A	Electronic Warfare Development	07	U	5,673	6,432		6,432
200	0607315A	Enduring Turbine Engines and Power Systems	07	U				
201	0607665A	Family of Biometrics	07	U	1,101	1,114		1,114
202	0607865A	Patriot Product Improvement	07	U	125,851	152,312		152,312
203	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	U	24,556	19,311		19,311
204	0203735A	Combat Vehicle Improvement Programs	07	U	272,438	194,229		194,229
205	0203743A	155mm Self-Propelled Howitzer Improvements	07	U	168,683	116,510		116,510
206	0203744A	Aircraft Modifications/Product Improvement Programs	07	U	10,000			
207	0203752A	Aircraft Engine Component Improvement Program	07	U	127	148		148
208	0203758A	Digitization	07	U	3,759			
209	0203801A	Missile/Air Defense Product Improvement Program	07	U	122	3,109		3,109
210	0203802A	Other Missile Product Improvement Programs	07	U	9,956	9,027		9,027
211	0205412A	Environmental Quality Technology - Operational System Dev	07	U	253	793		793
212	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	U	58,516	20,180		20,180
213	0208053A	Joint Tactical Ground System	07	U	11,379	8,813		8,813

*Includes enacted funding in the Ukraine Supplemental Appropriation Act, 2023 (Division B of Public Law 117-180) and Additional Ukraine Supplemental Appropriation Act, 2023 (Division M of Public Law 117-328).

Department of the Army
FY 2024 President's Budget
Exhibit R-1 FY 2024 President's Budget
Total Obligational Authority
(Dollars in Thousands)

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Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2024 Request
194	0607143A	Unmanned Aircraft System Universal Products	07	U	25,393
195	0607145A	Apache Future Development	07	U	10,547
196	0607148A	AN/TPQ-53 Counterfire Target Acquisition Radar System	07	U	54,167
197	0607150A	Intel Cyber Development	07	U	4,345
198	0607312A	Army Operational Systems Development	07	U	19,000
199	0607313A	Electronic Warfare Development	07	U	6,389
200	0607315A	Enduring Turbine Engines and Power Systems	07	U	2,411
201	0607665A	Family of Biometrics	07	U	797
202	0607865A	Patriot Product Improvement	07	U	177,197
203	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	U	42,177
204	0203735A	Combat Vehicle Improvement Programs	07	U	146,635
205	0203743A	155mm Self-Propelled Howitzer Improvements	07	U	122,902
206	0203744A	Aircraft Modifications/Product Improvement Programs	07	U	
207	0203752A	Aircraft Engine Component Improvement Program	07	U	146
208	0203758A	Digitization	07	U	1,515
209	0203801A	Missile/Air Defense Product Improvement Program	07	U	4,520
210	0203802A	Other Missile Product Improvement Programs	07	U	10,044
211	0205412A	Environmental Quality Technology - Operational System Dev	07	U	281
212	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	U	75,952
213	0208053A	Joint Tactical Ground System	07	U	203

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FY 2024 President's Budget
Exhibit R-1 FY 2024 President's Budget
Total Obligational Authority
(Dollars in Thousands)

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Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2022 Actuals	FY 2023 Less Supplementals Enactment	FY 2023 Supplementals Enactment*	FY 2023 Total Enactment
216	0303028A	Security and Intelligence Activities	07	U	24,506			
217	0303140A	Information Systems Security Program	07	U	15,680	17,209		17,209
218	0303141A	Global Combat Support System	07	U	43,643	22,600		22,600
219	0303142A	SATCOM Ground Environment (SPACE)	07	U	16,186	18,297		18,297
222	0305179A	Integrated Broadcast Service (IBS)	07	U	5,430	9,926		9,926
223	0305204A	Tactical Unmanned Aerial Vehicles	07	U	8,410	4,500		4,500
224	0305206A	Airborne Reconnaissance Systems	07	U	11,782	17,165		17,165
225	0305219A	MQ-1C Gray Eagle UAS	07	U				
226	0307665A	Biometrics Enabled Intelligence	07	U	2,066			
227	0708045A	End Item Industrial Preparedness Activities	07	U	101,466	132,270		132,270
999	999999999	Classified Programs	07	U	2,993	6,664		6,664
	Operational Systems Development				**1,416,677**	**1,286,510**	**2,500**	**1,289,010**
228	0608041A	Defensive CYBER - Software Prototype Development	08	U	108,041	94,831		94,831
	Software And Digital Technology Pilot Programs				**108,041**	**94,831**		**94,831**
Total Research, Development, Test and Evaluation, Army					**14,660,654**	**17,142,121**	**9,100**	**17,151,221**

*Includes enacted funding in the Ukraine Supplemental Appropriation Act, 2023 (Division B of Public Law 117-180) and Additional Ukraine Supplemental Appropriation Act, 2023 (Division M of Public Law 117-328).

Department of the Army
FY 2024 President's Budget
Exhibit R-1 FY 2024 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Mar 2023

Appropriation: 2040A Research, Development, Test and Evaluation, Army

Line No	Program Element Number	Item	Act	Sec	FY 2024 Request
216	0303028A	Security and Intelligence Activities	07	U	301
217	0303140A	Information Systems Security Program	07	U	15,323
218	0303141A	Global Combat Support System	07	U	13,082
219	0303142A	SATCOM Ground Environment (SPACE)	07	U	26,838
222	0305179A	Integrated Broadcast Service (IBS)	07	U	9,456
223	0305204A	Tactical Unmanned Aerial Vehicles	07	U	
224	0305206A	Airborne Reconnaissance Systems	07	U	
225	0305219A	MQ-1C Gray Eagle UAS	07	U	6,629
226	0307665A	Biometrics Enabled Intelligence	07	U	
227	0708045A	End Item Industrial Preparedness Activities	07	U	75,317
999	999999999	Classified Programs	07	U	8,786
	Operational Systems Development				**1,105,748**
228	0608041A	Defensive CYBER - Software Prototype Development	08	U	83,570
	Software And Digital Technology Pilot Programs				**83,570**
Total Research, Development, Test and Evaluation, Army					**15,775,381**

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 2024 Army												Date: March 2023
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*							
COST ($ in Millions)	**Prior Years**	**FY 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
Total Program Element	-	358.521	391.642	296.670	-	296.670	309.571	320.379	340.802	350.897	0.000	2,368.482
AA1: *ILIR - AMC*	-	10.486	11.532	11.758	-	11.758	12.070	12.084	12.092	12.224	0.000	82.246
AA2: *ILIR - SMDC*	-	0.957	1.039	1.068	-	1.068	1.096	1.073	1.074	1.086	0.000	7.393
AA3: *Single Investigator Basic Research*	-	86.464	97.025	108.599	-	108.599	107.794	112.803	123.367	127.116	0.000	763.168
AA4: *Training and Human Science Research*	-	20.862	22.180	21.024	-	21.024	21.026	20.979	24.112	24.397	0.000	154.580
AA5: *Biotechnology and Systems Biology*	-	5.842	6.421	6.547	-	6.547	6.614	6.622	9.555	9.518	0.000	51.119
AA6: *Robotics and Mobile Energy*	-	19.857	21.854	25.268	-	25.268	27.467	27.511	27.538	27.811	0.000	177.306
AA7: *Mechanics and Ballistics*	-	32.114	35.234	35.014	-	35.014	35.482	35.525	37.889	38.635	0.000	249.893
AA8: *Sensing and Electromagnetics*	-	13.092	13.619	16.383	-	16.383	26.083	31.647	29.340	33.406	0.000	163.570
AA9: *Information and Networking*	-	38.956	42.839	43.075	-	43.075	43.520	43.568	46.644	47.199	0.000	305.801
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	36.137	4.405	4.508	-	4.508	4.664	4.641	4.644	4.696	0.000	63.695
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	17.311	19.201	19.564	-	19.564	19.860	20.026	20.644	20.863	0.000	137.469
CH9: *Advancing Concepts and Technology Forecasting*	-	3.443	3.793	3.862	-	3.862	3.895	3.900	3.903	3.946	0.000	26.742
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	73.000	112.500	-	-	-	-	-	-	-	0.000	185.500

A. Mission Description and Budget Item Justification

This Program Element (PE) builds fundamental scientific knowledge contributing to the sustainment of United States (US) Army scientific and technological superiority in land warfighting capability and to solving military problems related to long-term national security needs, investigates new concepts and technologies for the Army's future force, and provides the means to exploit scientific breakthroughs and avoid technological surprises. This PE fosters innovation in Army niche areas (e.g., lightweight armor, energetic materials, and night vision capability) and areas where there is no commercial investment due to limited markets (e.g., vaccines for tropical diseases).

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

It also focuses university single investigator research on areas of high interest to the Army (e.g., high-density compact power and novel sensor phenomenology). The in-house portion of the program capitalizes on the Army's scientific talent and specialized facilities to transition knowledge and technology into appropriate developmental activities. The extramural program leverages the research efforts of other government agencies, academia, and industry. This PE also supports basic research at the Army laboratories through the In-House Laboratory Independent Research (ILIR) program. The ILIR program serves as a catalyst for major technology breakthroughs by providing laboratory directors flexibility in implementing novel research ideas, by nurturing promising young scientists and engineers, and is used to attract and retain top doctoral degreed scientists and engineers. The ILIR program also provides a source of competitive funds for peer reviewed efforts at Army laboratories to stimulate high quality, innovative research with significant opportunity for payoff to Army warfighting capability. This PE also identifies emerging and disruptive basic scientific research outcomes in order to translate, integrate, and ingrain research outcomes with Army Warfighting Concepts which describe how the Army will fight in the far-term future.

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

B. Program Change Summary ($ in Millions)	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total
Previous President's Budget	368.751	279.328	283.521	-	283.521
Current President's Budget	358.521	391.642	296.670	-	296.670
Total Adjustments	-10.230	112.314	13.149	-	13.149
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	112.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-10.230	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	13.149	-	13.149
• FFRDC Transfer	-	-0.186	-	-	-

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

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

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2022	FY 2023
Congressional Add: *Unmanned Aerial Systems Propulsion*	5.000	-
Congressional Add: *Program Increase - ARTIFICIAL INTELLIGENCE (AI) FUSION*	-	2.500
Congressional Add: *Program Increase - BASIC RESEARCH*	-	25.000
Congressional Add: *Program Increase - CENTER FOR UAS PROPULSION*	-	5.000
Congressional Add: *Program Increase - COUNTER UAS TECHNOLOGY RESEARCH*	-	5.000
Congressional Add: *Program Increase - HIGH ENTROPY METALLIC ALLOYS*	-	5.000
Congressional Add: *Program Increase - RENEWABLE ENERGY TECHNOLOGIES*	-	15.000
Congressional Add: *Program Increase - SUSTAINABLE AVIATION FUEL PROPULSION*	-	7.500
Congressional Add: *Program Increase - UNMANNED AERIAL SYSTEMS HYBRID PROPULSION*	-	10.000
Congressional Add Subtotals for Project: T14	73.000	112.500
Congressional Add Totals for all Projects	73.000	112.500

Change Summary Explanation

Increased funding to support basic research enhancements for strategic competition.

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA1 / *ILIR - AMC*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA1: *ILIR - AMC*	-	10.486	11.532	11.758	-	11.758	12.070	12.084	12.092	12.224	0.000	82.246

A. Mission Description and Budget Item Justification

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

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

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Conduct research on methods to simulate breakup, ablation, and component connectivity change on novel composite structural materials for light weight armament systems. Conduct research on methods to directly model surface texture and its modification to alter mechanical response. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Structural Materials - ILIR within this Project.			
Title: Tank Automotive Research, Development and Engineering Center (TARDEC) ***Description:*** This effort funds basic research in ground vehicle technologies that include power, mobility, autonomous systems, materials and manufacturing. ***FY 2023 Plans:*** Conduct competitively-selected, basic, in-house research to improve the fundamental understanding of ground vehicles and establish the underlying physics in such areas as semi- and fully autonomous vehicles; soft soil mobility modeling; active protection and signature management; advanced combustion engine thermal control; multi-physics battery modeling and simulation; lightweight materials and additive manufacturing; corrosion modeling; cognitive loading and crew station design; vehicle control systems; and cybersecurity threat detection. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Advanced Mobility - ILIR within this Project.	1.189	1.294	-
Title: Natick Soldier Research, Development and Engineering Center (NSRDEC) ***Description:*** This effort funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection. ***FY 2023 Plans:*** Examine the effects of diverse food forms (e.g. varied compression and lipid levels) on human systems and perception to understand the impact of condensing and altering combat ration components in support of improved Soldier performance and sustainment. Characterize optoelectronic and electronic properties of two-dimensional materials (MXenes) and investigate molecular structure-function relationships. Interpret results to advance understanding related to the use of unique two-dimensional materials for controlling conductivity and EMI shielding efficiency. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Functional Materials - ILIR within this Project.	1.112	1.214	-
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts (AMRDEC-MI)	2.310	2.460	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Description: This effort funds the underlying fundamental science of Lethality and Protection Superiority for guided missile and rocket systems, directed energy weapons, unmanned vehicles, and related components. ***FY 2023 Plans:*** Explore the fundamental nature of complex dynamics in networks of coupled identical oscillators using the experimental unclocked Boolean circuit for secure communications and device protection; continue to explore and begin experimentation with compressive sensing techniques based on deep learning methods to augment existing sensor suites and maximize information collected from sensor hardware while reducing size, weight, power, and cost (SWAP-C); continue basic research into advanced modeling techniques to investigate, simulate, and fabricate new proof-of-principle designer devices and artificial materials to enable disruptive opto-electro-plasmonic systems for sensors and devices for sensor protection and masking; study the role of temperature on noise and entangled photon generation in a Josephson junction based quantum integrated circuit; investigate the fundamental models that could enable the use of machine learning techniques to predict new materials and the provide direction for their synthesis. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Optical Electronics - ILIR (Aviation and Missile Center, Missile Technology) within this Project.			
Title: Aviation and Missile Research, Development and Engineering Center: Aviation Efforts (AMRDEC-AV) ***Description:*** This effort funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science. ***FY 2023 Plans:*** Develop a permeable-surface acoustics formulation that will accurately capture the acoustic scattering and shielding effects due to impingement of pressure waves on solid surfaces prevalent in emerging configurations with multiple rotors/propulsors and lifting surfaces; conduct experimental tests to better understand fundamental behavior of single and coaxial propeller over a range of configurations and operating conditions. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Sol Struct Mech - ILIR within this Project.	1.327	1.436	-
Title: Communications Electronics Research and Engineering Directorate (CERDEC) ***Description:*** Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors. ***FY 2023 Plans:***	2.154	2.298	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Research unconventional vision-aided landmark navigation using spectral signature beacons; investigate methods for wireless power transfer; study thermal runaway inhibitors to reduce cell charge transfer at elevated temperatures in lithium-ion batteries; investigate algorithms to fuse different aspects of Lidar and Radar data for improve target tracking; characterize and analyze material inhomogeneity in type-II superlattice materials for infrared detectors; investigate the use of electron channeling contrast imaging (ECCI) to identify and characterize crystalline defects in epitaxial materials grown for infrared detectors; investigate atmospheric properties of the intraThermal Infrared (intraTIR) spectral band (4.5 - 8.5 um). ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Comms Cyber IR RF-ILIR within this Project.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.227	-
Title: Chemical Materials - ILIR ***Description:*** Basic research in chemistry, biology, biotechnology, toxicology, material science, and aerosols for creating the science base needed for countering improvised explosive devices (IEDs), explosives forensics, obscurants, sensing, advanced materials, and defeating targets. ***FY 2024 Plans:*** Will conduct competitively selected basic research on chemical and biological phenomenology to expand the body of knowledge and serve as the foundation for characterizing, assessing, and protecting against emerging threats; study basic principles of biological systems to broaden our understanding of detection and our ability to exploit these principles to aid in detection; expand the employment of artificial intelligence, machine learning, and predictive modeling to include computation tools that analyze novel biological and chemical synthetic pathways in the identification of novel precursors, materials, or threats. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Edgewood Chemical Biological Center (ECBC) within this Project.	-	-	1.081
Title: Structural Materials - ILIR ***Description:*** Funds basic research in weapons component physics, explosives synthesis/detection, and the fundamental science base of area denial.	-	-	1.590

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
FY 2024 Plans: Will research chemical sciences, computational sciences, life sciences, and material sciences for structural materials related to armament systems; study intermolecular interactions and kinetics related to energetic and organic solids; explore optical computing methods, distributed deep fusion, and algorithms for object detection, target recognition, and component collaboration. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Armaments Research, Development and Engineering Center (ARDEC) within this Project.			
Title: Advanced Mobility - ILIR ***Description:*** This effort funds basic research in ground vehicle technologies, including power, mobility, and unmanned systems. ***FY 2024 Plans:*** Will competitively select in-house basic research topic areas and use them to advance fundamental scientific understanding in support of ground vehicle systems, including: control systems for vehicles, autonomous systems control and characterization, lightweight and composite materials, additive manufacturing, multi-physics energy conversion modeling, hydrodynamic modeling, and internal combustion heat transfer modeling. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Tank Automotive Research, Development and Engineering Center (TARDEC) within this Project.	-	-	1.328
Title: Functional Materials - ILIR ***Description:*** This effort funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection. ***FY 2024 Plans:*** Will explore nonlinear optical properties of bio-inspired small-molecule materials towards advancement of responsive material systems for sensing and energy harvesting; use machine learning to establish a high-dimensional mathematical model of 3-D fluid-structure interaction dynamics of braided cords. Resulting models will inform strategies to reduce guided parachute drag and innovative methods for controlling, or even harvesting the energy from, cable vibrations to improve airdrop accuracy. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Natick Soldier Research, Development and Engineering Center (NSRDEC) within this Project.	-	-	1.240
Title: Optical Electronics - ILIR ***Description:*** This effort funds the underlying fundamental science of Lethality and Protection Superiority for guided missile and rocket systems, unmanned vehicles, and related components.	-	-	2.630

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Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
FY 2024 Plans: Will investigate the use of emerging information theoretic quantities and statistical approaches to understand their potential utility for advanced sensing techniques; continue basic research into the effects of the free electron layer on light-matter interactions at metal-vacuum boundaries to inform its use in next generation metamaterial design for sensors and devices for signal detection, sensor protection, and masking; study the fundamental characteristics of radio frequency signals containing entangled photons to provide a basis for an assessment of their potential for advanced sensing applications; explore and model key chemical functional groups enhancing molecular interactions between the Nitrocellulose polymer and plastic fillers (e.g., ionic liquid plasticizers, ionic solids, and novel nano materials) to inform the design of next generation multifunctional energetic materials; explore the nature of noise propagation through continuous time digital signal processing techniques to provide a foundational understanding that could enable a more comprehensive comparison of these techniques against traditional digital signal processing techniques. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Aviation and Missile Research, Development and Engineering Center: Missile Efforts (AMRDEC-MI) within this Project.			
Title: Sol Struct Mech - ILIR ***Description:*** This effort funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science. ***FY 2024 Plans:*** Will combine visualization and high fidelity flow measurements of secondary vortex structures present in rotor wakes to develop a fundamental understanding of their formation, evolution, and associated instabilities; explore new mathematical formulations and algorithms for higher-order near-body solvers as a building block for a truly higher-order overset computational fluid dynamics solution framework. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Aviation and Missile Research, Development and Engineering Center: Aviation Efforts (AMRDEC-AV) within this Project.	-	-	1.480
Title: Comms Cyber IR RF-ILIR ***Description:*** Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors. ***FY 2024 Plans:*** Will conduct research on tunable dielectric materials that will be created by deposition by Pulsed Laser Deposition (PLD) and Magnetron Sputtering and Molecular Beam Epitaxy (MBE); investigate Jet Propellent 8 (JP8) reforming catalyst and processes to	-	-	2.409

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
augment the decomposition of contaminants, while minimizing the use of noble metals to broaden potential fuel sources for fuel cells; conduct research on the band structure engineering of low cost perovskite materials and their potential applications in ultra-high power conversion efficiency multi-junction photovoltaic devices; conduct research to modify and characterize the interface between plasma enhanced atomic deposition layer and III-V infrared detector material layer to optimal surface preparations for strained layer superlattices infrared detector test devices. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Communications Electronics Research and Engineering Directorate (CERDEC) within this Project.			
Accomplishments/Planned Programs Subtotals	10.486	11.532	11.758

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA2 / *ILIR - SMDC*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA2: *ILIR - SMDC*	-	0.957	1.039	1.068	-	1.068	1.096	1.073	1.074	1.086	0.000	7.393

A. Mission Description and Budget Item Justification

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: SMDC In-house Laboratory Independent Research (ILIR)	0.957	1.015	1.068
Description: This effort provides ILIR at USASMDC-TC. This basic research on lasers and directed energy lays the foundation for future developmental efforts on high energy lasers and directed energy systems by identifying the fundamental principles governing various directed energy phenomena with the goal of developing technologies that will significantly reduce size, weight and power requirements for laser systems.			
FY 2023 Plans: Will expand atmospheric propagation data collection to include slant and vertical path to investigate the boundary layer as a function of time of day, weather conditions, solar loading, and terrain parameters. Will expand models to better match data. Will collect data using the Ultra Short Pulsed Lasers (USPL) lab capability to investigate propagation and filamentation phenomenology and material interaction.			
FY 2024 Plans: Continue Basic Research of DE Technologies. Will compare vertical path optical turbulence boundary layer data to advanced models with a high fidelity of accuracy in location, terrain, and meteorological data as inputs. Update Numerical theory as data is			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
fitted to current models. Will evaluate data collected with the Ultra Short Pulsed Lasers (USPL) to better understand the interaction with the atmosphere and other materials to better understand the applicability of weaponization. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.024	-
Accomplishments/Planned Programs Subtotals	0.957	1.039	1.068

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army											Date: March 2023	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA3 / *Single Investigator Basic Research*			
COST ($ in Millions)	**Prior Years**	**FY 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
AA3: *Single Investigator Basic Research*	-	86.464	97.025	108.599	-	108.599	107.794	112.803	123.367	127.116	0.000	763.168

A. Mission Description and Budget Item Justification

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Basic Research in Life Sciences	10.115	10.975	11.721
Description: This effort fosters fundamental discoveries in life sciences with the ultimate goal of facilitating the development of novel biomaterials to greatly enhance Soldier protection and performance. More specifically, i) molecular genetics research that pursues fundamental studies in molecular and systems biology, and genetics, ii) neurosciences research to investigate the physiology underlying perception, neuro-motor output, and potential methods of monitoring cognitive states during activity, iii) biochemistry research focused on studies in structural and cell biology, metabolic processes, and biophysics, iv) research in microbiology that pursues studies in microbial physiology, ecology, and evolution, v) social science research that aims to elucidate the social, cultural, and other influences to human actions, and vi) auditory and signal processing research that maps the cognitive implications of multisensory information integration.			
FY 2023 Plans: Will dissect and characterize the L-form phenotype in specific prokaryotes to be able to induce it temporarily or permanently as a key step forward for bioengineering, as L-form prokaryotes induce less or no host response and are anticipated to be able to better release their payload, that if successful may enable the Army to produce new types of materiel and to enable new systems for better warfighter protection; attach nickel catalysts and photocatalysts to a variety of specific bioconjugation sites within different cross-linked protein crystals and characterize the structures and catalytic properties of the resulting hybrid materials			

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
that if successful, will be a key step toward using porous protein frameworks as scaffolds to organize dual abiotic catalysts to enable new-to-nature chemical transformations for the synthesis of Army-relevant materials including energetic materials, precursors to energetic materials, polymers, and composites; measure the native growth activity of microbial communities in cold region ecosystems and provide the foundation for establishing how microbial activity in these cold environments responds to environmental change which, if successful, will contribute to the Army's strategy in regaining Arctic dominance by providing the Soldier with new tools to assess the impact of warming in Arctic environments on the integrity of infrastructure assets in these regions; measure changes in brain oxygenation with a genetically encoded bioluminescence reporter in rodents, that if completed will offer a precise tool to determine whether sleep deprivation affects oxygen tension under operationally-relevant functional tasks and pave a path to link overall brain metabolism with Soldier cognitive performance and the impacts of brain aging on resilience to disease or sleep deprivation. ***FY 2024 Plans:*** Will determine how interspecies electron transfer influences the architecture of a microbial community on an electrode, that if successful may enable the development and control of novel biofilms for improved microbial fuel cells and bioelectrical sensors; investigate the neurophysiological mechanisms that enable human and non-human primates to monitor and recognize other's emotions and exploit this information to regulate one's own behavior during social interactions in close-to-natural contexts that if successful, will inform models of human-human teaming and training; determine the genetic and external factors that influence mitochondrial cellular thymidylate synthesis that lead to changes in mitochondrial genome integrity and mitochondrial function, which if successful will enable non-invasive strategies that reduce mitochondrial damage in order to be able to meet the energy demands of brain and muscle tissues to enable optimization of soldier cognitive and physical performance capabilities; determine the role of hydrophobic-hydrophilic balance in guiding shape-change of silk-elastin copolymers in response to specific stimuli, and to modulate the kinetics of these changes, that if successful may provide the foundation for tailored biomaterial properties for future sensors, functional coatings, and on-demand material manufacturing. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Basic Research in Chemical Sciences	10.950	10.361	10.587
Description: This effort fosters basic research to achieve advanced energy control, improved threat detection, and novel responsive materials for Soldier protection. Research efforts will lead to: light-weight, reliable, compact power sources, more effective, lower vulnerability propellants and explosives for tailored precision strikes with minimum collateral damage, new approaches for shielding the Soldier and Army platforms from ballistic, chemical, and biological threats, and reducing signatures for identification by the enemy, and advance warning of explosive, chemical, and biological weapons and dangerous industrial chemicals. ***FY 2023 Plans:***			

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will identify the physical limitations to the rate of water dissociation in bipolar membranes and how they can be used to pass ionic current commensurate with currents observed in practical reversible fuel cells that if successful, will potentially enable the next generation of polymer electrolyte fuel cells with the goal of reducing soldier-borne weight associated with power generation; develop a quantitative model that links the molecular structures, adsorption strengths, and oxidation kinetics of organics in the aqueous phase of complex environmental matrices that if successful, will be a key step towards designing novel waste stream remediation technologies or reducing corrosion rates and surface film formation to protect the Soldier and materiel; integrate polymer science and biostatistical sequence analysis to better understand the fundamental design rules needed to rationally design polymeric materials to effectively interface with biological proteins that if successful, may lead to new functional hybrid biomaterials with enhanced stability and activity of proteins in non-biological environments, enabling new technologies for energy harvesting and conversion, catalysis, sensing, and bioremediation. ***FY 2024 Plans:*** Will elucidate the organization and dynamics of confined fluids in nanoporous environments at freezing conditions to probe the mechanisms underlying the immobilization of contaminants such as aqueous hydrocarbons and gasses such as carbon dioxide and methane, that if successful will enable improved storage for hydrocarbon fuels in cold climates; uncover the molecular-level mechanism of reconfiguration in self-healing and reconfigurable materials from both single layer materials and multi-layer self-healing structures that if successful, will enable the design of future materials for use in sensors and chem-bio defense applications; synthesize high entropy perovskite oxide nanosheets that are large area, high quality, and ultrathin and assess candidate 2D oxide nanosheets for their potential as electrocatalysts, that if successful will enable increased performance and functionality in future electrochemical energy conversion devices including batteries, fuel cells, electrolyzers, and chemical sensors. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Basic Research in Physics	11.522	12.488	13.220
Description: This effort fosters research in many subfields of physics, including condensed matter physics, optical physics, atomic and molecular physics, and quantum information, with an emphasis on discovering new realms of quantum and optical phenomena. Pursuit of fundamental physics in these subfields provides new opportunities for future developments in superior optics, ultra-sensitive sensors, and novel electronic architectures for classical and quantum computing. ***FY 2023 Plans:*** Will devise new theoretical approaches for analyzing quantum systems using light-matter coupling through the tuning of material properties via strong coherent coupling to vacuum fluctuations of terahertz (Thz) metamaterials and analyze properties of electrons in mono- and twisted bilayer two-dimensional materials embedded in terahertz cavities that if successful will enable the creation of materials with new functionalities for sensing, information storage, and processing; advance recent demonstrations			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
of second-order nonlinear interactions in Aluminum Nitride (AlN) optical parametric oscillators (OPO) by utilizing chip-based coherent sources of light in the visible (VIS) and near-infrared (NIR) to construct broadband, self-referencing optical frequency combs that if successful, will enable fieldable light sources able to provide precise frequency standards for inertial sensors with increased sensitivity; identify challenges associated with the nature of fundamental structural and electronic microwave properties of superconductor-semiconductor interfaces to work toward optimal interfaces for qubits that if successful, will possess properties ideal for quantum computation platforms that are amenable for scaling up to the number of qubits necessary to carry out computations of Army relevance such as those related to optimization, logistics, and advanced material simulation. ***FY 2024 Plans:*** Will systematically study the potential of a novel quantum-optical neuromorphic optimization implementation which employs a unique multimode cavity to couple atoms via intracavity photons to act as an associative memory that, if successful, may serve as a fundamental neural network suitable for use in optimization problems, such as Army logistics, distribution, and routing on the battlefield; assess a new class of matter-wave interferometer in which ultracold lithium atoms are continuously trapped in a modulated lattice with a sculpted band structure to enable the attainment of new regimes of precision and control that if successful, will enable new methods for precision inertial navigation; determine the rules and guidelines for developing volumetric meta-optics and investigate both the opportunities and challenges provided by the 3D optical design space that if successful, will enable new sensing methods in the future battlefield. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Basic Research in Electronics and Photonics	8.453	9.324	9.312
Description: This effort fosters discoveries in electronic sensing, optoelectronics, solid state and high frequency science, electromagnetics, microwaves, and power electronics for situational awareness, communications, information processing, electro-magnetic warfare, and power efficiency. ***FY 2023 Plans:*** Will study the fundamental structure/property relationship between metasurface geometries and Silicon Germanium Oxide (SixGeyO1-x-y) sensing layers for uncooled microbolometers that if successful, will enable improved sensitivity and resolution in night vision imaging systems; investigate ultrafast dynamics and coherent control on the surfaces of Weyl semimetals using a novel terahertz scanning tunneling microscope technique that if successful, may lead to new electronic device concepts capable of operating at THz frequencies supporting next generation high bandwidth communication systems; study extracellular bioelectrical stimulation and theoretical modeling with other published technologies to understand the impact of extracellular bioelectric fields on the structures and functions of intracellular liquid condensates that if successful, may lead to new insights and therapies for traumatic brain injury; investigate silicon nitride on lithium niobate as an optoelectronics materials platform along with the necessary design, fabrication, and characterization processes to validate the material's unique capabilities for realizing			

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
modulator architectures with unprecedented performance that if successful, will enable high performance computing hardware for artificial intelligence (AI) applications such as target recognition or natural language processing; study the nature of magnetic coupling across interfaces between topological materials and magnetic materials that if successful, will provide a foundation for new energy efficient electronic technologies that will enable Soldiers and small systems to extend mission length and reduce dependence on extensive portable power systems. ***FY 2024 Plans:*** Will explore the ability to stack-engineer the interaction between vibrational motion and electronic states in van der Waals thin layers that if successful could enable new quantum sensors; study the electrical impedance of biological cells over a broad range of frequencies under mechanical stimulation that if successful could lead to new ways of manipulating cell behavior; examine the use of balanced coherent detection to enhance photonic analog tensor accelerators that if successful could improve the accuracy and speed of artificial neural networks; study the relationship between the circular photogalvanic effect in topologically non-trivial materials and the heterostructure configuration that if successful could enable new smaller polarization sensitive photodetectors; investigate comprehensive mapping of bioelectric fields and engineer consciousness down to a single cell level, via precisely understood and controlled bioelectric fields in a community of cells. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding decrease reflects the planned lifecycle of this effort.			
Title: Basic Research in Materials Sciences ***Description:*** Research that provides innovations in materials design and process through the elucidation of fundamental relationships linking composition, microstructure, defect structure, processing and properties of materials. Revolutionary materials provide support for the Army in firepower, mobility, communications, personnel protection, infrastructure and installations, and will directly affect virtually all mission areas. ***FY 2023 Plans:*** Will investigate the ability of polystyrene sulfonate and polyacrylic acid microgels to selectively sequester and release colistin and polypeptide-based anti-microbials using optical microscopy, electron microscopy, and computer simulations that could be used to tune these chemical interactions so that the microgels release their cargo in response to biologically and environmentally relevant changes in pH and ionic strength that if successful, could enable self-disinfecting surfaces, advanced surgical treatments, or systems for chemical-biological defense; identify thermodynamic, electronic, magnetic, and piezoelectric properties of twodimensional transition metal silicates and calculate oxidation states of the transition metals that if successful, will enable low power, more resilient electronics; identify phase transformation mechanisms of two dimensional materials under pressure and transition to structures with extraordinary mechanical properties that if successful, could enable Soldier protection systems which actively increase stiffness and strength in response to extreme events like blast and impact; conduct experiments to characterize the local heating stages of an ultrasonic consolidation method that is expected to enable safer processing of energetic materials	10.809	13.315	14.089

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
in order to understand the relationships between the processing conditions and the resulting material's microstructure and properties; develop supramolecular, nano-porous peptide materials that undergo localized reconfiguration upon selectively binding of target molecules that if successful, may lead to sensitive sensor platforms for Army needs in chemical and biological warfare agent detection. ***FY 2024 Plans:*** Will investigate the use of self-assembly techniques to create colloidal crystals with "diamond lattice" symmetry to fabricate photonic crystals with a full 3D photonic band gap at infrared and optical frequencies that if successful, could enable new classes of materials for applications in directed energy, control over thermal and optical emission, and 3D integrated photonic circuits; determine if and how responsive peptide crystals can exhibit induced fit binding and reactivity as enzyme-inspired catalytic materials to support condensation reactions, which if successful, will provide new molecular sensing modalities and reconfigurable systems and materials; investigate the physics of rigid granular flow through mechanical experiments on 3D systems of complex-shaped grains and through discrete element modeling that if successful, could enable damage adaptive Soldier and vehicle protection systems or reconfigurable robotic platforms; employ atomistic theoretical modeling approaches and realistic simulations to understand light-matter interactions in advanced materials such as functional dipolar systems that if successful, will enable novel opto-ferroic devices, especially ultrafast, nonvolatile ferroelectric memories; conduct vibration experiments to create ordered arrangements of spherical particles as templates for polymer and metallic lattice structures designed to provide high mechanical strength at extremely low mass that if successful, will establish a new processing method for the fabrication of extremely lightweight macroscale structural concepts that previously have only been fabricated at the microscale. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Basic Research in Mechanical Sciences ***Description:*** This effort focuses on improved understanding of propulsion and combustion for improved efficiency and fuel flexibility, energetics initiation for insensitive munitions, fluid dynamics for rotorcraft, complex dynamic systems for novel sensors, energy generation and multi-dimensional systems, and solid mechanics especially at high strain rates in composite materials for novel armor and protection systems. ***FY 2023 Plans:*** Will derive precursors for the prediction of flow instabilities leading to separation around airfoils using partially observed states and validate a rigorous framework for the prediction of extreme events for specified quantities of interest, using partially observed states that if successful, will improve the control and maneuverability of rotorcraft; study how thermodynamic forces and information processing drive adaptive, emergent, and intrinsic computation in intelligent systems that if successful, could yield self-adapting autonomous systems; investigate high-pressure deformation mechanisms and constitutive behavior at grain boundaries, intermetallic inclusions, and nanoscale precipitates in aluminum 7075 that if successful, could enable lighter weight vehicle armor;	8.421	9.124	11.248

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
assess the hypothesis that crystallographic orientation and particle morphology are major contributors to fracture behavior of single and multiple silica sand particles during high strain rate loading and if successful, has the potential to improve the ground penetration of projectiles. ***FY 2024 Plans:*** Will study the flow physics of force generation and aeroacoustic noise of small rotors that if successful could enable new modeling and analysis tools for improving small rotorcraft; investigate principles of dual energy and information processing in far-from-equilibrium systems such a robot swarms that if successful could enable robotic materials with computational abilities; construct a novel physics-based crystal plasticity model of precipitation-strengthened metals which if successful could enable new lightweight materials for protection; study how high-frequency seismic waves are produced in sheared granular flow which could enable better understanding and sensing of the seismic signature of ground vehicles; develop new mathematically robust computational tools and the corresponding validative experiments to predict complex material phenomena and behaviors in extreme environments. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research into computational tools for materials behavior in extreme environments.			
Title: Basic Research in Computing Sciences ***Description:*** This effort provides the backbone for performing complex, multi-system analysis, modeling, and simulation for understanding information systems. Advancements in computer sciences have a direct impact on enhancing the Warfighters' decision-making and situation awareness. ***FY 2023 Plans:*** Will explore the theoretical underpinnings of vulnerabilities of deep learning and create robust methodology to defend against potentially backdoored Deep Neural Networks that if successful, will enable the detection of the presence of adversarial triggers (backdoors) and to accurately recover the correct output label even when presented with a poisoned/adversarial input; develop a dynamic learning framework that effectively extracts Activity-Based Intelligence in highly complex and plausible military operations, specifically, Dynamic Scene Graphs over large-scale multimodal time series data may be such a candidate for representation learning; determine how systems that serve as the backbone of modern computing infrastructure can exploit heterogeneous storage to achieve faster performance at a lower cost by incorporating heterogeneous storage into databases, which are a core system of any computing application in any environment; investigate how meta-learning and multi-task learning methods can adapt to both changes in the environment and changes in specific tasks by developing online meta-learning methods that can use past experiences of adapting to changes in the environment and task and by distilling this past experience into a compositional and modular multi-task representation. ***FY 2024 Plans:*** Will explore extending causal modeling to describe a much larger class of phenomena and show how causality can be applied to a variety of domains, including security and fairness that if successful, could discover meaningful relationships from data,	6.342	7.358	7.335

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
assessing system failures, determining fairness, and building robust and secure autonomous software agents; develop a framework that will feature an expert-in-the-loop capability to address the challenges related to building causal models that if successful, could disentangle cause-effect relations from observational data to both predict and explain affective polarization; develop a geometric terrain model for natural terrain that extracts, learns, and compresses topological features and supports scalability and fast information retrieval that if successful, could produce novel approaches to modeling the terrain for use in the autonomous vehicles and modern intelligence gathering; develop a comprehensive theoretical and algorithmic framework for learning fine-grained instructions from uncurated long procedural videos with minimal to no supervision that if successful, could enable more robust human-agent teaming by increasing the throughput for training new skills of the machine. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding decrease supports planned lifecycle of this effort.			
Title: Basic Research In Network Sciences	10.453	11.470	12.017
Description: This effort focuses on gaining an understanding of the fundamental aspects of how networks develop, function, and adapt to the environment and the rate of information flow in man-made and naturally occurring networks. This understanding will have a direct impact on net-centric force operations, such as better communication system design and operations, and more efficient logistics or communications support. ***FY 2023 Plans:*** Will develop wireless networking algorithms for ultra-reliable-low-latency communications with various constraints, such as strict deadline constraints and age of information constraints, facilitated by network function virtualization, starting with single hop contention based network and working towards multi-hop wireless; develop multi-Agent Reinforcement Learning algorithms in networked autonomous systems that operate in dynamic, uncertain, and possibly adversarial environments to support autonomous behavior of agents working in concert to accomplish a mission, including transfer learning for agents from each other, as well as learning the objectives of other agents from their actions and identify agents whose objectives might diverge from the mission goals; explore control methodologies to reduce the error rates of qubits in quantum systems to enable scalable quantum computers and efficient quantum communication systems; investigate quantum error correction codes to ensure that they can produce useful virtual qubits from a practically realizable number of physical qubits; assess human-agent teaming to reduce errors associated with knowledge handoffs during human shift changes in complex intelligence activities, with specific focus on reduction in the risk inherent in human processing of intelligence, particularly in settings where the body of information is so complex it requires a team of analysts to execute the mission; investigate the use of interactive agents to assess the impact on communication and coordination problems such as blind spots, biases, and human-introduced inaccuracies during shift handovers of intelligence work; develop a method to use Neural Networks to identify events, given that identification of events depends on contextual information, and how to bring the context into Deep Neural Networks while processing text. ***FY 2024 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will leverage advances in dynamic analysis, machine learning, cognitive models, and adaptive planning and control to synthesize, plan, assess, and adapt deception mechanisms with minimal human intervention to manipulate and mislead adversarial decision making that if successful, could lead to degrading adversarial decision making or situational awareness; develop novel computational methods to facilitate maximum likelihood estimation when more than half of the network data is missing that if successful, could enable more accurate situational awareness of a given social network from less intelligence data; develop an information theory of multidimensional spatial networks, extending into two- and three-dimensions, particularly spatial network entropy that if successful, could be applied to problems such as wireless communications network topology compression to increase robustness of those networks; develop concepts and methods to model and control networked oscillatory systems with potential applications in computing, power systems, and biology that if successful, could enable novel methods in decision and control theory; investigate methods and techniques that will enable spectrum space radio frequency (RF) signal interrogation and the subversion of the sensing and computational components of systems that if successful, could prevent the identification and tracking (surveillance) of mission personnel; research the interaction between adversarial statistical signal processing and inverse reinforcement learning in cognitive sensing that if successful, could lead to a reconfigurable sensor that dynamically adapts its sensing mechanism by using stochastic control to optimize its sensing resources; investigate co-design of communications and radar signals so they to coexist that if successful, could reduce radar and communication interference while maintaining each having its own individual signal. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Basic Research in Mathematical Sciences	7.011	7.868	8.173
Description: This effort fosters the creation of new mathematical tools and methods for performing complex, multi-system analysis and modeling to enhance Soldier and weapon-system performance. More specifically, the focus is on creating mathematical principles and practical algorithms for stochastic analysis and control, analysis and control of biological systems, numerical computation of infinite-dimensional systems, and modeling of irregular geometric and social phenomena. ***FY 2023 Plans:*** Will develop new methods for manipulating and synthesizing large amounts of noisy data to characterize in a more mathematically structured form, and therefore a form that may be ultimately more useful in applications; investigate the foundations of mathematics based on type theory in order to develop a fusion of logic and computation that is capable of developing scale-bridging mathematical modeling methodologies; will solve some of the key difficulties in heterogeneous data analysis like the individual difficulties of identifying what portions of the data are related and which are not, and then developing principled methods to partition, while also identifying key relationships between partitions; investigate the homotopical certification of algorithms to be used in complex data analysis, which have shown potential in areas such as self-assembly of micro or nano-structures, where structural evolution and energy release are mapped out so as to cooperatively construct useful structures in situ, such as for material healing or in-body drug assembly/activation; explore homotopy methods for hierarchical control in the previously			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
mentioned contexts; explore homotopy methods in other multiscale applications of Army interest, such as in characterizing the dynamical and state properties of complex biological systems. ***FY 2024 Plans:*** Will investigate some of the fundamental questions involved in multimodal optimization, with the goal of enabling global optimization in the presence of separated local optima and non-smooth objective functions that if successful, could enable more optimized models and algorithms in machine learning for areas such as mean time between failure and component wear; determine the fundamental law(s) of biology which create a well-defined relationship between motor/actuator mass and motor force over 25 orders of magnitude in mass and which hold for diverse species, individual biomolecular motors, and even extend to man-made motors that if successful, could improve the performance of macroscale motors of all types in biological systems; create a homotopical certification of algorithms used in complex data analysis that if successful, could improve the analysis of data generated by quantum information systems; investigate the design and interaction of radar signals and communications that if successful, could lead to a better understanding of category theory, in the context of algorithms, error correction, and complexity, such as are present in quantum information; develop personalized optimal regulation strategies for circadian rhythms and the related processes that if successful, could detect and mitigate the impacts of mild traumatic brain injury; develop a framework to mathematically summarize prior information that is easily combined with information in a current data set that if successful, could provide the statistical analysis techniques needed to analyze imagery to determine whether an object, such as a vehicle is present or not present, thus increasing robustness of situational awareness. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: HBCU/MI Single Investigator ***Description:*** This effort supports extramural basic research to create and exploit new scientific discoveries from Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) that will improve the Army's transformational capabilities. Areas of interest include chemical sciences, computing sciences, electronics and photonics, life sciences, material sciences, mathematical sciences, mechanical sciences, network sciences, and physics. ***FY 2023 Plans:*** Continue to identify and support competitively-selected extramural research conducted at HBCU/MI institutions to provide increased knowledge and understanding in fields related to long-term future force needs; support faculty immersion program where HBCU/ MI faculty are aligned with R-1 universities and Army research laboratories in order to grow organic research capabilities at the HBCU/MI institutions and contribute to the long-term Army modernization priority needs. ***FY 2024 Plans:*** Will identify and support competitively-selected extramural research conducted at HBCU/MI institutions to provide increased knowledge and understanding in fields related to long-term future force needs; support faculty immersion program where HBCU/	2.388	2.677	5.105

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
MI faculty are aligned with R-1 universities and Army research laboratories in order to grow organic research capabilities at the HBCU/MI institutions and contribute to the long-term Army modernization priority needs; increase infrastructure and research support to establish true partnerships and expand capacity at HBCU/MI institutions. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional infrastructure and research capabilities that will be developed at the HBCU/MI institutions.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	2.065	-
Title: Energy Sciences ***Description:*** This effort supports studies to enable the design of novel materials for energy storage and generation through development of isomers where manipulations to half-life enables the molecules' energy to be harvested, the creation of multi-fuel tolerant electrodes for fuel cells and batteries to avoid contaminant poisoning while preventing electrode degradation, and the emergence of multivalent electrode chemistries and their electrolytes to achieve a higher capacity battery without issues related to dendrite formation, electrode degradation, and long life as a recharge asset. ***FY 2024 Plans:*** Will dynamically control isomer atomic state population through external means by manipulating the interplay between atomic and nuclear degrees of freedom, beginning with the use of nuclear excitation by electron capture to switch isomers into energy-output states, followed by achieving a change in the half-life of the isomer into a shorter-lived state; design electrolytes and their interfaces to avoid degradation for multivalent electrode chemistries that if successful, will reveal new chemistries to enable higher capacity batteries while avoiding degradation; explore new nitride ferroelectric and anti-ferroelectric materials with enhanced polarization, temperature stability, and robustness. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Basic Research in Electronics and Photonics and Basic Research in Chemical Sciences in FY 2024 to support research in Energy Sciences within this Project.	-	-	2.792
Title: HBCU/MI Early Career Award for Science and Engineering	-	-	1.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Description: The HBCU/MI Early Career Award for Science and Engineering (HBCU/MI ECASE) is modeled from the Presidential Early Career Award for Science and Engineering (PECASE) award, which embodies the high priority placed by the government on maintaining the leadership position of the United States in science by producing outstanding scientists and engineers and nurturing their continued development. The HBCU/MI ECASE awards will specifically seek outstanding U.S. citizen scientists and engineers beginning their careers at HBCU/MIs. Each award will provide significant support for students and internships within DEVCOM ARL or at Army-funded academic laboratories. ***FY 2024 Plans:*** Will support basic research contributing to Army modernization needs conducted by outstanding scientists and engineers beginning their careers at HBCU/MI institutions; award 8 new HBCU/MI Early Career Awards at a cost of $1.1875M each over a duration of 5 years. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research in support of establishing true partnerships with outstanding U.S. citizen scientists and engineers beginning their careers at HBCU/MIs.			
Title: Minerva Research Initiative (MRI) ***Description:*** The MRI is a university-based social science research program initiated by the Secretary of Defense. It focuses on areas in the social sciences of strategic importance to national security policy. It seeks to increase the Department's intellectual capital in basic social science research to address future challenges by bringing together universities in multidisciplinary approaches to address global social and geopolitical questions. MRI will bring together universities, research institutions, and individual scholars to support multidisciplinary and cross-institutional projects addressing specific topic areas determined by the Department. ***FY 2024 Plans:*** Will investigate individual and group generated methods and signals (such as open-source data, geophysical signals, spatial data, population mobility patterns, and/or bioinformation) to predict when, where, and how conflict is likely to emerge. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research in social sciences to enhance national security.	-	-	2.000
Accomplishments/Planned Programs Subtotals	86.464	97.025	108.599

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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D. Acquisition Strategy

N/A

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Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA4 / *Training and Human Science Research*			
COST ($ in Millions)	**Prior Years**	**FY 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
AA4: *Training and Human Science Research*	-	20.862	22.180	21.024	-	21.024	21.026	20.979	24.112	24.397	0.000	154.580

A. Mission Description and Budget Item Justification

This Project focuses on research that improves Soldier-system performance in future force environments by looking at key phenomena underlying Soldier integration with intelligent technologies and autonomous agents. This Project researches optimal methods for information exchange between Soldiers and intelligent technologies including 1) human performance in automated, mixed-initiative (human control-machine control) environments; 2) visual scanning and target detection; 3) performance-related Soldier state changes; 4) integration across multiple sensory modalities; and 5) collaborative (team) and independent multi-task, multi-modal, multi-echelon Soldier-system performance - all cast against the influx of emerging intelligent technologies and autonomous systems. Technical solutions are being pursued in the areas of data generation and algorithm development in these emerging environments in order to update and improve our understanding of performance boundaries and requirements. These solutions include multi-disciplinary partnerships, metrics, simulation capabilities, and modeling tools for characterizing Soldier-system performance, and provide a shared conceptual and operational framework for militarily relevant research on critical aspects of human-agent teaming.

In the area of translational neuroscience, research is carried out to examine leading edge methodologies and technologies to improve the measurement and classification of neural states and behavior in operationally-relevant environments; to examine the potential for application of neuroscience theories to autonomous systems to improve Soldier-system interactions; to model the relationship between brain structure and cognitive performance for understanding individual differences and injury; and to assess how neural pathways implicated in functional processing can be enhanced through dynamic system interface technologies for improving in-theatre performance and training.

In the area of cybernetics, which is a scientific discipline that bridges the fields of control theory and communication theory for the study and modeling of behavior in complex systems, research is carried out to examine the complex human-system-environment relationships that define, constrain, and influence the interactions between Soldier and system. Research efforts are pursued to advance theory, models, and methodological approaches that capture the dynamic and multidimensional nature of human behavior, including the temporal dependencies inherent to human behavior, through an integrated program of research efforts focused on: novel cybernetic models of human multisensory integration and human-system communication; neuro-inspired, bio-inspired, and engineering approaches to computational algorithms for multisensory integration and multi-sensor fusion to enable enhanced and augmented Soldier perception in human-system interactions; new methodological approaches for the design of multisensory displays and human-system communications; and multisensory test bed platforms for examining experimental hypotheses driven by model predictions and proof-of-principle applications of identified algorithms and methods.

This Project also investigates innovative theories, models, and methods to improve personnel assessment, training, and leader development, as well as provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. The research within these domains will enable advances in psychometrics to support the development of the next generation of psychological assessments for selection, classification, and assignment. The research also will target how to improve the assessment of difficult-to-measure skills and enable theoretical advances to inform and support the

accelerated development of complex cognitive and social skills. This research lays the foundation for future applications that address the behavioral and organizational dynamics that impact Army flexibility, effectiveness, and resilience.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Translational Neuroscience	3.827	4.162	4.399
Description: This effort integrates neuroscience with traditional approaches to understanding Soldier behavior to enable system designs that maximize Soldier performance. ***FY 2023 Plans:*** Combine multiple models of embedded abstract representations to simulate interactions between brain regions observed in the mammalian spatial reasoning system; embed abstract representations discovered from the mammalian spatial reasoning system into topological neuronal networks; integrate opportunistic signals collected during search task with machine learning models to optimize search performance within human-machine teams; apply novel approaches to simultaneous neural recordings from multiple individuals working together as a team. ***FY 2024 Plans:*** Will combine multiple models of abstract representation into a single unified map to simulate spatial reasoning; create neural network with features that mirror the mammalian spatial reasoning system to improve network performance in a spatial reasoning task; investigate the inter-brain system interactions underlying human-technology systems solving complex problems with creative solutions. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Human System Integration	5.063	4.671	4.228
Description: This effort applies a cybernetic approach (i.e., a theoretical study and comparison of communication and control processes in biological and artificial systems) to human systems integration to achieve tighter control of devices and communications among humans and between machines and humans. Use social, computational, and information approaches to extend the scope of interaction beyond individual systems to the full network context. ***FY 2023 Plans:*** Create approaches that enable intelligent systems to predict changes in human adaptation over time to drive optimal human-machine mutual adaptation; discover human-in-the-loop approaches to guide human-machine adaptation by isolating and prioritizing task-relevant information in the environment; create novel biometric-based objective functions that can improve the			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
rate of mutual human-machine adaptation; uncover approaches to gather critical information from groups of people to guide stable machine learning; create mathematical approaches to resolve conflict within groups of people when guiding machine learning. ***FY 2024 Plans:*** Will generate models and approaches capable of predicting changes in the adaptation state of human-human teams over time using neuro/physiological measurements; investigate the emergent properties of non-linear machine and human performance across tasks unique to the capabilities of machines and humans; examine human-system mutual adaptation in response to varying human-in-the-loop adaptive paradigms; generate models and approaches that enable stable machine learning from sparse group feedback. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned to Hybridization of Team Thinking within this Project in order to support increased research in human-systems science.			
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***Description:*** This effort investigates technologies that provide the foundation for future Army systems to adapt to individual Soldier states, behaviors, and intentions in real-time. Enable high fidelity, continuous prediction that can account for continuous changes in Soldier physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. ***FY 2023 Plans:*** Identify which contextual history features and timescales (e.g., days, weeks) explain the most variation in human decisions within human-autonomy teams; create models that characterize human variability of irrational decision making and its contextual correlates; advance human physiological complexity matching indices to enhance predictability of human brain and heart variability; quantify influences of long-timescale processes (> weeks) on human performance variability as compared to short- and mid-timescale processes. ***FY 2024 Plans:*** Will quantify improvements of predictive models that transfer knowledge based on measurements over long timescales (e.g., 1 month) to the performance of tasks measured over shorter timescales; characterize the generalizability of complexity matching for behavior prediction better than current state-of-the-art across diverse tasks and measures; improve predictive models of individual performance and long term ability over models based on typical sample sizes (n < 100) by using very large sample sizes (n > 100,000). ***FY 2023 to FY 2024 Increase/Decrease Statement:***	4.207	4.571	3.248

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Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Funding realigned in FY 2024 to PE 0601102A Project AA6 Robotics and Mobile Energy to increase research in Foundational Energy for Sustained Operations.			
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance and behavior. Understand the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to affect performance similar to that in an operational environment. Characterize the appropriate use of different classes of simulated environments to ensure valid results. Develop guidelines for using mobility platforms in simulators to induce physical and cognitive stress representative of the operational environment. Implementation of these guidelines will enhance training effectiveness.	1.285	-	-
Title: Novel Forms of Joint Human-Intelligent Agent Decision Making ***Description:*** This effort investigates methods for joint human/intelligent agent learning and decision making so that strengths of individual humans and intelligent agents are accentuated and weaknesses are mitigated for improved, emergent group performance. This effort emphasizes deep learning approaches that function under conditions of limited, mismatched, or dynamic data. ***FY 2023 Plans:*** Investigate human-in-the loop artificial intelligence (AI) algorithms that can rapidly learn a wide range of skills to be able to adapt to novel tasks with minimal additional training. ***FY 2024 Plans:*** Will investigate techniques using human feedback that will enable a human to easily train and adapt multi-agent systems that can be generalized to perform a variety of teaming tasks with minimal training. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of the effort.	0.939	1.042	1.062
Title: Hybridization of Team Thinking ***Description:*** This effort merges novel advances in human-system sciences with neuroscience and training sciences to reconceive human brain processes and optimize human-machine thinking to allow humans to influence technology enabled decisions previously believed to be outside of human capabilities. The effort aims to optimize how humans could think within complex human-technology ecosystems to maximize human potential to adapt the Army on the battlefield. ***FY 2023 Plans:***	-	2.259	2.914

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Merge novel advances in human-guided machine learning with novel advances in neuroscience into a hybrid thinking experimental test-bed; conduct laboratory experiments to show hybrid human-machine adaptation for decisions at the edge of human capability. . ***FY 2024 Plans:*** Will investigate the limitations of machine and augmented human intelligence in a complex decision-making task; investigate the hybridization of the capabilities of multiple humans with machine intelligence to increase the speed of decisions; perform experiments that hybridize the human learning process with technology to more rapidly adapt to changing conditions in open-ended scenarios. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from Human System Integration within this Project in order to support increased research in human-systems science.			
Title: Science of Measurement of Individuals and Collectives ***Description:*** This basic research effort develops advanced psychometric theory and measurement of Soldiers and teams in order to maximize talent management. ***FY 2023 Plans:*** Conduct research to advance psychometric theory and measurement of Soldiers and teams to improve selection and assignment. ***FY 2024 Plans:*** Will conduct research to develop novel approaches to measurement of cognitive and non-cognitive knowledge, skills, and abilities. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.	1.851	2.092	2.100
Title: Context of Behavior in Military Environments ***Description:*** This basic research effort develops an integrative theory to understand and model the contextual drivers of individual and group performance.	0.932	-	-
Title: Understanding Multilevel and Organizational Dynamics ***Description:*** This basic research effort develops advanced methods and models to understand the relationship of human states, traits, and behaviors on individual, group, and organizational dynamics. ***FY 2023 Plans:***	1.771	2.045	2.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Conduct research to develop multilevel models of teams in complex organizations to advance understanding of the relationship of human states, traits, and behaviors on individual, group, and organizational dynamics. ***FY 2024 Plans:*** Will conduct research to develop new methods and computational models for assessing, predicting, and optimizing team and organizational dynamics and operational effectiveness. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding decrease supports planned lifecycle of the effort.			
Title: Formal and Informal Learning and Development ***Description:*** This basic research effort develops a holistic model to understand and inform individual and group learning across assignments, platforms, and contexts throughout the career span. ***FY 2023 Plans:*** Conduct research to advance theoretical understanding of learning methods to maximize the transfer of complex tactical, technical, and interpersonal skills from formal & informal learning environments. ***FY 2024 Plans:*** Will conduct research to develop theory and practices conducive and specific to adult learning. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of the effort.	0.987	1.012	1.073
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.326	-
Accomplishments/Planned Programs Subtotals	20.862	22.180	21.024

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA5 / *Biotechnology and Systems Biology*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA5: *Biotechnology and Systems Biology*	-	5.842	6.421	6.547	-	6.547	6.614	6.622	9.555	9.518	0.000	51.119

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Engineered Biotechnology	2.478	2.722	2.788
Description: This effort investigates biological materials for devices and sensors that can be used in the future by the Army to improve force protection and reduce logistical burden. Investigates biological construction of novel materials, structures, and processes for future development of biologically derived materials, sensing materials, information processing, and power and energy to transcend critical gaps in adaptability, manufacturability, and stability in Army relevant environments.			
FY 2023 Plans: Investigate material specific microbes and communities based on analytical and computational techniques; explore synthetic biology genetic tool-kits on selected organisms to modulate microbial interactions with materials for controlled degradation and assembly; investigate the temporal and spatial properties of modulated microbial interactions with materials; investigate interactions of modulated organisms with natural microbial communities and explore the effects on the microenvironment of the materials during degradation and assembly; use predictive community models to identify designer communities for targeted degradation and assembly.			
FY 2024 Plans:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will investigate the relationship of environmental parameters on modulated microbes and natural communities; investigate sense and respond processes in modulated organisms and how they affect material specific communities and the strength of the response; design community models for modulating the response. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of the effort.			
Title: Synthetic Biology for Dynamic Materials ***Description:*** This effort researches the concept of responsive materials imparting living functions for operation in Army-relevant environments to enable disruptive capabilities, such as self-healing, adaptation, protection, and situational awareness. Perform research to enable design and synthesis of materials both enabled by and including biological entities to provide these living functions. ***FY 2023 Plans:*** Pioneer synthetic biology and advanced analytical tools to drive selection of control mechanisms in indigenous (local to Army environment) organisms; investigate and explore tuning parts and control mechanisms for harnessing indigenous biology; investigate dynamic range of orthogonal tools in individual organisms and explore control across different organisms to understand agility; investigate control mechanisms in indigenous organisms exploring behavior in different laboratory contained environments (e.g, temperature, salinity); pioneer synthetic biology methods to tune sequence defined material properties and investigate interface and assembly of materials; explore and investigate strategies for using material analytics bioinformatics and material informatics to understand synthetic biology materials. ***FY 2024 Plans:*** Will continue to investigate novel synthetic biology control mechanisms for indigenous (local to Army environment) organisms and tune the synthetic biology tools for temporal and or spatial control; study how control mechanisms for indigenous organisms function in laboratory contained environments in the presence of natural communities; investigate synthetic biology tools for in situ modification of indigenous organisms and study specificity of these tools; pioneer synthetic biology tools for new Army relevant sense and reporter mechanisms. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of the effort.	3.364	3.644	3.759
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:***	-	0.055	-

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638			
Accomplishments/Planned Programs Subtotals	5.842	6.421	6.547

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

N/A

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA6 / *Robotics and Mobile Energy*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA6: *Robotics and Mobile Energy*	-	19.857	21.854	25.268	-	25.268	27.467	27.511	27.538	27.811	0.000	177.306

A. Mission Description and Budget Item Justification

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Vehicle Propulsion and Power Research	1.332	1.603	1.706
Description: Basic research to investigate concepts and theories to provide enhanced tools, methods, and innovative concepts to enable improvements in propulsion power density, energy efficiency, reliability, and lifecycle costs for increased performance and capabilities in future Army systems.			
FY 2023 Plans: Perform experiments on smart materials that serve to articulate thin airfoils (e.g., turbine blades) to enable engines that operate efficiently at different speeds; explore discontinuous ultra-high temperature ceramic (UHTC) fibers to fabricate ceramic matrix composites for future hot engine components; develop high fidelity models to study interactions between gas turbine engine combustor and turbine sections.			
FY 2024 Plans:			

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will explore advanced combined-cycle aeroengine concepts; investigate full-engine simulations and engine component interactions for turbulent flow effects; investigate thermo-mechanical and electromagnetic characteristics of advanced ultra-high temperature ceramics (UHTC) and high entropy ceramics. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Novel multi-fuel tolerant small vehicle power ***Description:*** Basic research to enable highly efficient, multi-fuel conversion in small engines with reduced sensitivity to fuel property variation and extreme ambient conditions. This includes research to characterize and investigate extreme fuel properties on ignition chemistry, variable spark enabling concepts for robust ignition, and lightweight highly durable materials for reduced heat loss and wear characteristics. ***FY 2023 Plans:*** Demonstrate aviation fuel ignition models at both high fidelity for combustion simulation and reduced order for engine control applications; investigate altitude ignition behavior for novel small combustor geometries; assess initial concepts for on platform fuel sensors; investigate production methods of advanced aluminum alloys in initial aviation engine combustion components; assess tailored materials and coatings for damage resistant fuel-lubricated mechanical interfaces with low lubricity fuels. ***FY 2024 Plans:*** Will augment existing fuel ignition models with a greater range of fuels and improve fidelity of detailed and reduced order combustion simulations; investigate optimized small combustor geometry at expanded operating regimes; assess miniaturized in-line fuel sensor; assess component scale aluminum alloy production weights and volumes for aviation applications; identify chemical interactions between fuels and optimized materials to understand damage resistance when lubricated with lowest lubricity fuels; assess protective behavior between synergistic material pairs in complex geometries in fuels. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.	3.203	3.119	3.163
Title: Fundamentals for Alternative Energy ***Description:*** Explore novel concepts in energy generation and capture in technologies for efficient conversion of ambient energy to electrical energy for use and storage. Design novel structures to include microscale power devices for multimodal harvesting and efficient distributed power conversion. Focus areas include: energy storage and release from atomic nuclei, new electrochemical materials and processes for energy storage and conversion, and new approaches for solar energy harvesting. ***FY 2023 Plans:***	0.888	0.973	1.005

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Study electrocatalytic and thermocatalytic processes for chemical energy storage at the interfaces of liquid media, nanocatalysts, and visible/infrared absorbing nanoparticles using electrochemical and spectroscopic characterization methods; study the energy dependences of nuclear excitation by electron capture or other processes for on-demand isomer energy release; investigate isomer production approaches; design a proof-of-concept experiment for an isomer power source. ***FY 2024 Plans:*** Will investigate the chemical mechanisms and impact of electrocatalytic and photothermocatalytic processes at nanocatalyst interfaces for relevant chemical reactions to energy conversion using electrochemical and spectroscopic methods; examine and assess the impact of broadening and excited configurations on the theoretical prediction of isomer switching efficiency using nuclear excitation by electron capture. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
Title: Reconfigurable Platform Mechanics and Propulsion ***Description:*** Basic research in reconfigurable platform mechanics and propulsion science to investigate technologies to enable subsystem configuration concepts for efficient hover and high-speed/range Vertical Take-Off and Landing (VTOL) aircraft. ***FY 2023 Plans:*** Explore optimization algorithms for vehicle reconfiguration and employ machine learning/molecular modeling approach to conceptualize new shape reprogrammable structures by introducing new bio-inspired functionalities for UAS platforms; explore the design space enabled by reconfiguration technologies; develop mathematical models of aeromechanics and flight control of morphing aircraft platform subsystems and incorporate them in the conceptual design framework to achieve extreme performance and agility attributes. ***FY 2024 Plans:*** Will explore aeromechanics analysis and design tools for reconfigurable/morphing technologies to enable agile and weaponized kinematics platform; investigate bio-inspired active materials suitable for actuation mechanism that will enable complex dynamic behavior of air vehicles; design a methodology for mechanical systems to describe platform agnostic reflexive mobility. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	0.937	1.027	1.061
Title: Robotics Autonomy and Human Robotic Interface Research ***Description:*** Basic research focused on enabling robust autonomous mobility for small and human-scale robotic systems, including autonomous teaming behavior with hybrid human-robotic teams. Enablers for robust autonomous mobility include	1.559	1.811	1.878

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
planning, behaviors, energy efficient maneuver, and the interface of manipulation technologies to support manned-unmanned teaming constructs. ***FY 2023 Plans:*** Identify characteristics and continue to develop algorithms that enable autonomous energy distribution between ground and air vehicles for sustained increase in operational duration; create algorithms for optimized vehicle route planning for robot teams which factor energy availability and mission constraints; explore alternative power generation methods that will extend autonomous vehicle endurance in logistically uncertain and contested environments. ***FY 2024 Plans:*** Will further assess algorithms that enable autonomous energy distribution between ground and air vehicles for sustained increase in operational duration, and identify methods for multiple size, weights, and types of robotic vehicles; examine the predictive capabilities and communication requirements of the algorithms for optimized vehicle route planning for robot teams which factor energy availability and mission constraints; continue to identify candidates for alternative power generation methods that will extend autonomous vehicle endurance in logistically uncertain and contested environments. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
Title: Intelligent Systems ***Description:*** Pursue research in autonomous systems that supports and unburdens Soldiers in a flexible, robust, survivable, and comprehensive manner. This work addresses the cognitive requirements of humans and (non-human) agents, both hardware and software based, operating individually or in collaboration, on the battlefield. Emphasis is placed on perception, reasoning, and collaboration techniques that can apply to and transfer between a broad range of systems (i.e., adaptive communication and data collection networks; crowd-sourcing and information retrieval software agents; and predictive and explanatory decision support systems). ***FY 2023 Plans:*** Explore navigation techniques capable of assessing route options in partially known environments, and adapting based on limited human examples; create algorithms that allow for rapid adaptation to incomplete or unexpected semantic observations in the environment; extend autonomous vehicle endurance through fundamental research in navigation algorithms which utilize all available resources for route planning while assessing multiple courses of action to enable longer planning horizons; validate algorithms that manage automated tuning of low level control parameters from limited human feedback; create algorithms that intelligently share representations and distributed context to enable planning across multiple vehicles. ***FY 2024 Plans:***	5.888	6.326	6.652

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will continue to investigate alternative navigation techniques capable of assessing route options in partially known environments while adapting based on limited human examples and system safety criteria; further assess the best algorithms that allow for rapid adaptation to incomplete or unexpected semantic observations in the environment; study autonomous vehicle endurance metrics of navigation algorithms which utilize all available resources for route planning while assessing multiple courses of action to optimize system performance for longer planning horizons; investigate the best algorithms that intelligently share representations and distributed context to enable planning across multiple vehicles. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
Title: Structurally-Adaptive Unmanned Air Systems Research ***Description:*** Basic research focused on topics that contribute to the body of knowledge required to create future intelligent, unmanned air systems that can effectively team with manned and unmanned aircraft, ground platforms, and human teammates. Emphasis is placed on topics of control and aeromechanics that expand the operational envelope for unmanned systems and enable maneuverability in complex, interactive, and mission relevant environments. ***FY 2023 Plans:*** Investigate novel active materials and structural design concepts to enable transformational capabilities within congested environments for advanced UAS platforms; explore evolutionary algorithms for design of autonomous platforms exhibiting reflexive agility and embodied intelligence to enhance mobility in terrain/environments, including control systems approaches and implications of air vehicle structures; validate computationally efficient methods and functional models of aerodynamic interactions for near real-time flight dynamics in virtual environments; explore the effects of unsteady environments that includes gusts, turbulence, and vehicle wakes, by performing basic research in a wind tunnel facility to identify active and passive control designs as well as novel maneuvers; create new computational modeling methods, active flow controls, and passive vehicle structural designs to mitigate negative impacts of unsteady fight conditions through wind tunnel experiments; pioneer new concepts for small UAS that include reconfigurable and resilient structures, super maneuverability, and extreme endurance. ***FY 2024 Plans:*** Will continue to analyze the effects of unsteady environments that includes gusts, turbulence, and vehicle wakes, by performing basic research in a wind tunnel facility to identify active and passive control designs as well as novel maneuvers critical for advancing the underlying autonomy needs and design features; analyze newly created computational modeling methods, active flow controls, and passive vehicle structural designs to mitigate negative impacts of unsteady fight conditions through wind tunnel experiments; further examine concepts for small unmanned aerial systems (UAS) that include reconfigurable and resilient structures, super maneuverability, and extreme endurance; explore a machine learning computational framework driven design of UAS platform enabling increased agility of UAS; further investigation of evolutionary algorithms for design of autonomous	2.883	3.141	3.247

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
platforms exhibiting reflexive agility and embodied intelligence to enhance mobility in terrain/environments, including control systems approaches and implications of air vehicle structures. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
Title: Air Mobility ***Description:*** Create robust experimental and computational approaches for understanding, modeling, and predicting the complex fluid flow and aerodynamics of next generation rotorcraft concepts. This research includes innovative numerical methods for capturing the details of steady state and non-steady state aerodynamics and acoustics occurring with multi-rotor, rotor-propeller, and rotor hub configurations; and associated experimental techniques needed to verify modeling results. ***FY 2023 Plans:*** Conduct high-fidelity computational simulations of detailed rotor wake structure to understand and quantify the vertical instabilities manifest as worm-like flow structures seen in high fidelity experimental measurements; explore reduced order models and machine learning algorithms to study interactional aerodynamics effects over a wide design space. ***FY 2024 Plans:*** Will conduct experimental investigations of the flow field surrounding a rotor hub to understand the effect of unsteady hub flow on the flow separation on fuselage/pylons, and to exploit these flow interactions in the hub wake to generate useful forces and moments; develop a formal uncertainty quantification framework to account for and document uncertainties in high-fidelity computational fluid dynamics (CFD) predictions to facilitate adoption of CFD for engineering applications. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	2.460	2.682	2.769
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency ***Description:*** Research in support of advanced military mobility technologies with emphasis on Terramechanics (vehicle-terrain interaction), and complex vehicle dynamics and simulation. This includes developing the data and underlying models to simulate and predict autonomous vehicle mobility in soft soil and complex organic terrain under a variety of environments. Research is directed at understanding advanced mathematical and computational methodologies using state-of-the-art analytical and empirical procedures. ***FY 2023 Plans:*** Continue investigative research into quantum computing approaches for computationally expensive multi-scale algorithms for modeling a military ground vehicle interaction with terrain / soft soil; expand research gaming engine algorithms for autonomous vehicle off-road mobility; continue researching the application of deep learning algorithms for generating Go/NoGo maps to other	0.707	0.776	0.803

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
geographic regions; investigate off-road intelligent autonomy for multi-scale vehicle fleets, including fleet energy management; investigative research into energy and power density for highly mobile systems, including reconfigurable in the context of energy routing to endure under potential damage. ***FY 2024 Plans:*** Will develop novel modeling and simulation computational approaches for complex, interdisciplinary, multi-physics, multi-scale systems, namely autonomous military ground systems in unstructured off-road environments; continue expanding the use of gaming engine algorithms for enhanced off-road mobility and further development of terrain identification for Go-No Go map in unknown and changing environments; continue to research power and energy dense highly mobile systems for improved battlefield energy characterization, optimization, and control; expand the use of modeling and simulation tools to verify and validate performance of autonomous systems across the spectrum of use and alleviate the need for physical testing. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.396	-
Title: Foundational Energy for Sustained Operations ***Description:*** Explore novel concepts in safe, domestic, high energy density storage and generation to meet and sustain the increasing energy needs of current and future Army technologies such as realizing electrification for autonomous systems, silent watch, and mounted/dismounted platforms. Conduct basic research on new materials for energy storage and generation through the exploration of isomers, multi-fuel tolerant materials, energy conversion approaches, rechargeable multivalent batteries, and conversion cathode battery chemistries. ***FY 2024 Plans:*** Will explore machine learning based analysis techniques and tools to accelerate processing of gamma spectroscopic data resulting from nuclear excitation by electron capture experiments; analyze experimental designs for implantation approaches to switch isomer materials based on nuclear excitation by electron capture; study electrode material candidates and design experiments that can investigate the impact on solid oxide fuel cell stack lifetime when operating from sulfur containing fuels at	-	-	2.984

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
low temperatures; study multivalent battery chemistry candidates and explore electrolytes and additives that impact utilization and cycle efficiency; investigate conversion and hybrid cathodes and design experiments to investigate dissolution and degradation. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from PE 0601102A Project AA4 Training and Human Science Research and PE 0601102A Project AA9 Information and Networking to support additional research in the area of energy science within this Project.			
Accomplishments/Planned Programs Subtotals	19.857	21.854	25.268

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA7 / *Mechanics and Ballistics*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA7: *Mechanics and Ballistics*	-	32.114	35.234	35.014	-	35.014	35.482	35.525	37.889	38.635	0.000	249.893

A. Mission Description and Budget Item Justification

This Project conducts basic research in materials and ballistic science to create higher performing, lighter weight, lower cost materials and processes, discover new ways to store and release chemical energy from novel energetic materials, explore fundamental chemistry and physics controlling the launch and flight of gun-launched projectiles and missiles, and understand the interaction of these weapons with armored targets, including the high deformation rate behavior of materials and the mechanics of threat impact and penetration of armored targets. Research involves the study of new experimental capabilities to measure, characterize, and visualize complex phenomena with high temporal and spatial resolutions as well as the development of state-of-the-art computational models that provide predictive capabilities based on at-scale and cross-scale numerical frameworks that capture the relevant physical phenomena. Research in atmospheric science seeks an in-depth understanding of the complex atmospheric boundary layer associated with high-resolution meteorology, the transport, dispersion, optical properties, and characterization of chemical and biological aerosols, the propagation of full-spectrum electro-magnetic and acoustic energy and physics-based multi-scale models for electronic, optical, mechanical, and chemical materials. Efforts seek to explore methodologies and computational capabilities for the quantification of uncertainty in predictive modeling enabling risk-informed decision analysis multi-scale material models and environmental impacts on complex Army systems (manned and unmanned). This research also conducts research in chemistry and physics controlling ballistic propulsion and launch; creating aerodynamic forces on flight bodies to permit radical maneuver at high speeds, and high altitude glide and flight maneuver for increased range of gun launched projectiles. This research results in knowledge products that lead to new materials for armor and armaments, disruptive explosives and propellants, more accurate and non-lethal (NL)/lethal projectiles and missiles, omnisonic maneuver of projectiles, and advanced armors for increased survivability of Army combat systems. This research also funds efforts in the characterization of chemical and biochemical phenomena occurring at or near solid surfaces and interfaces; the interactions between chemical reactions and transport processes on surfaces; theory and modeling of processes at complex surfaces; and the synthesis and characterization of catalysts that function at the nanoscale. Investment in basic research centered on the surface science disciplines will enable growth of a knowledge base that will result in improved understanding of the interactions of complex materials in real world environments.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Protection Sciences	5.193	5.471	5.658
Description: This effort seeks to improve fundamental knowledge of mechanisms that can be exploited to ensure the next generation of lightweight and efficient armor technologies. Provides physics-based discovery of novel Soldier protection			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
mechanisms through increased understanding of wave propagation through tissue, and the resulting deformation and damage of tissue during ballistic and blast events. ***FY 2023 Plans:*** Develop computational toolsets and experimental techniques that provide core insight into fracture and failure of ceramics and dynamic response of multi material systems; improve understanding along the continuum of armor material response from current near-skin protection to those that may be decoupled from the human body; develop multi-scale modeling and simulations and conduct experiments to optimize performance leading to improved V50 penetration velocity metric in monolithic ceramic material with a goal of 25% predicted improvement in V50 over commercial monolithic ceramic materials; fabricate engineered multi-phase ceramic with structure and properties to provide optimum control and granular flow during a ballistic event. ***FY 2024 Plans:*** Will investigate how mechanical forces can be manipulated within materials and structures to optimize stresses and control deformation and penetrator-target interactions; conduct experiments with transient magnetic fields affecting phase transformation; conduct simulations of dynamic impact including tailored waveforms under fluctuating magnetic fields; investigate possible effects of magnetic fields on ballistic penetration resistance. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
Title: Microscopic/Nanostructural Materials ***Description:*** This effort explores new materials and creates new computational capabilities based upon fundamental concepts derived from studies of structure, process, and property relationships at the microscopic and nanostructural levels. Research includes synthesis, processing, characterization, and modeling of novel metal alloys and armor ceramics, including control and manipulation of nanostructural features, grain boundaries, texture, and other nano-to-microscale structure. ***FY 2023 Plans:*** Investigate active, tunable materials with high stiffness that can act over short time scales with minimal energy requirements for an integrated approach to Army structural, protection, and lethality applications; develop materials that focus on leveraging mesoscale material architecture modifications to intensify response mechanisms without sacrificing mechanical properties of the material. ***FY 2024 Plans:***	3.183	3.442	3.559

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will develop computational physics-based and data-driven models to exploit and discover mesoscale compositional and processing methodologies to design and predict microstructural properties and extreme performance of materials; develop multiscale materials design tools for damage tolerant, structural composite materials. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: High Deformation Rate Materials ***Description:*** This research addresses Army-unique issues in fundamental materials research involving the performance of advanced materials at high deformation rates for applications including armor and armaments. Fundamental understanding is developed to enable design, processing, and characterization of materials specifically intended for high loading-rate applications, including improved physics based models, methods to characterize materials microstructure, interfaces, and defects and their role on materials response, and the determination of rate-dependent constitutive and failure/fracture behavior of materials. ***FY 2023 Plans:*** Perform modeling and simulation of prescribed, simplified defect structures within metals, ceramics, and polymers, and correlate these results with measured properties from characterization efforts, laying the foundation for future predictive tools; investigate assessment methods that allow for rapid analysis of dominant failure modes and deformation mechanisms in specimens under high rate, high temperature conditions. ***FY 2024 Plans:*** Will develop a materials-by-design methodology to identify failure mechanisms resulting from a combination of dynamic events, such as coupled ballistic loading and extreme heating. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned from this effort to support research in Additive Manufacturing Sciences within this Project.	3.283	3.549	2.470
Title: Materiel Research and Processing Using High Energy Fields ***Description:*** Explore interactions between materials and intense energy fields (e.g., magnetic, electric, pressure, etc.) to discover new pathways and mechanisms for controlling and altering material structure, enabling the development of new materials with unique property combinations and abilities to respond adaptively to battlefield conditions. ***FY 2023 Plans:*** Develop a theoretical framework to define the relationship between applied magnetic fields and diffusion mechanisms in alloy compositions; perform ballistic assessment of lightweight armor materials, developed utilizing novel synthesis techniques, for increased Soldier protection and mobility. ***FY 2024 Plans:***	2.395	2.593	2.681

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will develop energy field-driven post-processes to create novel complex shapes and properties by design; develop exceptional classes of materials designed to take advantage of emerging convergent manufacturing processes (including but not limited to combinations of additive manufacturing, traditional subtractive manufacturing, and energy-field driven processes) to embed integrated functionalities with complex shape and geometrical structures. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
Title: One Dimensional (1D) and Two Dimensional (2D) Materials and Processing Research ***Description:*** Discover novel building block materials that provide disruptive protection mechanisms. Research includes synthesis, processing, characterization, and modeling to discover new 1D and 2D building block materials and associated assembly into protective membranes, smart fibers and films, and other molecular composite architectures. ***FY 2023 Plans:*** Develop unifying theory of 2D polymer failure at the molecular level and integrate into multiscale finite element models; implement AI/ML into multiscale models to predict mechanical properties and benchmark with experiments; develop optimal functional groups within 2D polymers for enhanced toughness, stiffness, and strength. ***FY 2024 Plans:*** Will develop multifunctional material design framework to construct and optimize conduction / insulation with anisotropic material properties; develop tunable interfaces under extreme dynamic thermomechanical loading or environmental conditions; develop mechanistic understanding of the dissimilar material interfaces functionally created by design. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.	1.601	1.746	1.807
Title: Bio-enabled Precision Materials Synthesis and Assembly ***Description:*** Explore new biology-based methods for controlled synthesis and assembly to create materials with precise chemistries, microstructures, properties, and responsive functionalities through controlled molecular placement, spatial architectures, and interfacial structures. This research utilizes biological platforms that can act as micro-environments to control local thermodynamics and kinetics to govern reactions and molecular assembly, thereby providing completely new pathways for materials discovery. ***FY 2023 Plans:*** Continue to identify compatible organisms and material scaffolds for precision placement and integration of biological and composite behavior; investigate and tune precision placement of compatible organisms and material scaffolds for improved meso-scale assembly; improve material, biopolymer, and composite properties for sequence-defined function properties during scalable	1.743	1.878	1.941

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
integration and processing; create predictive models of biopolymer meso-scale assembly for rational design of material scaffolds based on structure-function properties and sequence defined assembly. ***FY 2024 Plans:*** Will investigate the link between genetic sequence with tuning interfaces and assembly of materials to obtain desired material properties across length scales; leverage bioinformatics and material informatics to inform the genotype to phenotype link and identify new control mechanisms to alter material properties; pioneer high throughput methods to screen across sequence and material space. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle for this effort.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles ***Description:*** Improve the fundamental understanding of the mechanisms controlling the launch and flight of gun-launched projectiles and missiles, and understand the interaction of these weapons with armored targets. ***FY 2023 Plans:*** Investigate shock-boundary layer interactions and boundary layer stability/transition for canonical problems; establish feasibility of coupled discipline computational toolset; obtain experimental validation of aero-thermodynamics in sub-scale high-speed ballistic range facility; develop high uncertainty tolerant flight control algorithms for weapons; formulate data-driven multi-agent/sensor estimation algorithms for collaborative delivery; explore emergent behaviors for offensive strike using artificial intelligence and machine learning algorithms. ***FY 2024 Plans:*** Will continue exploration of basic fluid mechanics such as turbulence, separation, transition, and flow interactions relevant to military vehicles; pursue novel maneuver mechanisms; formulate basic algorithms for low- (vehicle) and high- (mission) level control; synthesize model-based and data-driven approaches for high-speed, multi-agent perception, action, and communication. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.	3.094	3.344	3.461
Title: Energetic Materials Research ***Description:*** Expand and confirm physics based models and validation techniques to enable design of novel insensitive propellants and explosives with tailored energy release for revolutionary future force survivability and weapons effectiveness. ***FY 2023 Plans:***	3.486	3.767	4.049

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Explore and synthesize novel strained ring materials, extended solids, and core-shell nanometals for use in explosive and propulsion applications; explore mesoscale-continuum scale model coupling as well modeling and validation of novel rocket propulsion concepts for eventual transition to long-range fires. ***FY 2024 Plans:*** Will discover and synthesize novel high-temperature organic-based and organometallic (or metallic alloy) based energetic materials for use in explosives and propellants; explore mesoscale models striving for 100s of microns in length regime, as well as machine learning models to accelerate kinetic rate equations used for propellant and explosive applications. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
Title: Theory in Atmospheric Characterization, Sensing, and Modeling	4.007	4.330	3.578
Description: New algorithms and methods are developed to account for a variety of complex-terrain physical processes in microscale models. Novel instrumentation and observational methods are developed to advance the understanding of physical processes in the atmosphere. Employ optical techniques to advance detection methods for chemical/biological agents mixed in with atmospheric constituents. Data from high-resolution instrumentation arrays are used to advance and verify evolving atmospheric characterization theory focused on complex terrain and dense urban areas. ***FY 2023 Plans:*** Conduct field experiments of environmental effects on acoustic and electromagnetic signal propagation in urban environments; validate machine-learning methods to enable multi-modal sensor adaptability and optimal data fusion; explore new formulations of thermal forcing in lattice-Boltzmann-based fluid dynamics models; explore algorithms to better simulate warm microphysics processes; study and validate methods to provide bulk characterization of atmospheric quantities such as turbulence, aerosol concentration, and thermal profiles based on non-traditional, limited atmospheric observations; explore methods to connect microscopic scattering processes with detection and bulk impact of aerosols on radiative transfer; investigate impacts of atmospheric and boundary-layer processes on electromagnetic/radio frequency propagation; study aerosol transport due to terrain-related variability in the boundary-layer momentum and heat fluxes and the evolution of transient and recurring flow instabilities on aerosol concentrations and transport; conduct experiments on promising methods for optical detection of biological materials. ***FY 2024 Plans:*** Will conduct multi-national field assessment to investigate environmental effects on acoustic and electromagnetic signal propagation in urban environments; refine machine-learning methods enabling multi-modal sensor adaptability and optimal data fusion; continue to investigate impacts of atmospheric and boundary-layer processes on electromagnetic/radio frequency propagation and signature; develop new optical methods and techniques to advance capabilities for optical detection and characterization of biological, chemical and other threat materials; explore methods to connect microscopic scattering processes			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
with detection and bulk impact of aerosols on energy transfer; study aerosol transport due to terrain-related variability in the boundary-layer momentum and heat fluxes. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, a portion of funding was realigned from this effort to PE 0601102A Project AA9 Information and Networking to support research in Assessing and Mitigating Climate Risk for Decision Making.			
Title: Environmental Quality ***Description:*** This effort conducts research on innovative environmentally-friendly technologies that support the warfighter focusing on pollution prevention technologies. ***FY 2023 Plans:*** Conduct research on environmental issues associated with the exploration of current and future energetic development to include: fundamental aspects of compounds, solvents, precursors, and bench scale synthesis; conduct research in the replacement of hazardous solvents and alternative methods to process chemicals for energetics to reduce environmental, safety, and occupational health (ESOH) issues. ***FY 2024 Plans:*** Will explore the systematic study of environmental friendly energetics and processing methods; investigate the degradation of current and potential monomers for the demilitarization of cast cured explosives; analyze alternatives to hazardous chemicals to prevent corrosion to metals and reduce environmental, safety, and occupational health issues. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	1.068	1.164	1.204
Title: Surface Science Research ***Description:*** The activities in this program are related to performing basic research in chemistry, biology, and physics on fundamental problems related to surfaces, interfacial dynamics, thin film materials, chemical-biological catalysis, and opto-electronic/sensory technologies. ***FY 2023 Plans:*** Conduct basic research related to fundamental studies, predictive modeling, for advanced materials processes as it relates to chemical-biological materials and sensors. Research will focus on expanding the body of knowledge related to processing parameters, structure property relationships, surface interactions and performance of materials and sensors with respect to chemical/biological exposure, decontamination, aging and use in extreme temperatures; explore the utilization of novel manufacturing processes such as 3-dimensional bio-printing, integrated heterogeneous materials (i.e. Metal-Organic Frameworks) and in-situ polymerization and/or component integration during processing; advance fundamental scientific understanding	2.297	2.487	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
of particle dispersion for novel utilization of next generation obscurants with novel pyrotechnics in areas such as disrupting command, control, and communications; investigate advanced/multispectral obscurant payload or concealment/camouflage/ deception/false targets resulting in overall signature management or sensor defeat. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned to Chemical-Biological Advanced Materials and Manufacturing Science within this Project.			
Title: Terminal Ballistic Design and Evaluation for Next Generation Materials ***Description:*** Research will focus on novel terminal ballistic designs utilizing engineered materials to provide lightweight protection and low-energy penetrator solutions for combat-relevant threats. Specific architecture materials will be identified and utilized based on high-throughput material synthesis and characterization, and data-driven physics based modeling approaches. ***FY 2023 Plans:*** Combine computational modeling and automated processes to assist in the design and assessment of alloys as structural materials for use in armor and weapon systems applications. ***FY 2024 Plans:*** Will continue computational modeling in the design of structural alloys; implement synthesis and characterization via high-throughput methodologies to assess use in armor systems. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	0.764	0.815	0.834
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.648	-
Title: Additive Manufacturing Sciences ***Description:*** The research in this Project focuses on manufacturing processes to achieve transformational lethality. This involves the development of converging virtual manufacturing using heterogeneous materials in one platform, while implementing additive, subtractive, transformative, and bulk manufacturing. ***FY 2024 Plans:***	-	-	1.200

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will investigate interfacial microstructural kinetics from precision additive and transformative manufacturing and bonding of dissimilar materials. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding realigned from High Deformation Rate Materials within this Project to support research in additive manufacturing sciences.			
Title: Chemical-Biological Advanced Materials and Manufacturing Science (CBAMMS) ***Description:*** Chemical-Biological Advanced Materials and Manufacturing Science (CBAMMS) program activities are related to performing basic research in chemistry, biology, physics, and material science to investigate interactions between materials and surfaces and between materials, catalysis, and energy dispersion/disruption that will advance the knowledge related to chemical and biological sensors, obscurants, and bio-manufacturing. ***FY 2024 Plans:*** Will conduct basic research from competitively selected proposals related to fundamental studies and predictive modeling for advanced materials processes as it relates to chemical-biological materials and sensors; study basic principles of biological systems to broaden our understanding of detection and our ability to exploit these principles to aid in detection; expand the body of knowledge related to material processing and properties and the impact of surface interactions on the performance of protective materials; explore novel sensing phenomenology along with new biosynthetic processes for the development of new or existing materials; study the fundamental properties of materials in addition to the impact of existing and novel manufacturing processes on critical performance characteristic of materials; study particle dispersion and novel material properties for utilization in next generation obscurants and novel pyrotechnics. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned from Surface Science Research within this Project.	-	-	2.572
Accomplishments/Planned Programs Subtotals	32.114	35.234	35.014

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AA8: *Sensing and Electromagnetics*	-	13.092	13.619	16.383	-	16.383	26.083	31.647	29.340	33.406	0.000	163.570

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Advanced Materials Research	3.333	1.533	1.562
Description: This effort conducts research in modeling, fabrication, and characterization of semiconductor materials and structures that leads to revolutionary device functionality in sensing, low power electronics, quantum networks, and power generation. This effort investigates novel complex crystal structures that can lead to devices with performance beyond normal semiconductor transistors, including neuromorphic computing structures and topological insulator based heterostructure with low operating voltage.			
FY 2023 Plans: Investigate fundamental properties of acoustic, seismic, electric field, magnetic, gravimetric, passive radar, and integrated photonic analogs of macro-scale non-traditional sensor systems (e.g. laser vibrometry) to determine cross-correlative properties as a function of sensing vantage and range; research multi-modal and distributed sensing for detection confidence, clutter rejection, range enhancement, and Signal-to-Noise Ratio (SNR) improvement; investigate distributed sensor processing architectures for single and multi-agent state estimation, leveraging the ability to process sensor data locally with limited computational processing and distribute the processed data over an austere and intermittent network to achieve high confidence detection.			
FY 2024 Plans: Will model advanced functional materials (i.e. topological materials and two dimensional materials) and heterostructures for use in low power device concepts; investigate different modalities of negative electron affinity materials (such as diamond) for use in			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
radio frequency (RF) and sensor applications. The work will include different terminations of the diamond surface and assessment of their electronic and environmental stability. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** This increase supports the planned lifecycle of this effort.			
Title: Distributed Sensor Research ***Description:*** This effort creates more survivable and secure sensors and displays, investigates new acoustic, seismic, magnetic- and electric-field sensor technologies for personnel, activity, vehicle, and weapon-fire, and develops means to correlate, fuse, and interpret data from diverse sensors. This effort investigates novel algorithms and electromagnetic models to better understand radio frequency (RF) propagation and exploitation in complex clutter environments for improved RF and radar sensing.	1.676	-	-
Title: Materials Science for Army Power and Communications ***Description:*** This research includes modeling of advanced battery materials and structures, and modeling of electromagnetic fields interacting with catalytic materials. High bandgap materials including silicon carbide and gallium nitride with modified composition will be used to fabricate diodes for improved performance as optical communication sources, sensors, and high power components. Materials, designs, and fabrication techniques will be studied for the future development of Micro-Electro-Mechanical Systems (MEMS) for radio frequency (RF) devices and sensors. ***FY 2023 Plans:*** Examine impact of planar versus vertical architectures on leakage currents in SiC diode structures under high electric (E)-fields; validate interfacial interactions of adsorbed chemical species and excited states; investigate novel materials and structures enabling low-size, weight, and power (SWaP) optical communication and time transfer and investigate material systems for chip-scale lasers for next-generation clocks and sensors; study the nature of how adsorbed species impact charge and thermal energy transfer across interfacial boundaries between photocatalytic substrates and reaction media and investigate how to modulate the thermal envelope around a plasmonic nano-heating reactor to control reaction rate dynamics when illuminated; study molecular and atomistic processes at interface in aqueous and multivalent battery systems and investigate ionic, electronic, and water transport at these interfaces to suggest model-based strategies to promote stable, high rate interfaces with enhanced cycle stability. ***FY 2024 Plans:*** Will examine effects of impact ionization rates, doping, and device fabrication on spatial uniformity of electric fields (E-fields) under high E-field conditions; investigate role of ionic solvation, ordering, and structure on transport, reactivity, and charge transfer at electrochemical interphases; examine and validate a temperature model for local nanoscale photothermal heating driving	1.132	1.248	1.709

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
chemical reactions; research novel material approaches and micro structures for low-size, weight, and power (SWaP) free-space optical time transfer unit. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research into ionization as it relates to E-fields.			
Title: Fundamentals for Precision Measurement for Contested Environments ***Description:*** This effort explores new materials, novel device architectures, and unique processing techniques to successfully maintain communication and information sharing protocols in GPS-denied, actively jammed, or austere environments. ***FY 2023 Plans:*** Investigate epsilon-near-zero resonator bidirectional coupling mechanisms with purpose-built waveguides for advanced testing and future coupling to optical frequency comb micro-resonators; experimentally explore use of new locking mechanism of optical frequency comb to epsilon-near-zero resonator. ***FY 2024 Plans:*** Will develop integrated micro-resonator optical frequency comb that is waveguide coupled with an injection-locked laser; investigate injection-locking mechanisms to generate and lock a soliton-based optical frequency comb; design and fabricate next-generation epsilon-near-zero metamaterial-based environmental insensitive resonators. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	0.701	0.765	0.789
Title: Functional Materials ***Description:*** This effort supports basic research in polymer science and textile technology, nano and biotechnology, and multifunctional materials to achieve technologies that support the Soldier of the future through multi-functional materials with clothing/protective equipment functionality that also embody electronic functionality. ***FY 2023 Plans:*** Combine experimental and modeling approaches to investigate molecular structure, interactions, and dynamic behavior of mechanochromic liquid crystals incorporated within polymer matrices with varying mechanical properties. Results will support advances in smart materials that rapidly sense and respond to external stimuli for situational awareness and signature management applications; gain understanding of molecular-scale properties and dynamic deformation behavior of various polymer and composite materials to inform future development of material systems for improved Soldier protection. ***FY 2024 Plans:*** Will investigate cephalopod-derived reflectin protein conformation dynamics and ability to tune reflected color under electrical stimulation to inform advances in materials for self-healing, chemical protection, and signature management applications; identify	1.186	1.290	1.332

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
and model fundamental material failure mechanisms of coated polycarbonate resulting from high-velocity impacts to support advances in eye protection and transparent armor technologies. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: High Energy Laser (HEL) Materials and Thermal Management ***Description:*** This effort investigates and matures novel laser gain materials and other laser components with advanced thermal, thermo-mechanical, and thermo-optical properties. This effort investigates new materials and methods for controlling thermal transients to reduce the size and weight of thermal management components while increasing the energy magazine of systems operating in burst modes. ***FY 2023 Plans:*** Investigate and assess the tenability of phase change thermal materials and study the thermal transfer characteristics of the materials and interfaces; conduct laser experiments using fibers with advanced glass compositions aimed at improving thermo-mechanical and thermo-optical properties for better power scaling. ***FY 2024 Plans:*** Will investigate, explore, and assess multi-constituent phase change thermal materials, architectures, and modeling approaches to understand and tune transient/dynamic thermal transfer; explore novel glass core compositions for Raman fibers with greatly enhanced Raman gain and maximized thermal conductivity; investigate novel alternative crystalline fiber core materials with greatly improved thermal properties. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort	1.241	1.030	1.062
Title: Physics-Informed Machine Learning for Complex Phenomena ***Description:*** Existing machine-learning approaches are not guided by the laws governing physical systems and unable to provide predictions of a physical system response with quantifiable uncertainty. Research will explore and develop modeling techniques incorporating machine-learning approaches to support fundamental studies of physical systems. Resulting models will be used to design and develop novel physical systems, such as diamond for high power RF applications. ***FY 2023 Plans:*** Explore methods to improve major deficiencies of existing machine-learning approaches when modeling physical systems; based on previous accuracy assessments, identify classes of physical systems on which to focus; examine the use of geometrical methods for incorporating physical constraints into machine-learning models of physical systems; validate most promising	3.150	3.381	3.498

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
methods for assimilating of multiple-fidelity data into machine-learning models of physical systems; analyze existing techniques for uncertainty quantification of machine-learning models for efficacy. ***FY 2024 Plans:*** Will explore existing methods for dimensionality reduction in machine learning when applied to physical systems; validate most promising approaches for construction of surrogate models of relevant physical systems based on previous assessment of geometrical methods for constraints in machine-learning models of physical systems; identify knowledge gaps in methods for assimilating of multiple-fidelity data into machine-learning models of physical systems; identify means of addressing deficiencies based on previous analysis of techniques for uncertainty quantification of machine-learning models. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Semiconductor Modeling for Advanced Electronics ***Description:*** 3D numerical modeling basic research activities are scattered and insular, not effectively leveraging the combined capabilities of Government, Academia, and Industry. The problems are diverse and complicated, and need a focused and multi-disciplinary approach to gain fundamental understanding. This effort will build an ecosystem for foundational modeling and research in semiconductor materials and devices that leverages the broad combined knowledge base from academia, industry, and government laboratories to develop new and advanced semiconductor materials and devices for sensors, emitters, neuromorphic, and topological device applications. ***FY 2023 Plans:*** Apply new materials understanding to Type-II super lattice (T2SL) device structures in collaboration with industry/academia materials to study performance; transition higher order modeling code for high field electro-optical simulations in house for investigation, design, and optimization of avalanche photodiodes (APDs); predict transport and magnetic exchange characteristics of low power switching electronic devices comprised of TI and either ferromagnetic or antiferromagnetic layers. ***FY 2024 Plans:*** Will utilize high fidelity modeling codes to formulate new sensing modalities; develop and apply techniques to assess sub-wavelength imaging; develop models of neuromorphic devices and small circuits incorporating standard semiconductors with emerging materials to gain understanding of material interactions and function; update models of beta and alpha particle interactions with ultra-wide bandgap semiconductors to include experimental data to study defect generation and radiation tolerance of ultra-wide bandgap semiconductors. ***FY 2023 to FY 2024 Increase/Decrease Statement:***	0.673	0.956	0.693

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Funding decrease reflects a reduction in research specifically targeting new materials as research is now shifting to additional modeling.			
Title: Foundational Distributed Radar ***Description:*** This research seeks to investigate novel signal processing techniques to develop distributed, Global Positioning System (GPS)-independent, autonomous capabilities. This effort investigates tools and techniques for modeling, simulations, and emulation of distributed radio frequency (RF) sensors and effectors. This research investigates advanced materials-based antennas for low size, weight, power, and cost (SWaP-C), multi-function systems. ***FY 2023 Plans:*** Investigate concepts for novel radar and multi-function RF signal processing in distributed and complex environments; explore modeling, simulation, and emulation techniques for phenomenology of complex distributed environments for phase synchronous and distributed operation; explore concepts for reconfigurable materials-based antennas and harmonically-operated array elements. ***FY 2024 Plans:*** Will investigate increasing the complexity of electromagnetic environments and investigate the distributed aspects to gains for distributed RF sensors; identify and study distributed RF sensor capabilities through adaptive signal processing techniques to address traditional RF sensor short-comings and solutions to overcome via distributed approaches when used in cluttered Electromagnetic Environment (EME); explore analysis of software-controlled and adaptive Software Defined Radar (SDRadar) concepts for developing signal processing techniques and approaches to provide increased capabilities to the warfighter. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	-	1.211	1.248
Title: Foundational Sensing ***Description:*** This effort explores innovative methods to remotely sense and discriminate threat vehicle formations deep in the battlefield. This effort investigates novel mechanical wave sensing physics to enhance signal features in complex and high noise environments as well as investigates fundamental properties of electric field (E-field) and Magnetic (H)- field signals in cluttered environments. ***FY 2023 Plans:*** Investigate multi-component, reduced size, weight, and power (SWaP) acoustic, seismic, gravimetric, passive radar, and integrated photonic analogs of macro-scale non-traditional sensor systems (e.g. laser vibrometry) and sensing methods that are insensitive to decoys, obscurants, and jamming on ground or airborne platforms; validate sensor performance in tactical environments with improved wide-area modeling and simulation of sensor response and target signatures; research novel domain adaptive processing/learning algorithms for robust target tracking and implement distributed processing framework for single	-	1.988	1.606

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
and multi-agent state estimation, leveraging the ability to process target data locally with limited computational processing and distribute the processing of data over an austere and intermittent network. ***FY 2024 Plans:*** Will leverage and extend multi-modal sensing and incorporate a priori environmental and target knowledge to maximize likelihood of detection and identification; characterize and extend sensor models to enhance robustness of detection and fusion; develop network adaptation techniques, both algorithmic and physical, to enhance detection capability or lower expended power; develop methodologies to efficiently store and recall sensing and environmental data to support learning and adaptation over extended periods of time; investigate high-performance modeling and simulation tools for efficient prediction and processing methods of magnetic and electric field sensor data. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding decrease reflects a reduction in research supporting the distributed processing framework as research is now shifting to additional modeling.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.217	-
Title: Complex Effects Understanding and Modeling ***Description:*** This effort seeks to develop the fundamental understanding necessary to realize complex effects utilizing multiple geographically distributed sensor-effector nodes. This effort will develop new computational methods to accomplish simulations of complex systems that are intractable with current methods due to required interactions of multiple, dynamic physics formulations. This effort will pursue modelling and simulation to identify robust state spaces for distributed apertures capable of beam-forming, cross modal, and coherent sense and effect. Additionally, this effort will investigate sensitivity to synchronization quality and identify opportunities for cancellation and self-referencing. Focal instances include electronic warfare (EW), laser sense and effect, and kinetic effects. Science of design concepts will be investigated to efficiently pare down complex physical systems into tractable solutions including topology optimization and co-design. ***FY 2024 Plans:***	-	-	1.514

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will investigate new computational methods to accomplish simulations of currently intractable physical systems due to the required interaction of multiple, dynamic physics formulations; investigate geometric methods for reducing the dimensionality of inputs under complex interacting physical processes. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research into intractable physical systems and the computational methodologies needed to investigate them.			
Title: Compact Non-Linear Elements and Non-Linear Arrays ***Description:*** This effort seeks to identify novel materials, physics, and architectures to achieve highly non-linear and high-density effects when synchronized in distributed arrays. Research will focus on enablers for emerging applications including electromagnetic (EM) windows for operation in hypersonic plasmas, compact, efficient, and multi-field array elements, intelligent-agent schemas for dynamic arrays, and novel materials for alternate EM bands. ***FY 2024 Plans:*** Will investigate techniques to accelerate the feedback loop for informing dynamic control across the full EM spectrum, for correcting distortions due to complex physical processes; investigate novel energy and power methods for distributed sensing; conduct research into novel ultra-efficient nodes for distributed aperture sensing; investigate fast computational imaging techniques to inform feature detection in infrared (IR) camera images. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research into energy and ultra-efficient nodes for sensing applications.	-	-	1.370
Accomplishments/Planned Programs Subtotals	13.092	13.619	16.383

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army											Date: March 2023	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA9 / *Information and Networking*			
COST ($ in Millions)	**Prior Years**	**FY 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
AA9: *Information and Networking*	-	38.956	42.839	43.075	-	43.075	43.520	43.568	46.644	47.199	0.000	305.801

A. Mission Description and Budget Item Justification

This Project supports basic research to enable intelligent and survivable command, control, communication, computing, and intelligence (C4I) systems for the future force. As the combat force structure decreases and operates in more dispersed formations, information systems must be more robust, intelligent, interoperable, and survivable if the Army is to retain both information and maneuver dominance. This research addresses the areas of information assurance, signal processing for wireless battlefield communications, information extraction from multi-modal data human-agent naturalistic communication, and intelligent systems for C4I. Research will focus on understanding and solving inherent vulnerabilities associated with using standardized protocols and commercial technologies while addressing survivability in a unique hostile military environment that includes highly mobile nodes and infrastructure, bandwidth-constrained communications at the edge, resource-constrained sensor networks, diverse networks with dynamic topologies, high-level multi-path interference and fading, jamming and multi-access interference, levels of noise in speech signals and document images, and information warfare threats. These C4I technologies must accommodate heterogeneous security infrastructures, multi-service and multi-national interoperability, and information exchange/security mechanisms between multiple levels of security. The intelligent systems for C4I research focuses on providing machine learning methods to overcome noisy, sparse, and heterogeneous data with artificial intelligence algorithms that can transfer learning from one domain to another. This foundational research will help identify highly relevant tactical events for mounted or dismounted commanders, leaders and Soldiers; improve the timeliness, quality, and effectiveness of actions; and speed the decision-making process of small teams operating in complex natural or urban terrain.

Work in this Project supports key Army needs and provides the theoretical underpinnings for PE 0602146A (Network C3I Technology), PE 0602143A (Soldier Lethality Technology), and PE 0602145A (Next Generation Combat Vehicle Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Communications in Complex Dynamic Networks	5.128	5.621	5.739
Description: Perform research to provide communications capability for a fully-mobile, fully-communicating, and situationally-aware force operating in a highly dynamic, wireless, mobile networking environment populated by hundreds to thousands of networked nodes. This research includes techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldier information needs, modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber-attacks. Also to be considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information.			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
FY 2023 Plans: Explore techniques and experimentation capabilities that dynamically monitor and identify adaptations of network resources and distributed analytics configurations to account for dynamics in-network resource availability and environmental state; conduct simulation- and emulation-based experiments to characterize performance of emerging networking capabilities, including high-speed networking technologies, unconventional spectrum, and joint classical/quantum networking; conduct research into heterogeneous networks comprising diverse communications capabilities, focusing on identifying and analyzing intelligent protocols for adapting to complex, dynamic, and/or spatially varying mission requirements and environments by leveraging unique features of component network technologies. ***FY 2024 Plans:*** Will explore analysis and simulation frameworks for multi-hop multi-modal routing protocols that optimize multiple simultaneous flows; analyze performance/overhead tradeoffs associated with the degree of integration of heterogeneous networks; investigate techniques to dynamically and efficiently adapt intelligent networked services that enhance performance of complex analytics in dynamic networks and environments; study approaches to efficiently orchestrate complex network resources using software defined networks and virtualized or containerized services; explore experimentation capabilities that deploy large-scale emulation-based experiments within high-performance, hardware-based next-generation software defined network switching/routing environments; explore techniques for managing and analyzing experimental data from large-scale simulation and emulation-based experiments; conduct experiments on network protocols for increased robustness and optimized planning; explore emerging quantum network simulation technology and conduct Army-feasibility experiments on quantum network protocols. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Data to Knowledge to Support Decision Making (Information Mediation)	4.063	4.459	4.554
Description: Research a laboratory-scale common information processing infrastructure, inclusive of cloud computing, for networking processes that aids the transformation of data into actionable intelligence to support decision-making under uncertainty. Perform research to utilize real-time, tactical, Soldier-centric information for improved decision-making and situational awareness. Perform research in support of rapidly enhancing long-duration, complex, dynamic decision-making capabilities of individual Warfighters and units through the integration of cognitive augmentation and course of action recommender technologies. ***FY 2023 Plans:*** Investigate theories and fundamental models for facilitating increased comprehension, decreased uncertainty, and maintaining effective op-tempo decision making and responsive situational awareness and understanding; research design methods of visualizations to characterize impact of information in the dynamic operating environment under conditions of time sensitive and dynamically changing information; investigate gaps related to human cognition and system interface in decision making on			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
novel and emerging cross-reality visualization technologies; explore fundamental understanding of, and theories for, decision making phenomena in immersive environments and Joint, Coalition, and/or multi-domain data; investigate computational models, linguistic approaches, and rule-based algorithms for automated systems to detect, analyze, and interpret content from multimodal information sources and create methods and algorithms for knowledge networks for concept recognition, information foraging, semantic search, and advanced data analytics; explore theories for inferencing algorithms to derive context from multimodal, multisource information; investigate theoretical and computational models of causality, information uncertainty, and automated reasoning to recognize changing context, course of action recommendations, and ad hoc autonomous or collaborative decision making. ***FY 2024 Plans:*** Will investigate the effect of visual information overload across different types of display modalities, specifically augmented reality, virtual reality, and traditional single screen displays; investigate how a human's perception degrades under high visual workloads; explore the effects of head and eye movement tracking and display technology on dense search space; create algorithms to enable agents to interpret multisource information to infer meaning, create shared understanding, and support decision-making; investigate methods to enable autonomous systems to create mission relevant narratives using natural language text or audio; define causal inferencing algorithms to derive context from multimodal content for semi-autonomous decision-making and course of action generation. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Information Protection in Mobile Dynamic Networks ***Description:*** Perform research on protecting information in highly mobile, wireless tactical environments, where networks must operate under severe bandwidth, energy, and processing constraints, and without reliance on centralized security services. ***FY 2023 Plans:*** Conduct experiments on the direct transmission of entangled quantum states through various networking elements, including fiber and free-space channels, switches, and frequency converters; explore and analyze methods for creating, manipulating, and measuring hyper- and multipartite-entangled states; investigate defenses to adversarial machine learning based attacks on network security systems; reduce/eliminate misclassification of malicious network traffic as legitimate; reduce/eliminate misclassification of legitimate network traffic as malicious traffic to cause false positives; develop techniques to improve model performance through adversarial retraining. ***FY 2024 Plans:*** Will develop and assess computationally efficient methods for characterizing entangled states in network scenarios, enabling high-fidelity simulations of quantum networks; experimentally investigate the transmission of quantum states through a series of linked quantum networking elements, such as switches concurrently serving several network users; conduct research on hybrid quantum	4.887	5.363	5.570

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
networking processes, including quantum frequency conversion; investigate network routing strategies with global multi-objectives accounting for message priority, latency, covertness, and robustness. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Advanced Computing Architectures and Algorithms ***Description:*** Investigate advanced computing and high performance computing (HPC) networking architectures, memory/ storage architectures, processing algorithms, and visualization techniques to support advanced battle command applications for Command, Control, Communications, Computers, and Intelligence (C4I) systems. ***FY 2023 Plans:*** Explore algorithms to discover and assess resource availability and capability in decentralized teams of agents; research optimized, constraints-based, resource allocation methodologies and algorithms for system of systems; analyze generalized algorithm reduction, compression, and scaling methodologies for size, weight, power and time constrained devices at the tactical edge; study emerging computing architectures designed specifically for neural network inferencing to determine best viable candidates; develop algorithms, benchmarks, and techniques to measure performance of a neural network on a specific architecture; engage in hardware / software co-design efforts to maximize inferencing performance; enable trade-space analysis of performance characteristics in order to meet specified requirements in machine learning inferencing. ***FY 2024 Plans:*** Will explore model simulation and emulation of neural network designs employed in open-source field programmable gate arrays (FPGAs); assess the potential of neural network designs employed in open-source FPGAs in a hybrid central processing unit with specialized neural networking elements in order to maximize computational efficiency while minimizing energy usage for tactical edge processing of image data obtained in a multi-domain operating environment; create a specialized domain specific computer programming language for neural network design in order to interface with processors using a co-neural network processor order to perform federated and distributed tactical learning in a hierarchical neural networking topology. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.	3.757	4.124	4.212
Title: Assured Operations in the Physical, Social and Cyber Domain ***Description:*** Conduct research that will enhance the survivability of information by radically dispersing and continuously moving data across a multitude of inter-networked devices. This effort seeks to address the growing demands on information assurance, reliability, and transmission in resource constrained environments. Theories and methods will be investigated for securing information across heterogeneous devices/sources and networks, detecting and creating information obfuscation and deception	6.084	6.505	5.144

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. ***FY 2023 Plans:*** Conduct research to develop algorithms to efficiently and robustly understand performance of complex analytics in a variety of situations and network and environmental states, and can optimally identify adaptation and reconfiguration strategies toward the allocation of network and analytics resources; study algorithms for multi-agent systems to allow optimal decision making in teams of agents that are resilient to critical failures; investigate scientific theories and methods that optimize information synthesis under constrained battlefield environment; research methodologies to identify and exploit high-value information from physical sensors, information assets, and intelligence given highly dynamic and optempo conditions, unreliable network, and adversarial presence; research contextually-sensitive resilient dissemination and mediation of multi-domain battlefield information based on value-based selection, prioritization, and mission factors; investigate theories and novel methods for resilient information-network that allow dynamic information pathways and improve time and reliability of information/data over constrained tactical networks; study new methods for single and multi-modal machine-learning based reconstruction algorithms for one-dimensional (1-D) and two-dimensional (2-D) signals; investigate machine-learning methods to derive controlling parameters from data in physical systems (inverse problems); assess performance of low-resource methods for aggregating and propagating uncertainty in physical systems. ***FY 2024 Plans:*** Will explore distributed methods to efficiently maintain situational awareness of multilayer networked information and dynamic network environments; investigate dynamic programming and distributed optimization techniques for resource allocation of complex analytics; develop algorithms and methodologies for automated network analytics, and integrated Machine Learning techniques and Machine Learning Poisoning mitigation; research methods for cyber situational awareness and threat classification methods; investigate theories and machine learning algorithms that automate cyber defense reasoning; develop a concept for an algorithm for prioritizing and filtering information in dynamic tactical environments, allowing the right information to reach the right Soldier at the right time; investigate the contexts and features of the Soldier state and information space which influence the value of information and derive information utility accordingly. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned from this effort to PE 0601102A Project AA6 Robotics and Mobile Energy to support research in Foundational Energy for Sustained Operations.			
Title: Machine Learning for Intelligent Agent and Human Decision Making	5.533	6.066	6.291
Description: This effort researches methodologies and algorithms for machine learning with incomplete, unstructured, potentially deceptive, and heterogeneous information, enabling joint decision making for Intelligent Agent-Human teams which adapt to			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
unknown environments and missions. Research includes methods for learning and decision making that occur under short time frames and constrained resources (e.g., computation, power, spectrum, and networks). ***FY 2023 Plans:*** Explore the tradeoffs of performance and accuracy in machine learning algorithms while exercising model-efficiency techniques; investigate ability to instantiate realistic honeynets in a novel multi-fidelity testbed; develop and assess proof-of-concept approaches for SDN-based technologies for tactical applications; examine phenomena and create theoretical approaches that allow small teams of heterogeneous agents to coordinate, decide, and act based on environmental context and observations for tactically relevant situations; determine best mathematical methods and create algorithms for shared representations across teams of heterogeneous assets using salient data streams; research collaborative game-theoretic Intelligence, Surveillance, Reconnaissance (ISR) task execution in contested environments, adversarial evasion, and autonomous maneuver to a position of advantage, and autonomous navigation to target location while avoiding detection; investigate fundamental methods for dynamic bi-directional interaction between Soldiers and autonomous systems to maintain a consistent world model and shared understanding during joint collaborative tasks; explore fundamental techniques to enable multi-agent systems to autonomously adapt group behaviors through machine learning and theoretical models of coordination. ***FY 2024 Plans:*** Will investigate methods for multi-agent systems to autonomously adapt group behaviors through reinforcement learning and computational models of coordination; define modeling and simulation frameworks with context-aware agents and reinforcement learning approaches to enable artificial intelligence (AI)-driven course of action analysis; investigate multimodal content to determine context and build a consistent world view within intelligent systems; use Machine Learning (ML) methods to enable autonomous systems to interact with Soldiers through natural communication and maintain shared understanding of task goals; explore coordination strategies that allow teams of autonomous agents to share environmental observations with limited network connectivity; create algorithms that enable distributed task planning in partially observable environments. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Image Analytics and Understanding ***Description:*** This effort investigates new methodologies and techniques for improved scene and situational understanding using multi-modal imaging sensors from heterogeneous air and ground platforms. This work explores novel machine learning approaches for applications in resource constrained environments. ***FY 2023 Plans:*** Investigate machine learning methods for situational understanding based on vision sensor data for rapid decision-making in complex and dynamic environments with constrained computing resources; investigate methods for synthesizing image data	2.148	2.366	2.416

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
for training machine learning algorithms for improved real-world performance; investigate methods for fusing information from aerial geospatial data with ground data for context-aware route planning and autonomous navigation; conduct experiments with electro-optical infrared (EO/IR) data collections using unmanned aerial vehicles (UAVs) of humans performing activities; develop computer graphics and motion capture solutions to generate synthetic activity data, increasing the amount of data available over real-world only data for algorithm training. ***FY 2024 Plans:*** Will investigate Machine Learning (ML) methods for situational understanding based on multi-modal sensors onboard size, weight, and power (SWaP)-constrained platforms (Unmanned Aerial Vehicles or Unmanned Ground Vehicle) subject to austere and adverse imaging conditions, such as high altitudes, high winds, drone vibration, and low illumination, producing shaky images/videos with degraded image quality; investigate robust scene synthesis methods that utilize hybrid datasets of real and synthetic images of objects and activities of interest to optimize ML models representing varying battlefield conditions to ensure pre-deployment operational readiness at the tactical edge; investigate fundamental limits and boundary conditions of ML models to reduce prediction uncertainty and increase the trustworthiness of the ML outcome at the tactical edge given operational requirements; investigate joint learning of synthetic foregrounds and backgrounds of a variety of scenes of interest using advanced rendering tools to achieve rapid per-deployment adaptation of ML models. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Fundamentals for Energy Efficient Electronic & Photonic Components	1.872	2.064	2.109
Description: This effort addresses the power draw (demand) of radio frequency (RF) front ends for communication and electronic materials for the digital back-end, as well as efficient materials for delivery of power (supply) for electronics on energy constrained platforms. The work explores new materials with inherently higher energy efficiencies in conjunction with advances in circuits and systems to provide improvements in power efficiencies, linearity, and noise at the subsystem level for unique Army requirements for demand and supply electronics. ***FY 2023 Plans:*** Investigate and identify limitations of radiation tolerance in Ultra-Wide Bandgap (UWBG) materials through modeling and alpha and electron beam radiation exposure assessments; investigate structurally metastable nitrides for electric field-induced phased transitions using x-ray crystallography and electrothermal characterization; explore the effects of metallization of additively manufactured composite materials on circuit performance in 3-Dimensional (3-D) printed structural power devices and electronics; design and fabricate metasurfaces specific for addressing future needs in imaging, radar, and communications applications. ***FY 2024 Plans:*** Will validate and measure metasurface aperture designs; investigate devices based on functional materials for analog compute-in-memory and efficient neural network hardware architectures; investigate the thermal properties of diamond transistors			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
and heterostructures for increased efficiency RF systems; study the radiation tolerance of Ultra-Wide Bandgap (UWBG) semiconductors by investigating different alpha and beta-voltaic structure designs and assess device lifetimes under high energy radiation; examine the ability to achieve anitferroelectric behavior in a nitride material system and explore the energy density and thermal stability performance; investigate mechanical interfaces for thru-metal acoustic wave wireless power transfer with peripheral electronics for control of power transfer based on arbitrary placement of a receiver. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.			
Title: Quantum Information Sciences ***Description:*** This effort investigates interactions between light and quantum systems, including atoms, ions, and solid-state materials, for developing the fundamental building blocks of distributed quantum systems. A particular emphasis is efficient light matter interfaces, including optical cavities, nanophotonics, and high density atomic systems. This effort also explores quantum algorithms for entanglement distribution. ***FY 2023 Plans:*** Investigate interfaces between electromagnetic fields and atomic/material systems for novel sensors, building blocks of entanglement distribution, and approaches to low size, weight, and power timekeeping; investigate experimental implementation of proposed techniques for quantum gate operations in atomic systems; explore 1-D physics of interacting quantum systems; explore sub-thermal readout of electric field sensors; investigate all-optical approaches to photonic qubits; explore effect of defect density on clock and sensor performance in solid-state sensors. ***FY 2024 Plans:*** Will investigate approaches for strong light matter interfaces for next-generation clocks, sensors, and quantum information components; investigate solid-state defects confined to microwave resonators as an athermal frequency standard; investigate growth processes in Silicon Carbide (SiC) for magnetometry and qubit operation; explore atoms strongly coupled to radio frequency (RF)/microwave resonators for sensitive measurement of electric fields; investigate collective, long-range atom-atom interactions in nanofibers; investigate quantum-enhanced gravimeters. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	5.484	6.013	6.140
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:***	-	0.258	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638			
Title: Assessing and Mitigating Climate Risk for Decision Making ***Description:*** Lead Army-focused environmental basic research within climatological time frames (multi-year to decades), specifically researching changes and impacts of dynamic processes in the lower atmospheric boundary layer in Multi Domain Operation (MDO) environments (complex terrain and dense-urban) as underpinning science to inform applied research projects in climate impact decision support systems. ***FY 2024 Plans:*** Will investigate the development of a climatological database derived from a Distributed Virtual Proving Ground (DVPG) instrumentation array in New Mexico; design computational tools to predict the magnitude and impact of climate change on operations, weapon systems, and personnel utilizing the DVPG climatological database. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding realigned from PE0601102A Project AA7 Mechanics and Ballistics to support research in climate risk for decision making.	-	-	0.900
Accomplishments/Planned Programs Subtotals	38.956	42.839	43.075

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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

A. Mission Description and Budget Item Justification

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

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

Work is performed by the Army Futures Command.

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

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will develop models and basic science approaches to translate injury mechanisms from the cellular level to higher tissue and organ level to understand their applicability in injury prevention and performance sustainment. Will continue to develop scaling models for injury utilizing models to translate injury criteria for use in human Person Protective Equipment (PPE) development. ***FY 2024 Plans:*** Will finalize mechanistic translational models from cellular and tissue level to the whole body in order to develop strategies to mitigate injury risk and performance degradation. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects to re-baselining of basic research efforts post-USAMRDC transition to DHA.			
Title: Physiological Health ***Description:*** This effort conducts fundamental research on the physiological mechanisms of sleep, fatigue, and nutrition on Soldier health, readiness and performance. In addition, this effort discovers basic understanding of physiological and genetic processes leading to biomedical performance enhancement in in the physical, cognitive and psychological domains. ***FY 2023 Plans:*** Will finalize basic research to understand field-based impact of sleep on operational performance. Will initiate research to understand neurobiological mechanisms of chronic fatigue incurred during extended operational conditions. Will finalize definition of the role of nutrition support for metabolic recovery from military activity. Will initiate research to understand the interface of nutrition modulation and immune regulation of disease susceptibility and injury recovery. ***FY 2024 Plans:*** Will finalize mechanistic translational models from cellular and tissue level to the whole body in order to develop strategies to mitigate injury risk and performance degradation. Will continue research prebiotic and probiotic modulation of the microbiota-gut-brain axis during acute stress to inform the role of nutrition support for metabolic recovery from military activity. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	3.861	1.416	1.443
Title: Environmental Health ***Description:*** This effort involves the understanding of physiological (human physical and biochemical functions) mechanisms of exposure to extreme heat, cold, altitude, and other environmental stressors. This effort establishes scientific evidence for specific and sensitive diagnostics of exertional heat illness to optimize Warfighter performance in austere environments. ***FY 2023 Plans:***	1.090	0.988	1.262

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Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

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

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

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

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	17.311	19.201	19.564	-	19.564	19.860	20.026	20.644	20.863	0.000	137.469

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Mapping, remote sensing, signature physics and terrain state	3.680	4.177	4.358
Description: Investigates compact mathematical representations of terrain data, explores automated learning of built elemental features unique to location, formulates new techniques for automatically retrieving Earth surface features, properties and patterns, explores sensing phenomenology and surface state as affected by terrain and weather, studies optimizing and adapting decision making based on changing geospatial conditions.			
FY 2023 Plans: Investigate parameterized anomalous sound propagation effects derived from ground turbulence blocking to localize and track elevated acoustic sources. Investigate if a link exists between mechanical properties of snow permeability, elastic modulus, and acoustic response. Quantify thin snow absorption, emission, and scattering processes influencing radiative transfer. Use this fundamental research to inform deep learning models for a forest canopy that predicts understory parameters.			
FY 2024 Plans: Will pursue fundamental and novel research on understanding Earth surface attributes and processes. Will investigate emergent patterns and behaviors derived from complex geospatial and ancillary numerical and/or semantic data. Will explore whether critical surface features identified from Deep Learning models can retrieve the observed subsurface features. Will examine the intrinsic properties of snow governing acoustic propagation and inverting formulated acoustic models for estimating snow properties.			
FY 2023 to FY 2024 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Funding change reflects the planned lifecycle of this effort.			
Title: Fundamental Adaptive Protection and Projection Research ***Description:*** Conduct fundamental studies on the theory and modeling of future revolutionary geological, structural, and signature reducing materials; and examine, investigate and model complex geophysical, littoral, and other environments that fill critical Army knowledge gaps in adaptive protection and projection. ***FY 2023 Plans:*** Determine if density class interactions in multiple density mixtures lead to nonlinear sediment transport curves based on the proportion of dense material. Use parallel treatment of grains and bonds to understand how microscale snow parameters, particularly sintered bonds, impact the macroscale compressive strength. Systematically investigate multi-scale steel fiber influence on damage processes in Ultra-High Performance Concrete (UHPC). Will combine this novel research and experimental data with recently available data-driven discovery methods to capture near-surface aerodynamics and wind-driven process characterizations in dry-land environments. ***FY 2024 Plans:*** Will gain fundamental scientific knowledge of the environmental phenomena that impact engineering system performance. Will investigate multi-scale characterization and modeling of materials. Will pursue the discovery and design properties of engineered materials with enhanced performance, improved function, and reduced weight for future force protection and force projection applications. Will explore the near-surface turbulent flow problem from a holistic environmental-system perspective with emerging data-driven machine learning methods. Will study complex nanoscale structure-property relationships of interfaces and soft/hard layers and apply a materials by design strategy for shock mitigation. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects the planned lifecycle of this effort.	4.470	4.670	4.865
Title: Fundamental Infrastructure Sciences ***Description:*** Explores fundamental theory of artificial intelligence, robotics, autonomous construction, three-dimensional (3D) printing materials, self-assembly and advanced or innovative material science as related to advancing military construction and Engineer operations. ***FY 2023 Plans:*** Investigate the protein responsible for the durable, water resistant and thermally regulated mud dauber wasp nest. Investigate characterizations of liquid Gallium diffusion in Aluminum to potentially inform future infrastructure engineering advancements. Use	1.730	1.912	2.051

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
dynamic hyperbolic data projection to reveal knowledge from hyperdimensional datasets that existing methods are incapable of exposing. ***FY 2024 Plans:*** Will explore fundamental elements of natural or manmade processes and materials, data science, complex systems, and energy science to inform future advances in Army infrastructure. Will explore computational underpinnings for the design of high-entropy alloy nanomaterials and control of atomic arrangement using thermal annealing. Will seek to understand the diffusion of elements such as liquid Gallium and Aluminum to inform control of the alloying process for future fabrication of components. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects the planned lifecycle of this effort.			
Title: Biological, Chemical and Physical Sciences ***Description:*** Explore novel approaches of innovative data analytics, bio-inspired materials, and chemical experimentation to understand basic principles of biological and chemical mechanisms, organisms, and natural processes of the environment. ***FY 2023 Plans:*** Investigate soil disturbance and emissions using volatile compounds. Explore the relationship between atmospheric phenomena and natural processes. Explore synthetic engineering of bacteria to function as a non-model synthetic biology chassis. Investigate fundamental principles of cryptobiosis by engineering mechanisms into cells. Explorative research to investigate current and signal propagation dynamics in fungal melanin. New research into genetic adaptations of lichens will be conducted to exploit biological engineering functionalities. Investigate biological reactivity of carbon nanofiber strength with select proteins; results acquired from Basic Research may inform future capability advancement and adverse impacts on Army operations. ***FY 2024 Plans:*** Will conduct fundamental research into novel biological mechanisms or natural and geological processes. Will pursue basic research in biotechnology to understand biological approaches and mechanisms for future Army technology advancements. Will investigate complex environmental, chemical, and biological processes and features to fill knowledge gaps and inform future Army applications. Will explore foundational research associated with extreme environments, to include cold regions. Will explore genetic adaptations that enable lichens to tolerate harsh conditions. Will evaluate the signal propagation properties of intracellular fungal melanin to determine characteristic frequency range at which it can propagate signals without attenuation. Will utilize cryptanalysis techniques to extract hidden structure in noise, providing an understanding of dynamics driving the collective motion of animals from tracking data. ***FY 2023 to FY 2024 Increase/Decrease Statement:***	7.431	7.980	8.290

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Funding change reflects the planned lifecycle of this effort.			
Title: SBIR/STTR Transfer	-	0.462	-
Description: Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638.			
Accomplishments/Planned Programs Subtotals	17.311	19.201	19.564

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

N/A

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) CH9 / *Advancing Concepts and Technology Forecasting*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
CH9: *Advancing Concepts and Technology Forecasting*	-	3.443	3.793	3.862	-	3.862	3.895	3.900	3.903	3.946	0.000	26.742

A. Mission Description and Budget Item Justification

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

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

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

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy. Work in this Project is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Advancing Concepts and Technology Forecasting	3.443	3.712	3.862
Description: Advancing Concepts identifies emerging and disruptive basic scientific research outcomes in order to translate, integrate, and ingrain research outcomes with Army Warfighting Concepts which describe how the Army will fight in the far-term future. Technology Forecasting provides long-range, scientifically grounded technology forecasts of basic research topics to enable informed decision-making.			
FY 2023 Plans: Combine basic scientific research outcomes into emerging Army Warfighting Concept priorities for far-term decision dominance, deception and protection, sustained operations, and maximizing human potential; provide objective estimates of anticipated basic scientific research advances, across the Army Priority Research Areas, to Army decision-makers to aid in basic research program formulation.			
FY 2024 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** CH9 / *Advancing Concepts and Technology Forecasting*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will integrate outcomes of far-term Army Warfighting Concept priorities for decision advantage into emerging basic scientific research programs in distributed sensing and artificial intelligence for agile command and control, and for sustained operations into emerging basic scientific research programs in energy sciences; provide objective estimates of anticipated basic scientific research advances of emerging scientific areas (novel computing architectures, alternative power sources, new communications mechanisms) with high relevance to the Army. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of this effort.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.081	-
Accomplishments/Planned Programs Subtotals	3.443	3.793	3.862

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T14 / *BASIC RESEARCH INITIATIVES - AMC (CA)*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	73.000	112.500	-	-	-	-	-	-	-	0.000	185.500

Note

Congressional Interest Item funding provided for Defense Research Sciences.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Defense Research Sciences.

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T14 / *BASIC RESEARCH INITIATIVES - AMC (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023
FY 2022 Accomplishments: Congressional Interest Item funding provided for Joint Research Labratories ***FY 2023 Plans:*** Congressional Interest Item funding provided for Joint Research Labrotories		
Congressional Add: Lightweight High Entropy Metallic Alloy Discovery ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Lightweight High Entropy Metallic Alloy Discovery	3.000	-
Congressional Add: Unmanned Aerial Systems Propulsion ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Unmanned Aerial Systems Propulsion	5.000	-
Congressional Add: Program Increase - ARTIFICIAL INTELLIGENCE (AI) FUSION ***FY 2023 Plans:*** Congressional Interest Item funding provided for ARTIFICIAL INTELLIGENCE (AI) FUSION	-	2.500
Congressional Add: Program Increase - BASIC RESEARCH ***FY 2023 Plans:*** Congressional Interest Item funding provided for Basic Research	-	25.000
Congressional Add: Program Increase - CENTER FOR UAS PROPULSION ***FY 2023 Plans:*** Congressional Interest Item funding provided for CENTER FOR UAS PROPULSION	-	5.000
Congressional Add: Program Increase - COUNTER UAS TECHNOLOGY RESEARCH ***FY 2023 Plans:*** Congressional Interest Item funding provided for COUNTER UAS TECHNOLOGY RESEARCH	-	5.000
Congressional Add: Program Increase - HIGH ENTROPY METALLIC ALLOYS ***FY 2023 Plans:*** Congressional Interest Item funding provided for High Entropy Metallic Alloys	-	5.000
Congressional Add: Program Increase - RENEWABLE ENERGY TECHNOLOGIES ***FY 2023 Plans:*** Congressional Interest Item funding provided for Renewable Energy Technologies	-	15.000
Congressional Add: Program Increase - SUSTAINABLE AVIATION FUEL PROPULSION ***FY 2023 Plans:*** Congressional Interest Item funding provided for Sustainable Aviation Fuel Propulsion	-	7.500
Congressional Add: Program Increase - UNMANNED AERIAL SYSTEMS HYBRID PROPULSION	-	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T14 / *BASIC RESEARCH INITIATIVES - AMC (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023
FY 2023 Plans: Congressional Interest Item funding provided for UNMANNED AERIAL SYSTEMS HYBRID PROPULSION		
Congressional Adds Subtotals	73.000	112.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army	Date: March 2023
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
Total Program Element	-	88.797	107.160	75.672	-	75.672	78.009	79.750	81.458	83.809	0.000	594.655
AB3: *MURI/PECASE/DURIP*	-	63.797	70.160	75.672	-	75.672	78.009	79.750	81.458	83.809	0.000	532.655
D58: *URI ACTIVITIES (CA)*	-	25.000	37.000	-	-	-	-	-	-	-	0.000	62.000

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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total
Previous President's Budget	91.241	70.775	71.842	-	71.842
Current President's Budget	88.797	107.160	75.672	-	75.672
Total Adjustments	-2.444	36.385	3.830	-	3.830
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	37.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-2.444	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	3.830	-	3.830
• FFRDC Transfer	-	-0.615	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army	Date: March 2023
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2022	FY 2023
Project: D58: *URI ACTIVITIES (CA)*		
Congressional Add: *Program Increase - Defense University Research Instrumentation Program*	25.000	30.000
Congressional Add: *Program Increase - Missile Soldier Touch Point Center*	-	7.000
Congressional Add Subtotals for Project: D58	25.000	37.000
Congressional Add Totals for all Projects	25.000	37.000

Change Summary Explanation

Increased funding due to revised economic assumptions.

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) AB3 / *MURI/PECASE/DURIP*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AB3: *MURI/PECASE/DURIP*	-	63.797	70.160	75.672	-	75.672	78.009	79.750	81.458	83.809	0.000	532.655

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 2022	FY 2023	FY 2024
Title: Multidisciplinary University Research Initiative	51.762	55.200	62.204
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 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 2024 Plans: Will provide continued support for active MURI efforts made in prior years, and award eight to ten FY24 MURI efforts at a cost of $1.5 million each per year to enable advances in select interdisciplinary basic science and/or engineering research areas determined to be of critical importance to national defense.			
FY 2023 to FY 2024 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** AB3 / *MURI/PECASE/DURIP*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Funding increase supports additional research investments in each new MURI awarded in FY2024.			
Title: Presidential Early Career Awards for Scientists and Engineers ***Description:*** Supports Presidential Early Career Awards for Scientists and Engineers (PECASE) investigators started in prior years as well as new award recipients. ***FY 2023 Plans:*** Will support prior year awardees and assess and recommend four new PECASE candidates in FY23. ***FY 2024 Plans:*** Will assess and recommend two PECASE candidates in FY24 and continue support for prior year awardees. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	4.510	4.611	5.061
Title: Defense University Research Instrumentation Program ***Description:*** Supports basic research through competitive grants for research instrumentation. ***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 2024 Plans:*** Will assess and award competitive research instrumentation grants to enhance universities' capabilities to conduct world class research, and enhance educational capabilities critical to Army transformation and modernization. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports planned lifecycle of this effort.	7.525	7.788	8.407
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:***	-	2.561	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** AB3 / *MURI/PECASE/DURIP*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Funding transferred in accordance with Title 15 USC §638			
Accomplishments/Planned Programs Subtotals	63.797	70.160	75.672

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) D58 / *URI ACTIVITIES (CA)*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
D58: *URI ACTIVITIES (CA)*	-	25.000	37.000	-	-	-	-	-	-	-	0.000	62.000

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 2022	FY 2023
Congressional Add: Program Increase - Defense University Research Instrumentation Program ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Defense University Research Instrumentation Program ***FY 2023 Plans:*** Congressional Interest Item funding provided for Defense University Research Instrumentation Program	25.000	30.000
Congressional Add: Program Increase - Missile Soldier Touch Point Center ***FY 2023 Plans:*** Congressional Interest Item funding provided for Missile Soldier Touch Point Center	-	7.000
Congressional Adds Subtotals	25.000	37.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army												Date: March 2023
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601104A *I University and Industry Research Centers*							
COST ($ in Millions)	**Prior Years**	**FY 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
Total Program Element	-	122.521	121.160	108.946	-	108.946	109.506	118.022	124.135	127.459	0.000	831.749
AB4: *Army Research Centers*	-	21.839	24.359	25.443	-	25.443	25.647	26.097	26.114	26.398	0.000	175.897
AB7: *Army Collaborative Research and Tech Alliances*	-	50.435	57.451	63.445	-	63.445	63.273	71.312	77.394	80.208	0.000	463.518
AB8: *Army Educational Outreach Program*	-	10.252	11.244	12.485	-	12.485	12.730	12.746	12.755	12.895	0.000	85.107
AC6: *International Science and Technology*	-	6.745	7.406	7.573	-	7.573	7.856	7.867	7.872	7.958	0.000	53.277
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	33.250	20.700	-	-	-	-	-	-	-	0.000	53.950

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.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army	Date: March 2023
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*

B. Program Change Summary ($ in Millions)	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total
Previous President's Budget	126.267	100.909	103.414	-	103.414
Current President's Budget	122.521	121.160	108.946	-	108.946
Total Adjustments	-3.746	20.251	5.532	-	5.532
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	20.700			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-3.746	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	5.532	-	5.532
• FFRDC Transfer	-	-0.449	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2022	FY 2023
Project: J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*		
Congressional Add: *Program Increase - MATERIALS IN EXTREME DYNAMIC ENVIRONMENTS*	5.000	5.000
Congressional Add: *Program increase - BIOTECHNOLOGY ADVANCEMENTS*	4.000	4.000
Congressional Add: *Program increase - Army artificial intelligence innovation*	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: *Program Increase - INFUSION OF CYBERSECURITY CONCEPTS INTO NONTECHNICAL HIGH SCHOOL COURSES*	-	2.000
Congressional Add: *Program Increase - NEXT GENERATION SURVIVAL RADIO*	-	3.800
Congressional Add: *Program Increase - QUANTUM COMPUTING TECHNOLOGIES*	-	1.400
Congressional Add: *Program Increase - HYPERSONIC TECHNOLOGY RESEARCH AND TESTING INITIATIVE*	-	4.500
Congressional Add Subtotals for Project: J13	33.250	20.700
Congressional Add Totals for all Projects	33.250	20.700

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army	Date: March 2023
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*

Change Summary Explanation

Increased funding to support basic research enhancements for strategic competition.

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) AB4 / *Army Research Centers*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AB4: *Army Research Centers*	-	21.839	24.359	25.443	-	25.443	25.647	26.097	26.114	26.398	0.000	175.897

A. Mission Description and Budget Item Justification

This Project encompasses three types of Centers. The first is the Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) Research Centers of Excellence which supports the Army's research partnerships with HBCUs/MIs. The HBCU/MI Research Centers of Excellence were established as the next phase of what was previously known as the Partnered Research Initiative (PRI) Program that ended in Fiscal Year 2020. 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 all supporting the Army's goal of broadening the performer base and diversifying the research ecosystem in the areas of information sciences, engineering, and physical sciences.

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 2022	FY 2023	FY 2024
Title: Centers of Excellence for Battlefield Capability Enhancements (BCE)	1.586	1.674	1.803
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 2023 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2024 Plans:*** Will foster the advancement of remote sensing technologies by focusing on acoustic and seismic sensing capabilities for military movement and maneuver in urban environments while advancing education and training of minority and underrepresented students in research targeted towards Army modernization needs. Acoustic and seismic sensing have promising potentials for passive, non-line-of-sight, detection, localization, and monitoring of natural and human activities. There will be a strong emphasis on undergraduate involvement in addressing this unique-to-Army challenge of sensing in the Dense Urban Environment. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of the effort.			
Title: Institute for Collaborative Biotechnologies	4.502	4.791	5.053
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 2023 Plans:*** 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 microbial consortia with dynamic properties for modular and programmable biological behaviors, such as event logging or syntheses of reactive materials. ***FY 2024 Plans:*** Will develop enzymatic systems where activation of diazirines yield highly-strained ring systems and design and implement multi-component synthetic cells for biofilm formation; create and assess ultrasound-actuated multifunctional synthetic biology circuits; combine experimental and computational species translation modeling tests for animal-human study relevance to bridge the			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
biotic-abiotic gap through electrical switching and control of reflectin and other proteins, that if successful will enable the use of synergy between synthetic biology and synthetic chemistry for the scalable synthesis of bioactive natural products. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of the 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 2023 Plans:*** 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 2024 Plans:***	4.458	4.810	5.127

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will research dynamics of emotional expression to obtain fine-grained understanding of emotion and human intent during person to person, or person to agent interactions; investigate how individual's information can be used during training and inference time for software agents to effectively communicate with humans without agents being able to personally identify the individual (differential privacy); explore fast three-dimensional (3D) scene generation to aid in synthetic data-generation and in Augmented Reality/Virtual Reality as part of synthetic training environments. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of the 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 2023 Plans:*** 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 2024 Plans:*** Will explore fundamental questions in the exploitation, understanding, and ultimate capabilities of nanophotonics including imaging metastructures in conjunction with computational imaging, and novel light sources for stable large area lasers, efficient THz sources, and free-electron lasers; develop computational, data science, and experimental methods to explore the field of superelastic ceramics that exhibits a martensitic transformation that permits large shape change; explore fundamental aspects of radiative thermal emission, in the far field and in the near field regimes, using the unique ability of photonic crystals and metamaterials to tailor the photon densities of states in these systems by developing mesoscale objects with nanoscale feature sizes that if successful, will enable new functional materials, portable power generation, and flexible electronics. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of the effort.	4.662	4.949	5.753
Title: Vertical Lift Research Center of Excellence (VLRCOE) ***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,	3.152	3.363	3.578

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Structures, Flight Dynamics and Control, Rotorcraft Design and Concepts, Vibration and Noise Control, Propulsion, Affordability, Safety and Survivability, and Naval Operations. ***FY 2023 Plans:*** Execute the second year of the five-year VLRCOE cooperative agreements with Georgia Tech, Penn State University, and University of Maryland. 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. 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 2024 Plans:*** Will conduct the second annual review followed by executing the third year of the VLRCOE program. The research conducted will focus on human-intuitable collision avoidance for semi/autonomous aircraft and adaptive pilot modeling for complex environments such as shipboard operations; explore new technologies such as electrified variable speed rotorcraft drivetrain and electric actuators for vibration control; continue research collaborations with a team of multi-agency (Army, Navy, and NASA) government subject matter experts (SMEs) and universities in relevant areas including high-fidelity simulations and wind-tunnel measurements of whirl-flutter and vibrations on advanced geometry tiltrotor configurations. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of the effort.			
Title: Automotive Research Center (ARC)	3.479	3.890	4.129
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 2023 Plans:*** 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			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2024 Plans:*** The ARC will work towards solving the complex, inter-disciplinary, multiscale problem that is required to develop the advanced modeling and simulation tools needed to assess the performance of off-road autonomous mobility. This research will include off-road autonomy algorithm development, human-machine trust advancement, innovative materials and structures, intelligent power systems, and multisystem coordination; develop the required companion technologies of computation enhancement, verification and validation improvements, and the understanding of uncertainty in unstructured environments. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports the planned lifecycle of the effort.			
Title: SBIR/STTR Transfer ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.882	-
Accomplishments/Planned Programs Subtotals	21.839	24.359	25.443

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) AB7 / *Army Collaborative Research and Tech Alliances*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AB7: *Army Collaborative Research and Tech Alliances*	-	50.435	57.451	63.445	-	63.445	63.273	71.312	77.394	80.208	0.000	463.518

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 2022	FY 2023	FY 2024
Title: Internet of Battlefield Things CTA (IoBT CTA)	2.789	2.997	3.166
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 2023 Plans: 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 2024 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB7 / *Army Collaborative Research and Tech Alliances*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will research resilient and efficient tactical edge intelligence by exploiting data from large-scale networks to support decision advantage in a set of intelligent systems-of-systems; research and develop algorithms that prioritize and filter information from vast amounts of ubiquitous sensor/actuators; explore methods to quantify uncertainty across uncontrolled resources with denied, degraded, intermittent, or limited characteristics; establish algorithms that expose adjustable system parameters to enable rapid reconfigurability utilizing lightweight and/or information-theoretic compression methods and resource provisioning across Command and Control information-networks; develop foundations for determining required sensing cadence and multi-scale sampling approaches to maintain longevity; investigate algorithms and theoretical foundations of edge node coordination in dynamic and contested networks. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the 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 2023 Plans:*** 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 2024 Plans:*** Will investigate theories and techniques to improve the efficiency of distributed resource awareness algorithms to reduce the required bandwidth and improve the freshness of the information; investigate theories and techniques to reduce the complexity and improve scalability of the resource allocation optimizations; investigate theories, models, and techniques for joint allocation and orchestration of networking resources, computational resources, and analytic microservice optimizations to support federated learning at the tactical edge; investigate theories, models, and techniques to automate and optimize neural network algorithms, and the discovery, monitoring, joint orchestration, and dynamic adaption of computational, network, and communication resources, across multiple tasks, to support dynamic, distributed analytics at the tactical edge. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.	2.610	2.825	3.013
Title: Distributed Collaborative Intelligent Systems Technology CTA	6.009	6.341	6.700

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB7 / *Army Collaborative Research and Tech Alliances*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2023 Plans:*** 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 2024 Plans:*** Will investigate theories and techniques to advance multi-robot collaborative autonomy to overcome the curse of dimensionality, increase robustness in complex and dynamic environments, and provide an understanding of performance guarantees and limitations in multi-agent operations; develop computationally efficient strategies for multi-robot real-time and high-tempo adversarial engagements to include methods for hierarchical planning and control and the development of models for the use of deception and misinformation; establish approaches to enable dynamic and coordinated mission specification task allocation and planning within and across large heterogeneous teams. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
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. ***FY 2023 Plans:*** 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	0.598	0.647	0.690

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2024 Plans:*** Will probe changes in neural task representations during training of complex decision tasks in the novice and mastery domains; develop Machine-Optimized Models of auditory scene perception; explore human and neuro-inspired artificial-intelligence visual reasoning; investigate behavioral and neural optimizations for adaptable decision-making during uncertainty; build a universal translator for neural codes to support cognitive tasks; develop methods for tracking the temporal dynamics of continuous changes in global state and cognition. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the 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.	2.793	-	-
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 2023 Plans:*** 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 2024 Plans:*** Will identify preferred human agent teaming futures and how to enable them; uncover the underlying meanings that humans attach to the guidance they provide to agents and explore allowances for agents to understand these implied meanings; research	4.707	5.044	5.333

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
what properties agents possess that human agent teams can use to naturally adapt on-the-fly through situated interactions; describe how human agent team performance is impacted by co-training humans and agents. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
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. ***FY 2023 Plans:*** 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 2024 Plans:*** Will increase artificial intelligence capabilities to process image classifiers for adversarial threat detection; develop autonomous agent skills to traverse rugged terrain through contested environments; identify and implement methods for automatic cyber protection in autonomous, mobile platforms; conduct experiments to refine and extend the ability of autonomous platforms to navigate indoor environments with awareness of adversarial threats and minimal human intervention; create algorithms that can use a robotic shield to deflect incoming projectiles in real time. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.	7.195	7.370	7.751
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	4.670	4.906	5.130

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2023 Plans:*** 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 2024 Plans:*** Will explore UWBG semiconductor devices for millimeter wave operation and how to achieve a 10x increase in power density; investigate the use of physics-informed multi-scale machine learning to augment the selection of both material parameters and device architectures to improve power density that if successful could enable improved communication systems, sensors, and electronic countermeasures. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the 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 2023 Plans:*** 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,	4.670	4.906	5.130

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
including gene transfer, persistence, and mutation that if successful, provide key elements of a synthetic biology research pipeline enabling the rapid and effective exploration and validation of novel material and cellular systems to protect the Soldier. ***FY 2024 Plans:*** Will expand protein-based functional material discovery by integrating modeling-directed protein designs with metals to emulate fibrous proteins from nature with an expanded tool kit; develop an experimental platform to functionally screen protein-metal composite libraries defined from the modeling, that if successful will enable future, advanced manufacturing methods that leverage synthetic biology to produce Army-relevant materials at a quality and efficiency not possible using existing tools; design and assess a resilient engineered living materials platform for the fabrication of robust biomaterials; develop genetic tools for creating a chassis using biomaterials fabrication; identify the mechanisms for cell surface functionalization and protein secretion, and elucidate the mechanisms and principles for the design of hierarchical, functional living biomaterials, that if successful, will enable the development of future biosensors and functional coatings. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Army Advanced Energetics Center ***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 2023 Plans:*** 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 2024 Plans:*** Will synthesize new high density energetic materials, (organic and inorganic) targeting higher detonation velocities, blast effects, thermal outputs, and for enhancing rocket propellants; create fundamental understanding of the initiation, break-up, and fragmentation of energetic materials during and after detonative energy release; develop advanced models and experimental methodologies to enhance fundamental understanding of polymers in formulations as pertains to stress/strain properties, aging,	4.670	4.906	5.129

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
impact of high temperatures, and understanding the evolution of microstructure during reactive and non-reactive events; develop understanding of how shockwaves interact with material grain boundaries, material interfaces, and material defects. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Tactical Behaviors for Autonomous Maneuver ***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 2023 Plans:*** 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 2024 Plans:*** Will explore foundational theoretical approaches to enable small teams of agents to utilize coordinated, tactically-relevant maneuvers to achieve positions of advantage with respect to adversaries with increasing degrees of complexity and uncertainty; create algorithms which enable the application of learned tactics in novel, adjacent domains; investigate methods and techniques to predict and project future positions of advantage?in scenarios with dynamic elements with limited prior information. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.	2.315	2.507	2.734
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 2023 Plans:*** 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	5.971	6.274	6.555

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
produce large variations in properties; down select most promising seedling efforts for continuation to Army Centers (multi-year, comprehensive anchor programs). ***FY 2024 Plans:*** Will continue to engage in collaborative research with selected Centers and Seedlings, with a focus on aligning internal research efforts with partners; collaborate with down-selected Data Management Seedling to further refine High-Throughput Materials Discovery for Extreme Conditions data management platform; conduct experiments with top candidate materials in relative environment; examine rapid screening methods for high dimensional material datasets; analyze high-throughput synthesis and characterization of material classes suitable for high-rate applications. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Fundamentals for Quantum Technologies ***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 2023 Plans:*** 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 2024 Plans:*** Will investigate approaches to magnetometry using nitrogen-vacancy (NV) centers in diamond and other defect systems; investigate collective effects in nanofiber; investigate entangled photon pair generation and propagation in topological systems; explore distributed sensing using ion traps; explore methods for using telecom-compatible energy levels for long-range entanglement generation; explore ion traps in optical cavities for increased generation of infrared photons suitable for propagation over fiber networks. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.	0.483	4.719	5.069
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,	0.955	0.981	1.039

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
gradual coefficient of thermal expansion changes, and gradual wavespeed changes to enable high performance under extreme ballistic and thermal conditions. ***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 2024 Plans:*** Will investigate novel transformative manufacturing, including strategies to affect quality of multi-material interfaces; investigate methodologies for development of high-performance interfaces between another set of dissimilar materials (planned as metal-ceramic) and characterize the resulting materials and interfaces; investigate multi-material model development for metal-ceramics to begin to enable digital twin development. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects the planned lifecycle of this effort.			
Title: Semi-Conductor Modeling Consortium	-	0.931	0.693
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:*** 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 2024 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will explore and assess new emerging semiconductors for electro-optical devices; apply new material understanding to reduce blinking pixels in imagers; assess diffractive devices for new imaging modalities; augment initiatives in new applied materials including ultra-wide bandgap materials or neuromorphic materials. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding decrease due to reduced research in the area of photonic devices for infrared imaging.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	2.097	-
Title: HBCU/MI Research Partnerships ***Description:*** These research partnerships will support basic research focused on partnerships with Historically Black Colleges and Universities and Minority Institutions (HBCUs/MIs). The focus of this effort is to advance innovative basic research in areas of strategic importance to the Army by bringing competitively selected HBCUs and MIs research teams into existing Army Futures Command Collaborative Research Alliances (CRAs), Collaborative Technology Alliances (CTAs), and centers. The Army CRAs, CTAs, and centers work with Army, industry, and other academic partners to transition research to technology demonstration. These new research partnerships will provide opportunities to recruit, educate, and train outstanding students and post-doctoral researchers in science and technology areas relevant to the Army. ***FY 2024 Plans:*** Will establish three to five new HBCU/MI research partnerships, each selected to enhance existing research under an individual Army CRA, CTA, or center. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding supports additional research in existing Army CRAs, CTAs, and centers.	-	-	2.000
Title: Army Military Academic CRA ***Description:*** This CRA provides a framework across the U.S. Army Combat Capabilities Development Command (DEVCOM) to establish and sustain efforts to strengthen the incorporation of the United States Military Academy (USMA) and Senior Military Colleges faculty and cadets into the Army Modernization Enterprise (AME) through research collaborations. This CRA seeks to	-	-	1.835

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
understand the ethical, legal, policy, and operational impacts on emerging technologies, and to build the framework to enhance personnel exchanges between DEVCOM, USMA, and Senior Military Colleges. ***FY 2024 Plans:*** Will conduct foundational research through seedling efforts in areas such as photonics, autonomy, power and energy, quantum sensing, cyber operations, materials for hypersonic systems, and recommendations for policy and strategy in ethics, operations, business, and legal domains for Army Modernization. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding supports increased research into a variety of foundational research areas necessary to support future Army needs.			
Title: Collective Judgement Formation ***Description:*** This effort establishes the underpinning science needed to understand how humans receive, process, and ultimately accept and reject information that leads to the formation of judgments. Individual and social constructs, the role of bias, and other cognitive and environmental factors will be incorporated. Research will address synthetic forms of intelligence, the speed and scale of information sharing, and integrating human and machine intelligence. ***FY 2024 Plans:*** Will develop preliminary models to characterize fundamental mechanisms of how human-technology relationships drive belief formation. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase supports additional research in the area of judgement formation for humans.	-	-	1.478
Accomplishments/Planned Programs Subtotals	50.435	57.451	63.445

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) AB8 / *Army Educational Outreach Program*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AB8: *Army Educational Outreach Program*	-	10.252	11.244	12.485	-	12.485	12.730	12.746	12.755	12.895	0.000	85.107

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 2022	FY 2023	FY 2024
Title: AEOP Coop Agreement	10.252	10.834	12.485
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 2023 Plans: 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			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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. Increase partnerships with like-minded organizations in an effort to increase participation from underserved students and military affiliated communities. Conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and engineering centers. ***FY 2024 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. 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 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.410	-
Accomplishments/Planned Programs Subtotals	10.252	11.244	12.485

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) AC6 / *International Science and Technology*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
AC6: *International Science and Technology*	-	6.745	7.406	7.573	-	7.573	7.856	7.867	7.872	7.958	0.000	53.277

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 2022	FY 2023	FY 2024
Title: International Technology Centers	4.397	1.664	4.936
Description: The ten International Technology Centers (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 2023 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AC6 / *International Science and Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2024 Plans:*** Will continue to 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 Army Modernization Priorities, 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 award 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort and conclusion of International Basic Research Mission within the same project.			
Title: Foreign Technology (& Science) Assessment Support	2.348	2.512	2.637
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 2023 Plans:*** 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			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AC6 / *International Science and Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Enterprise. 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 2024 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 Enterprise; 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 2023 to FY 2024 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:*** 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 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned conclusion of this effort	-	3.004	-
Title: SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 Plans:***	-	0.226	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AC6 / *International Science and Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Funding transferred in accordance with Title 15 USC §638			
FY 2023 to FY 2024 Increase/Decrease Statement: Funding transferred in accordance with Title 15 USC §638			
Accomplishments/Planned Programs Subtotals	6.745	7.406	7.573

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J13 / *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	33.250	20.700	-	-	-	-	-	-	-	0.000	53.950

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 2022	FY 2023
Congressional Add: Program Increase - MATERIALS IN EXTREME DYNAMIC ENVIRONMENTS ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Materials in Extreme Dynamic Environments ***FY 2023 Plans:*** Congressional Interest Item funding provided for Materials in Extreme Dynamic Environments	5.000	5.000
Congressional Add: Program increase - BIOTECHNOLOGY ADVANCEMENTS ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Biotechnology Advancements ***FY 2023 Plans:*** Congressional Interest Item funding provided for BIOTECHNOLOGY ADVANCEMENTS	4.000	4.000
Congressional Add: Program increase - Army artificial intelligence innovation ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Army Artificial Intelligence Innovation	20.000	-
Congressional Add: Soldier Protection Materials ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Soldier Protection Materials	1.000	-
Congressional Add: Hypervelocity Testing ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Hypervelocity Testing	3.000	-
Congressional Add: The Discovery Center at Waters Edge	0.250	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J13 / *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023
FY 2022 Accomplishments: Congressional Interest Item funding provided for The Discovery Center at Waters Edge		
Congressional Add: Program Increase - INFUSION OF CYBERSECURITY CONCEPTS INTO NONTECHNICAL HIGH SCHOOL COURSES ***FY 2023 Plans:*** Congressional Interest Item funding provided for INFUSION OF CYBERSECURITY CONCEPTS INTO NONTECHNICAL HIGH SCHOOL COURSES	-	2.000
Congressional Add: Program Increase - NEXT GENERATION SURVIVAL RADIO ***FY 2023 Plans:*** Congressional Interest Item funding provided for Next Generation Survival Radio	-	3.800
Congressional Add: Program Increase - QUANTUM COMPUTING TECHNOLOGIES ***FY 2023 Plans:*** Congressional Interest Item funding provided for Quantum Computing Technologies	-	1.400
Congressional Add: Program Increase - HYPERSONIC TECHNOLOGY RESEARCH AND TESTING INITIATIVE ***FY 2023 Plans:*** Congressional Interest Item funding provided for HYPERSONIC TECHNOLOGY RESEARCH AND TESTING INITIATIVE	-	4.500
Congressional Adds Subtotals	33.250	20.700

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army											Date: March 2023	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601121A / *Cyber Collaborative Research Alliance*							
COST ($ in Millions)	**Prior Years**	**FY 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
Total Program Element	-	5.067	5.355	5.459	-	5.459	5.514	5.521	5.525	5.585	0.000	38.026
CB5: *Cyber Collaborative Research Alliance*	-	5.067	5.355	5.459	-	5.459	5.514	5.521	5.525	5.585	0.000	38.026

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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total
Previous President's Budget	5.067	5.355	5.435	-	5.435
Current President's Budget	5.067	5.355	5.459	-	5.459
Total Adjustments	0.000	0.000	0.024	-	0.024
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	0.024	-	0.024

Change Summary Explanation

Increased funding due to revised economic assumptions.

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601121A / *Cyber Collaborative Research Alliance*	Project (Number/Name) CB5 / *Cyber Collaborative Research Alliance*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
CB5: *Cyber Collaborative Research Alliance*	-	5.067	5.355	5.459	-	5.459	5.514	5.521	5.525	5.585	0.000	38.026

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 2022	FY 2023	FY 2024
Title: Cyber Security Collaborative Research Alliance	5.067	5.355	-
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 2023 Plans: 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 2023 to FY 2024 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601121A / *Cyber Collaborative Research Alliance*	**Project (Number/Name)** CB5 / *Cyber Collaborative Research Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
In FY 2024, funding for this effort is realigned to the Adversarial-resilient Cyber Effects for Decision Dominance effort within this Project.			
Title: Adversarial-resilient Cyber Effects for Decision Dominance ***Description:*** Conduct foundational research to create innovative theories, models, and methods to understand, create, predict, and exploit Windows of Superiority (WoS) across the cyberspace-network to achieve operational advantage for Multi-Domain Operations (MDO) synchronization and convergence across domains. This effort seeks to identify, formalize, and measure the key attributes/features in the cyber domain that can identify and predict WoS. This effort will develop theories and methods to identify and predict emerging WoS and techniques to shape the cyber domain to achieve WoS, including cyber resilience and deception to mitigate adversarial deception, intrusions, and adversarial machine learning (AML) attacks. ***FY 2024 Plans:*** Will create an initial formalization for defining and reasoning about cyber domain Windows of Superiority; investigate methodologies to identify and exploit information from the network, network intrusion detection systems, information assets, and intelligence needed to assess cyber-network state and characterize a Window of Superiority in the cyber domain; develop techniques to detect adversarial deception in the cyber domain; explore techniques to provide cyber resilience for machine learning based algorithms for intrusion detection and network state estimation. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** In FY 2024, funding is realigned from Cyber Security Collaborative Research Alliance within this Project to support this effort.	-	-	5.459
Accomplishments/Planned Programs Subtotals	5.067	5.355	5.459

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army												Date: March 2023
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601601A *I Artificial Intelligence and Machine Learning Basic Research*							
COST ($ in Millions)	**Prior Years**	**FY 2022**	**FY 2023**	**FY 2024 Base**	**FY 2024 OCO**	**FY 2024 Total**	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**Cost To Complete**	**Total Cost**
Total Program Element	-	15.172	10.078	10.708	-	10.708	10.288	12.373	12.381	12.516	0.000	83.516
CL3: *AI/ML Basic Research Hub*	-	15.172	10.078	10.708	-	10.708	10.288	12.373	12.381	12.516	0.000	83.516

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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total
Previous President's Budget	15.183	10.456	10.661	-	10.661
Current President's Budget	15.172	10.078	10.708	-	10.708
Total Adjustments	-0.011	-0.378	0.047	-	0.047
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.011	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	0.047	-	0.047
• FFRDC Transfer	-	-0.378	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Army	Date: March 2023
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601601A *I Artificial Intelligence and Machine Learning Basic Research*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2022	FY 2023
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

Increased funding due to revised economic assumptions.

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army			Date: March 2023
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601601A / *Artificial Intelligence and Machine Learning Basic Research*	Project (Number/Name) CL3 / *AI/ML Basic Research Hub*	

COST ($ in Millions)	Prior Years	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
CL3: *AI/ML Basic Research Hub*	-	15.172	10.078	10.708	-	10.708	10.288	12.373	12.381	12.516	0.000	83.516

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 2022	FY 2023	FY 2024
Title: Intelligence support to Operations	1.550	1.448	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 2023 Plans: 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 2024 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601601A / *Artificial Intelligence and Machine Learning Basic Research*	**Project (Number/Name)** CL3 / *AI/ML Basic Research Hub*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Will continue research into improving artificial intelligence (AI) integration into the battlespace awareness and force application Joint Capability Area (JCA). This will include research on massive multi-modal data management to efficiently store, transport, and perform operations on data relevant to AI use cases that is captured and processed by devices throughout the battlespace. We will continue research into customized topical machine learning algorithm development, deployment, monitoring and security. In addition, will research planning and acting to improve situational awareness, decision-making, and command and coordination through user experience and user interface experimentation. Will conduct research into autonomy and coordination of sensors distributed throughout the battlespace. ***FY 2023 to FY 2024 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. Will conduct research in distributed AI fabric, algorithms, and human-computer interaction enables operations in multiple Joint Capability Areas (JCA), including command and control, force application, and logistics. The current centralized AI model can be improved with a distributed AI architecture that will: autonomously search for and discover heterogenous data sources; optimize AI processing across dynamic and opportunistic resources; fuse AI capabilities between the enterprise, the edge, and AI-enabled sensors and systems embedded on platform; model the availability and reliability of critical network and computational resources to autonomously adapt and optimize algorithmic processing; and use efficiently distributed learning without the need to move data across the network. No distributed AI solutions currently exist to comprehensively mitigate the identified vulnerabilities. AI2C will conduct foundational research in the ability of distributed AI to address these vulnerabilities to set the conditions for use in Army systems and downstream advanced AI-applications. ***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	5.522	5.173	5.752

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601601A / *Artificial Intelligence and Machine Learning Basic Research*	**Project (Number/Name)** CL3 / *AI/ML Basic Research Hub*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2024 Plans:*** Will investigate research into applying artificial intelligence (AI) to multiple Joint Capability Areas (JCA), including, but not limited to, force integration, force application, logistics, and command and control. With a focus on AI-application that leverage a distributed AI-fabric and enabling technologies, will conduct research on AI-enabling computing infrastructure, devices, algorithms, and human interaction in support of logistics, command and control, and force integration. Will conduct research in other novel AI-enabling technologies across the AI Stack, to include, but not limited to, computing, massive data management, machine learning, modeling, decision support, planning and acting, autonomy, and ethics in support of research priorities including AI development environments; understanding and leveraging social networks; force operations and decision support in modeling and simulation environments; analysis of text, photo, video, and audio data; and improving Soldier performance. Will identify and characterize phenomena in the cyber domain and information environment. Will conduct research toward using AI to integrate force generation and sustainment data with mission-specific operational requirements and situations with the goal of identifying mission-specific personnel, equipment, and logistics options. Will conduct foundational research into employing AI-enabled platforms in support of Join Capability Areas (JCA) including force integration, battlespace awareness, logistics, and command and control. Will conduct foundational research to improve the efficiency, survivability, resiliency, accuracy, and usefulness of AI-enabled platforms to commander priorities, understanding, and decision-making. Research will be conducted throughout the AI stack, focusing on efficient application of machine learning algorithms employed on devices and computing infrastructure distributed in denied, degraded, intermittent, or limited (DDIL) environments to improve data management and reduce network requirements. Will conduct research toward developing the Army's Command and Control architecture as a system of integration enabled by a framework to integrate and optimize data for more effective decision making. Will conduct research toward improving sensor and shooter capabilities with AI-enabled mission command systems. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned life cycle of effort.			
Title: ATR-MCAS ***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.	3.100	3.089	3.356

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601601A / *Artificial Intelligence and Machine Learning Basic Research*	**Project (Number/Name)** CL3 / *AI/ML Basic Research Hub*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2024 Plans:*** Will continue foundational research in emerging artificial intelligence (AI)-based applications to collaborative decentralized autonomy operation and force application. Will continue research in AI-based autonomy and machine learning algorithms 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 interaction for maneuver and force application in multi-domain operations. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding change reflects planned life cycle of effort.			
Title: SBIR/STTR Transfer ***FY 2023 Plans:*** Funding transferred in accordance with Title 15 USC §638 ***FY 2023 to FY 2024 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC §638	-	0.368	-
Accomplishments/Planned Programs Subtotals	10.172	10.078	10.708

	FY 2022	FY 2023
Congressional Add: Extreme Events in Structurally Evolving Materials (CA) ***FY 2022 Accomplishments:*** Congressional Interest Item funding provided for Extreme Events in Structurally Evolving Materials. Congressional Add to be executed by Army Futures Command.	5.000	-
Congressional Adds Subtotals	5.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Army		Date: March 2023
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601601A / *Artificial Intelligence and Machine Learning Basic Research*	**Project (Number/Name)** CL3 / *AI/ML Basic Research Hub*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A