Department of Defense
Fiscal Year (FY) 2022 Budget Estimates

May 2021

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, $12,799,645,000.00 to remain available for obligation until September 30, 2023.

The FY 2022 Overseas Contingency Operations accounted for in the base budget are as follows:

Direct War cost accounted for in the Base Budget $67,710,000: Direct War costs are those combat or direct combat support costs that will not continue to be expended once combat operations end at major contingency locations.

Enduring costs accounted for in the Base budget: $41,546,000: Enduring Requirements are enduring in theater and in CONUS costs that will likely remain after combat operations cease, and have previously been funded in OCO.

FY 2021 includes Division C, Title IX and Division J, Title IV of the Consolidated Appropriations Act, 2021 (P.L. 116-260).

FY 2020 includes Division A, Title IX and X of the Consolidated Appropriations Act, 2020 (P.L. 116-93), Division F, title IV and V from the Further Consolidated Appropriations Act, 2020 (P.L. 116-94) and the Coronavirus Aid, Relief, and Economic Security Act (P.L. 116-136).

COST STATEMENT

The following Justification Books were prepared at a cost of $472,560: 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 6, Budget Activity 7, and Budget Activity 8.

FY 2022 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 2021.

2.   Relationship of the FY 2022 Budget Submitted to Congress to the FY 2021 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
01	0601104A / CI9	Strategic University Basic Research Alliance
02	0602141A / CJ1	Lethality Enabling University Applied Research
02	0602147A / AF1	Long Range Maneuverable Fires (LRMF) Technology
02	0602181A / CM7	Collaborative Convergence Applied Research
02	0602182A / CN4	Network Enabling University Applied Research
02	0602183A / CL5	Air Platform Enabling University Applied Research
02	0602184A / CK9	Advancing Concepts and Technology Forecasting Tech
02	0602184A / CN2	Intelligent Weapons Concepts and Technologies
02	0602184A / CN9	Soldier Enabling University Applied Research
02	0602184A / CO1	Soldier Power And Energy Concepts and Technologies
02	0602184A / CO2	Soldier-Intelligent Technology Research
02	0602386A / CP6	Biotechnology Demonstration and Evaluation
03	0603025A / CK8	Advanced Technology Development and Convergence
03	0603041A / CL9	Collab Battlefield Networked Leth Sys Adv Tech
03	0603041A / CM2	Collaborative Convergence Adv Tech Development
03	0603041A / CM8	Convergence Battlefield Integration

03	0603042A / CN3	Network Enabling University Adv Development
03	0603043A / CL4	Air Platform Enabling University Adv Development
03	0603044A / CN8	Soldier Enabled University Advanced Development
03	0603119A / CJ9	Ground Enabling University Adv Development
03	0603386A / CP7	Foundational Biotechnology Design and Development
03	0603462A / BH4	Ground Vehicle Holistic Defense Adv Tech
03	0603463A / AO3	Network C3I Advanced Technology
03	0603463A / AO6	Network C3I Advanced Technology
03	0603463A / AP6	Network C3I Advanced Technology
03	0603463A / AP8	Network C3I Advanced Technology
04	0604019A / BU9	IFPC High Energy Laser
04	0604019A / CO6	IFPC High Power Microwave (HPM)
04	0604115A / CE4	Emerging Technology Initiatives Development
04	0604403A / FM3	Future Interceptor
04	0604531A / CQ5	C-SUAS JOINT NEW CAPABILITIES DEVELOPMENT
04	0604531A / CQ6	C-SUAS JOINT ENABLING CAPABILITIES DEVELOPMENT
05	0303667A / CR1	Citizen Broadband Radio System
05	0304270A / CK3	TLS Echelon Above Brigade (EAB)
05	0604601A / S70	Personnel Recovery Support System (PRSS)
05	0604802A / CE3	Precision Munition (Sniper)
05	0604804A / VR7	Combat Service Support Systems
05	0604818A / EJ6	TACTICAL ENHANCEMENT
05	0605053A / BS9	Robotic Payloads
05	0605143A / BX5	Biometrics Enabling Capability (BEC)
05	0605531A / CQ7	C-SUAS JOINT NEW CAPABILITIES
05	0605531A / CQ8	C-SUAS JOINT ENABLING CAPABILITIES
07	0307665A / BI7	Biometrics Enabled Intelligence
07	0607131A / CP2	Precision Fire Technology Improvements

Program Element/Project Restructures:

Budget Activity	Old OSDPE / Project: Title	New OSDPE / Project
01	0601102A / AA1 AA2 AA6 AA7 AA8 AB1 AB2 AB4 AC6: Multiple	0601601A / CL3
01	0602785A / 790: Manpower/Personnel/Training Technology	0603040A / CL1
02	0602787A / MM8: Infectious Diseases and Applied Rsch Technology	0603002A / CJ3
02	0602787A / MN1: Applied Sensory Systems Trauma Technology	0602787A / MK4, MM4
02	0602141A / AH9: Advanced Warheads Technology	0602141A / CJ6
02	0602141A / AI1: Advanced Terrain Shaping Technology	0602141A / CF8
02	0602143A / BC3: Soldier Decision Making & Comms Performance Tech	0602184A / CO2
02	0602143A / BD6: Soldier Sys Interfaces/Integration- Sensor Tech	0602180A / CL7
02	0602144A / CA9: Predictive Maintenance	0602180A / CN7
02	0602145A / BF6: Crew Augmentation and Optimization Tech	0602144A / CG8
02	0602145A / BF8: Artificial Intelligence & Machine Learning Tech	0602180A / CL7
02	0602145A / BF8: Artificial Intelligence & Machine Learning Tech	0602183A / CL5
02	0602145A / BF9: Sensors for Autonomous Operations and Surv Tech	0602180A / CL2
02	0602145A / BG6: Advanced Concepts for Active Defense Technology	0602144A / CG7
02	0602145A / BH5: Platform Electrification and Mobility Tech	0602144A / CG6
02	0602145A / BH9: Protection for Autonomous Systems Tech	0603041A / CM8
02	0602145A / BI2: Sensor Protection Technology	0602144A / CG5
02	0602146A / AN7: COE - Every Receiver is a Sensor Technology	0602180A / CL2
02	0602146A / AO5: Tag Track and Locate Small Satellites Technology	0602146A / CK1, CG3
02	0602146A / AP4: CEMA Camouflage Technology	0602182A / CM9, CN5
02	0602146A / AQ9: Expeditionary Data to Decisions Technology	0602146A / CI3
02	0602146A / AV6: Airborne Engineering Support Technology	0603463A / CI7
02	0602148A / AI5: Next Gen Tactical UAS TD Technology	0602148A / CH2
02	0602148A / AJ4: Digital Vehicle Management and Control Technology	0602148A / CG9
02	0602148A / AK2: Aviation Survivability Technology	0602183A / CN1
02	0602148A / AK2: Aviation Survivability Technology	0602148A / CH3
02	0602148A / AK4: Multi-Role Small Guided Missile Technology	0602148A / CI5

02	0602148A / AK9: Adv Teaming for Tactical Aviation Operations Tech	0602183A / CL8
02	0602148A / AM4: Opt Energy Stg & Therm Mgmt for FVL Survivability	0602148A / CH4
02	0602150A / AC9: High Energy Laser Tactical Vehicle Demonstrator Te	0603466A / AD1
02	0602150A / AD2: High Energy Laser (HEL) Enabling and Support Techn	0602141A / CF7
02	0602150A / AD3: Maneuver Air Defense Technology	0602141A / CJ7
02	0602213A / CY8: Cyber Security App Research and Exper Partner Tech	0603463A / CI7
02	0602213A / CY8: Cyber Security App Research and Exper Partner Tech	0602146A / CI3
02	0603002A / MO9: Vaccines to Prevent Dengue Fever Advanced Tech	0603002A / CJ3
02	0603007A / 792: Personnel Performance & Training	0603040A / CL6
03	0603116A / AI3: Terminal Weapons Effects Against Structures and Critical Targets Tech	0603116A / CH5
03	0603118A / BC4: Soldier Decision Making&Comms Performance AdvTech	0603465A / AL9
03	0603463A / AM9: Protected SATCOM Advanced Technology	0603463A / CI7
03	0603463A / AM9: Protected SATCOM Advanced Technology	0602146A / AN3
03	0603463A / AO3: Stand-In Advanced RF Effects (STARE) Adv Tech	0603463A / AO7
03	0603463A / AO6: Tag Track and Locate Small Satellites Adv Tech	0603463A / CJ8
03	0603463A / AP6: C4ISR Integrated Demonstrations Advanced Tech	0603463A / AN4, AM9, AP9
03	0603463A / AP8: Comms/Horiz Int for Army Mod Priorities Adv Tech	0603041A / CL9, CL2, CM8
03	0603463A / AQ1: Spectrum Obfuscation Advanced Technology	0603463A / CI7
03	0603463A / AQ5: Sensor CE-Integrated Sensor Architecture Adv Tech	0603463A / CI7
03	0603463A / AQ8: High Tempo Data Driven Decision Tools Adv Tech	0603463A / CI7
03	0603463A / AU6: Automated Analytics for Operational Environment AT	0603463A / CF9
03	0603463A / AV2: LEO Advanced Technology	0603463A / CJ8
03	0603463A / BZ8: Aerial Tier Networking (High Altitude)	0602146A / AN3
03	0603465A / AJ1: Future UAS Engine Advanced Technology	0603465A / AI8
03	0603465A / AJ5: Digital Vehicle Management & Control Advanced Tech	0603465A / CH6
03	0603465A / AK3: Aviation Survivability Advanced Technology	0603465A / CH8, CG1
03	0603465A / AM5: Opt Energy Stg & Therm Mgmt for FVL Surv Adv Tech	0603465A / CH7
03	0603466A / AD6: Next Generation Fires Radar Advanced Technology	0602141A / CG4
04	0603327A / FG9: Air and Missile Defense (AMD) Electronic Warfare	0604741A / 126
04	0603619A / 606: Cntrmn/Barrier Adv Dev	0603619A / CE5

04	0603639A / BQ4: 155mm Artillery Propulsion XM654	0604802A / BQ3
04	0603639A / FG1: Cannon-Delivered Area Effects Munitions (C-DAEM)	0604802A / FG1
04	0603766A / 907: Tactical Electronic Surveillance System - Adv Dev	0603766A / BX9, CC5, BY9
04	0603774A / VT7: Soldier Maneuver Sensors - Adv Dev	0603774A / BQ5
04	0603801A / F12: Future Attack Reconnaissance Aircraft	0603801A / CK7
04	0603807A / 811: Mil HIV Vac&Drug Dev	0604807A / 849
04	0604017A / FD2: Soldier Robotics Systems	0605053A / BS9
04	0604117A / FI4: Maneuver - Short Range Air Defense (M-SHORAD)	0604117A / CR9, CS1
04	0604120A / ED5: Assured Positioning, Navigation and Timing (PNT)	1206120A / FJ8
04	0604120A / EH8: DISMOUNTED	1206120A / FJ9
04	0604120A / EH9: PSEUDOLITES	1206120A / FK1
04	0604120A / EJ2: MOUNTED	1206120A / FK2
04	0604120A / EJ3: ANTI-JAM ANTENNA	1206120A / FK3
04	0604121A / FD6: Synthetic Training Environment Refine & Prototype	0604121A / CR2, CR3, CR4, CR5, CR7
04	0604121A / SV1: Soldier/Squad Virtual Trainer	0604121A / CR4, CR6
04	0604182A / HX1: Long-Range Hypersonic Weapon	0605232A / HX2
04	0604319A / DU3: IFPC2	0605052A / EY7
04	0604710A / L67: Soldier Night Vision Devices	0604710A / BQ6
04	0604807A / 812: Mil HIV Vac&Drug Dev	0604807A / 849
04	0604808A / 016: Close Combat Capabilities ENG DEV	0604808A / CS2, CS3
04	0604823A / L86: LIGHTWEIGHT COUNTER MORTAR RADAR (LCMR)	0607148A / BY8
04	0604823A / L88: Enhanced AN/TPQ 36	0607148A / BY8
05	0304270A / EW5: Electronic Warfare Development - MIP	0607313A / CE2
05	0304270A / EW6: ARAT-TSS - MIP	0304270A / CR8
05	0604798A / FG7: Emerging Technology Initiatives	0605054A / FI3
05	0605013A / 738: AcqBiz	0605013A / FL9
05	0605013A / FL9: Army Accessioning IT Development	0605233A / CP8
05	0605036A / EQ5: Combating Weapons of Mass Destruction (CWMD)	0605036A /CS6
05	0605041A / EV5: Defensive CYBER Operations	0608041A / CD1
05	0605053A / FB8: Soldier Borne Sensor (SBS)	0604827A / FK4

05	0605766A / DX9: National Integration To Tactical Systems(MIP)	0605766A / BV3
06	0604256A / 976: Army Threat Sim (ATS)	0604759A / FF1
06	0605898A / XW7: Command HQ - ARI	0605801A / M15
07	0303140A / DV4: Key Management Infrastructure (KMI)	0605144A / BY6
07	0305208A / D07: DCGS-A Common Modules (MIP)	0605148A / BY5
07	0305208A / D07: DCGS-A Common Modules (MIP)	0605224A / CK4
07	0305208A / D07: DCGS-A Common Modules (MIP)	0604037A / BY4
07	0205402A / EF2: Integrated Base Defense	0604785A / DS4
07	0607134A / ES1: Long Range Precision Fires (LRPF)	0605231A / CO3

Program Terminations (including transfers to Procurement and Sustainment):

Budget Activity	*OSDPE / Project*	*Project Title*
02	0602143A / BB7	Soldier Lethality Technology / Exoskeleton: Technology for Man-Machine Interface
02	0602145A / BF1	Next Generation Combat Vehicle Technology / Autonomous Ground Resupply Tech
02	0602146A / AM6	Network C3I Technology / Modular RF Communications Technology
02	0602146A / AP7	Network C3I Technology / Comms/Horiz Int for Army Mod Priorities Tech
02	0602146A / AQ7	Network C3I Technology / High Tempo Data Driven Decision Tools Technology
02	0602146A / AT2	Network C3I Technology / Subterranean Detection and Monitoring Technology
02	0602146A / AU3	Network C3I Technology / Geospatially Enabled Operational Design Technology
02	0602146A / AW3	Network C3I Technology / DoD PNT M&S Collaborative Initiative (CI) Technolo
02	0602146A / BZ6	Network C3I Technology / Narrowband SATCOM Technology
02	0602150A / AC9	Air and Missile Defense Technology / High Energy Laser Tactical Vehicle Demonstrator Te
02	0602150A / AE4	Air and Missile Defense Technology / Collaborative ISR Sensors Technology
03	0603118A / BB6	Soldier Lethality Advanced Technology / Physical Augmentation: Adv Tech for Field Demo
03	0603462A / BF2	Next Generation Combat Vehicle Advanced Technology / Autonomous Ground Resupply (AGR) Adv Tech
03	0603462A / BG5	Next Generation Combat Vehicle Advanced Technology / Extended Line of Sight (ELOS) Advanced Technology
03	0603462A / BH1	Next Generation Combat Vehicle Advanced Technology / Survivability Systems Controls Advanced Technology

03	0603462A / BK6	Next Generation Combat Vehicle Advanced Technology / Adv Direct InDirect Armament Sys (ADIDAS) Adv Tech
03	0603463A / AN6	Network C3I Advanced Technology / Prot SATCOM-WB Global SATCOM Inter Canc Adv Tech
03	0603463A / AW4	Network C3I Advanced Technology / DoD PNT M&S Collaborative Initiative (CI) Adv Tech
03	0603464A / AE9	Long Range Precision Fires Advanced Technology / Low-Cost Tact Ext Range Missile (LC-TERM) Adv Tech
03	0603466A / AE1	Air and Missile Defense Advanced Technology / Close Combat High Energy Laser Advanced Technology
04	0603639A / 694	Tank and Medium Caliber Ammunition / Medium Caliber Ammunition
04	0603747A / C08	Soldier Support and Survivability / Rapid Equipping Force
04	0603804A / G11	Logistics and Engineer Equipment - Adv Dev / Adv Elec Energy Con Ad
04	0603807A / VS7	Medical Systems - Adv Dev / MEDEVAC Mission Equipment Package (MEP) - Adv Dev
04	0604021A / AW7	Electronic Warfare Technology Maturation (MIP) / Electronic Warfare Technology Maturation (MIP)
04	0604115A / AX4	Technology Maturation Initiatives / Computational Prototyping Environment (CPE)
04	0604115A / AX6	Technology Maturation Initiatives / Active Protection Systems Integration
04	0604115A / AX7	Technology Maturation Initiatives / Multi-Mission High Energy Laser (MMHEL) Sys Demo
04	0604115A / AY1	Technology Maturation Initiatives / MUM-T Platform Enabler
04	0604115A / AY3	Technology Maturation Initiatives / Strategic Long Range Cannon
05	0604622A / VR5	Family of Heavy Tactical Vehicles / TWV Protection Kits
05	0604741A / 149	Air Defense Command, Con trol and Intelligence - Eng Dev / Counter-Rockets, Artillery & Mortar
05	0604768A / 688	Brilliant Anti-Armor Submunition (BAT) / ATACMS BLK II
05	0604780A / 582	Combined Arms Tactical Trainer (CATT) Core / Synthetic Envir Core
05	0604798A / DY5	Brigade Analysis, Integration and Evaluation / Production/Field Coordination for Capability Sets
05	0604802A / 613	Weapons and Munitions - Eng Dev / MORTAR SYSTEMS
05	0604802A / EU5	Weapons and Munitions - Eng Dev / .50 Caliber All-Purpose Tactical cartridge (APTC)
05	0604802A / XT2	Weapons and Munitions - Eng Dev / 40mm Door Breach
05	0604804A / FG4	Logistics and Engineer Equipment - Eng Dev / Ultra-Lightweight Camouflage Net System (ULCANS)
05	0604808A / 415	Landmine Warfare/Barrier - Eng Dev / Mine Neutral/Detection
05	0604854A / HB6	Artillery Systems - EMD / Mobile 155MM Howitzer
05	0605033A / EQ3	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E) / Grnd-Based Opnl

		Surv Sys -Exped (GBOSS-E)
05	0605053A / FB4	Ground Robotics / Common Robotic Systems
07	0203744A / EB6	Aircraft Modifications/Product Improvement Programs / MQ-1C Gray Eagle MODS
07	0305204A / 123	Tactical Unmanned Aerial V ehicles / Joint Technology Center System Integration

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

05 May 2021

Appropriation	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request
Research, Development, Test & Eval, Army	12,842,958	14,144,856	12,799,645
Total Research, Development, Test & Evaluation	12,842,958	14,144,856	12,799,645

Other RDT&E Budget Activities Not Included in the Research, Development, Test and Evaluation Title
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Chem Agents & Munitions Destruction	890,830	942,493	1,001,231
Total Not in Research, Development, Test & Evaluation Title	890,830	942,493	1,001,231

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

05 May 2021

Summary Recap of Budget Activities	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request
Basic Research	557,265	552,521	473,475
Applied Research	1,227,661	1,518,770	914,288
Advanced Technology Development	1,520,145	1,940,015	1,297,437
Advanced Component Development & Prototypes	2,895,592	3,577,387	3,806,330
System Development & Demonstration	3,072,662	2,948,445	3,392,358
Management Support	1,759,840	1,834,218	1,416,698
Operational Systems Development	1,809,793	1,716,794	1,380,248
Software and Digital Technology Pilot Programs		56,706	118,811
Total Research, Development, Test & Evaluation	12,842,958	14,144,856	12,799,645

Summary Recap of FYDP Programs	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request
General Purpose Forces	733,243	589,525	542,571
Intelligence and Communications	287,081	362,184	280,473
Research and Development	11,434,683	13,058,379	11,911,888
Central Supply and Maintenance	105,885	130,785	61,720
Administration and Associated Activities	61		
Space	274,732		
Classified Programs	7,273	3,983	2,993
Total Research, Development, Test & Evaluation	12,842,958	14,144,856	12,799,645

R-122BAS: FY 2022 President's Budget (Total Base Published Version), as of May 5, 2021 at 15:01:27

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

05 May 2021

	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request
Summary Recap of Non-RDT&E Title FYDP Programs			
Central Supply and Maintenance	890,830	942,493	1,001,231
Total Research, Development, Test & Evaluation	890,830	942,493	1,001,231

Department of the Army
FY 2022 President's Budget
Exhibit R-1 FY 2022 President's Budget
Total Obligational Authority   05 May 2021
(Dollars in Thousands)

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R-122BAS: FY 2022 President's Budget (Total Base Published Version), as of May 5, 2021 at 15:01:27

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

05 May 2021

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

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
1	0601102A	Defense Research Sciences	01	343,481	344,031	297,241	U
2	0601103A	University Research Initiatives	01	85,148	84,697	66,981	U
3	0601104A	University and Industry Research Centers	01	123,654	118,716	94,003	U
4	0601121A	Cyber Collaborative Research Alliance	01	4,982	5,077	5,067	U
5	0601601A	Artificial Intelligence and Machine Learning Basic Research	01			10,183	U
		Basic Research		557,265	552,521	473,475	
6	0602115A	Biomedical Technology	02		11,403	11,925	U
7	0602134A	Counter Improvised-Threat Advanced Studies	02		1,927	1,976	U
8	0602141A	Lethality Technology	02	68,852	117,484	64,126	U
9	0602142A	Army Applied Research	02	30,733	30,757	28,654	U
10	0602143A	Soldier Lethality Technology	02	141,154	201,750	105,168	U
11	0602144A	Ground Technology	02	143,172	158,158	56,400	U
12	0602145A	Next Generation Combat Vehicle Technology	02	255,041	258,351	172,166	U
13	0602146A	Network C3I Technology	02	133,804	202,257	84,606	U
14	0602147A	Long Range Precision Fires Technology	02	117,395	119,007	64,285	U
15	0602148A	Future Verticle Lift Technology	02	94,888	169,536	91,411	U
16	0602150A	Air and Missile Defense Technology	02	93,937	107,584	19,316	U
17	0602180A	Artificial Intelligence and Machine Learning Technologies	02			15,034	U
18	0602181A	All Domain Convergence Applied Research	02			25,967	U
19	0602182A	C3I Applied Research	02			12,406	U
20	0602183A	Air Platform Applied Research	02			6,597	U

R-122BAS: FY 2022 President's Budget (Total Base Published Version), as of May 5, 2021 at 15:01:27

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

05 May 2021

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

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
21	0602184A	Soldier Applied Research	02			11,064	U
22	0602213A	C3I Applied Cyber	02	17,351	18,816	12,123	U
23	0602386A	Biotechnology for Materials - Applied Research	02			20,643	U
24	0602785A	Manpower/Personnel/Training Technology	02	20,406	20,399	18,701	U
25	0602787A	Medical Technology	02	110,928	101,341	91,720	U
		Applied Research		1,227,661	1,518,770	914,288	
26	0603002A	Medical Advanced Technology	03	82,256	94,669	43,804	U
27	0603007A	Manpower, Personnel and Training Advanced Technology	03	10,225	11,344	14,273	U
28	0603025A	Army Agile Innovation and Demonstration	03			22,231	U
29	0603040A	Artificial Intelligence and Machine Learning Advanced Technologies	03			909	U
30	0603041A	All Domain Convergence Advanced Technology	03			17,743	U
31	0603042A	C3I Advanced Technology	03			3,151	U
32	0603043A	Air Platform Advanced Technology	03			754	U
33	0603044A	Soldier Advanced Technology	03			890	U
34	0603115A	Medical Development	03		26,711	26,521	U
35	0603116A	Lethality Advanced Technology	03			8,066	U
36	0603117A	Army Advanced Technology Development	03	66,424	62,663	76,815	U
37	0603118A	Soldier Lethality Advanced Technology	03	131,119	151,370	107,966	U
38	0603119A	Ground Advanced Technology	03	136,544	196,055	23,403	U
39	0603134A	Counter Improvised-Threat Simulation	03		24,087	24,747	U
40	0603386A	Biotechnology for Materials - Advanced Research	03			53,736	U

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Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
41	0603457A	C3I Cyber Advanced Development	03	25,492	43,357	31,426	U
42	0603461A	High Performance Computing Modernization Program	03	217,389	221,161	189,123	U
43	0603462A	Next Generation Combat Vehicle Advanced Technology	03	255,386	302,209	164,951	U
44	0603463A	Network C3I Advanced Technology	03	138,937	216,520	155,867	U
45	0603464A	Long Range Precision Fires Advanced Technology	03	196,393	177,142	93,909	U
46	0603465A	Future Vertical Lift Advanced Technology	03	180,163	220,334	179,677	U
47	0603466A	Air and Missile Defense Advanced Technology	03	79,817	175,703	48,826	U
48	0603920A	Humanitarian Demining	03		16,690	8,649	U
		Advanced Technology Development		1,520,145	1,940,015	1,297,437	
49	0603305A	Army Missle Defense Systems Integration	04	59,318	140,195	11,702	U
50	0603308A	Army Space Systems Integration	04		25,584	18,755	U
51	0603327A	Air and Missile Defense Systems Engineering	04	52,672	47,098		U
52	0603619A	Landmine Warfare and Barrier – Adv Dev	04	79,504	56,067	50,314	U
53	0603639A	Tank and Medium Caliber Ammunition	04	72,456	100,367	79,873	U
54	0603645A	Armored System Modernization – Adv Dev	04	138,300	138,685	170,590	U
55	0603747A	Soldier Support and Survivability	04	9,246	5,712	2,897	U
56	0603766A	Tactical Electronic Surveillance System – Adv Dev	04	37,490	182,400	113,365	U
57	0603774A	Night Vision Systems Advanced Development	04	192,530	15,429	18,000	U
58	0603779A	Environmental Quality Technology – Dem/Val	04	19,089	20,906	11,921	U
59	0603790A	NATO Research and Development	04	5,184	4,589	3,777	U
60	0603801A	Aviation – Adv Dev	04	488,397	694,296	1,125,641	U

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61	0603804A	Logistics and Engineer Equipment - Adv Dev	04	7,081	8,587	7,055	U
62	0603807A	Medical Systems - Adv Dev	04	36,307	33,085	22,071	U
63	0603827A	Soldier Systems - Advanced Development	04	25,204	23,184	17,459	U
64	0604017A	Robotics Development	04	80,909	95,367	87,198	U
65	0604019A	Expanded Mission Area Missile (EMAM)	04			50,674	U
66	0604021A	Electronic Warfare Technology Maturation (MIP)	04	23,043	15,034		U
67	0604035A	Low Earth Orbit (LEO) Satellite Capability	04		21,850	19,638	U
68	0604036A	Multi-Domain Sensing System (MDSS) Adv Dev	04			50,548	U
69	0604037A	Tactical Intel Targeting Access Node (TITAN) Adv Dev	04			28,347	U
70	0604100A	Analysis Of Alternatives	04	9,811	9,714	10,091	U
71	0604101A	Small Unmanned Aerial Vehicle (SUAV) (6.4)	04		1,328	926	U
72	0604113A	Future Tactical Unmanned Aircraft System (FTUAS)	04	40,745	57,083	69,697	U
73	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04	364,154	308,805	327,690	U
74	0604115A	Technology Maturation Initiatives	04	171,058	141,109	270,124	U
75	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04	41,690	4,813	39,376	U
76	0604119A	Army Advanced Component Development & Prototyping	04	117,335	172,990	189,483	U
77	0604120A	Assured Positioning, Navigation and Timing (PNT)	04		115,688	96,679	U
78	0604121A	Synthetic Training Environment Refinement & Prototyping	04	99,357	112,093	194,195	U
79	0604134A	Counter Improvised-Threat Demonstration, Prototype Development, and Testing	04		13,326	13,379	U
80	0604182A	Hypersonics	04	394,619	832,166	300,928	U
81	0604403A	Future Interceptor	04	1,918		7,895	U

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82	0604531A	Counter - Small Unmanned Aircraft Systems Advanced Development	04			19,148	U
83	0604541A	Unified Network Transport	04	28,478	39,192	35,409	U
84	0604644A	Mobile Medium Range Missile	04	4,794	88,100	286,457	U
85	0604785A	Integrated Base Defense (Budget Activity 4)	04	2,000	2,020	2,040	U
86	0305251A	Cyberspace Operations Forces and Force Support	04	58,611	50,525	52,988	U
87	1206120A	Assured Positioning, Navigation and Timing (PNT)	04	133,307			U
88	1206308A	Army Space Systems Integration	04	100,985			U
		Advanced Component Development & Prototypes		2,895,592	3,577,387	3,806,330	
89	0604201A	Aircraft Avionics	05	8,069	7,011	6,654	U
90	0604270A	Electronic Warfare Development	05	57,090	56,624	30,840	U
91	0604601A	Infantry Support Weapons	05	86,154	88,552	67,873	U
92	0604604A	Medium Tactical Vehicles	05		8,213	11,374	U
93	0604611A	JAVELIN	05	14,377	5,983	7,094	U
94	0604622A	Family of Heavy Tactical Vehicles	05	12,085	22,254	31,602	U
95	0604633A	Air Traffic Control	05	5,543	3,383	4,405	U
96	0604642A	Light Tactical Wheeled Vehicles	05	2,843	4,193	2,055	U
97	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05	273,433	123,992	137,256	U
98	0604710A	Night Vision Systems - Eng Dev	05	135,283	54,234	62,690	U
99	0604713A	Combat Feeding, Clothing, and Equipment	05	7,295	2,734	1,658	U
100	0604715A	Non-System Training Devices - Eng Dev	05	29,785	27,013	26,540	U
101	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	70,279	62,058	59,518	U

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102	0604742A	Constructive Simulation Systems Development	05	11,158	9,779	22,331	U
103	0604746A	Automatic Test Equipment Development	05	10,466	5,375	8,807	U
104	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	7,480	7,605	7,453	U
105	0604768A	Brilliant Anti-Armor Submunition (BAT)	05	19,177	24,064		U
106	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	8,861	3,438		U
107	0604798A	Brigade Analysis, Integration and Evaluation	05	29,852	18,737	21,534	U
108	0604802A	Weapons and Munitions - Eng Dev	05	182,119	268,858	309,778	U
109	0604804A	Logistics and Engineer Equipment - Eng Dev	05	105,668	53,676	59,261	U
110	0604805A	Command, Control, Communications Systems - Eng Dev	05	12,077	10,674	20,121	U
111	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	70,489	51,285	44,424	U
112	0604808A	Landmine Warfare/Barrier - Eng Dev	05	33,881	9,239	14,137	U
113	0604818A	Army Tactical Command & Control Hardware & Software	05	124,749	128,676	162,704	U
114	0604820A	Radar Development	05	91,782	105,271	127,919	U
115	0604822A	General Fund Enterprise Business System (GFEBS)	05	41,119	15,428	17,623	U
116	0604823A	Firefinder	05	16,583	18,278		U
117	0604827A	Soldier Systems - Warrior Dem/Val	05	4,606	6,296	6,454	U
118	0604852A	Suite of Survivability Enhancement Systems - EMD	05	81,899	62,012	106,354	U
119	0604854A	Artillery Systems - EMD	05	20,290	36,187		U
120	0605013A	Information Technology Development	05	89,541	126,498	122,168	U
121	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	97,873	111,078	76,936	U
122	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	80,381	76,140	35,560	U

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123	0605029A	Integrated Ground Security Surveillance Response Capability (IGSSR-C)	05	6,423			U
124	0605030A	Joint Tactical Network Center (JTNC)	05	15,228	15,671	16,364	U
125	0605031A	Joint Tactical Network (JTN)	05	39,130	30,540	28,954	U
126	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05	3,689	5,758		U
127	0605034A	Tactical Security System (TSS)	05	7,343			U
128	0605035A	Common Infrared Countermeasures (CIRCM)	05	22,226	29,770	16,630	U
129	0605036A	Combating Weapons of Mass Destruction (CWMD)	05	9,589			U
130	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05	5,805	4,669	7,618	U
131	0605041A	Defensive CYBER Tool Development	05	50,662	28,544	18,892	U
132	0605042A	Tactical Network Radio Systems (Low-Tier)	05	27,236	20,511	28,849	U
133	0605047A	Contract Writing System	05	16,379	22,025	22,960	U
134	0605049A	Missile Warning System Modernization (MWSM)	05	1,475			U
135	0605051A	Aircraft Survivability Development	05	130,211	99,208	65,603	U
136	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05	186,369	153,362	233,512	U
137	0605053A	Ground Robotics	05	24,747	12,010	18,241	U
138	0605054A	Emerging Technology Initiatives	05	36,146	294,366	254,945	U
139	0605143A	Biometrics Enabling Capability (BEC)	05			4,326	U
140	0605144A	Next Generation Load Device - Medium	05			15,616	U
141	0605145A	Medical Products and Support Systems Development	05		919	962	U
142	0605148A	Tactical Intel Targeting Access Node (TITAN) EMD	05			54,972	U

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143	0605203A	Army System Development & Demonstration	05	184,410	150,201	122,175	U
144	0605205A	Small Unmanned Aerial Vehicle (SUAV) (6.5)	05		5,780	2,275	U
145	0605224A	Multi-Domain Intelligence	05			9,313	U
146	0605225A	SIO Capability Development	05			22,713	U
147	0605231A	Precision Strike Missile (PrSM)	05			188,452	U
148	0605232A	Hypersonics EMD	05			111,473	U
149	0605233A	Accessions Information Environment (AIE)	05			18,790	U
150	0605450A	Joint Air-to-Ground Missile (JAGM)	05	6,314	7,566	2,134	U
151	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	211,634	206,850	157,873	U
152	0605531A	Counter - Small Unmanned Aircraft Systems Sys Dev & Demonstration	05			33,386	U
153	0605625A	Manned Ground Vehicle	05	197,304	171,890	225,106	U
154	0605766A	National Capabilities Integration (MIP)	05	7,835	7,670	14,454	U
155	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	7,119	1,678	2,564	U
156	0605830A	Aviation Ground Support Equipment	05	1,596	1,413	1,201	U
157	0303032A	TROJAN - RH12	05	3,936	3,451	3,362	U
158	0303267A	Auctioned Spectrum Relocation Fund	05	7,650			U
159	0303467A	SENSR Spectrum Pipeline SRF	05	251			U
160	0303567A	Non-SENSR Spectrum Pipeline SRF	05	1,236			U
161	0304270A	Electronic Warfare Development	05	18,432	59,755	75,520	U
		System Development & Demonstration		3,072,662	2,948,445	3,392,358	
162	0604256A	Threat Simulator Development	06	41,566	41,486	18,439	U

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163	0604258A	Target Systems Development	06	27,984	35,279	17,404	U
164	0604759A	Major T&E Investment	06	140,946	119,231	68,139	U
165	0605103A	Rand Arroyo Center	06	12,573	12,989	33,126	U
166	0605301A	Army Kwajalein Atoll	06	230,051	221,965	240,877	U
167	0605326A	Concepts Experimentation Program	06	35,403	50,394	79,710	U
168	0605502A	Small Business Innovative Research	06	392,999	369,715		U
169	0605601A	Army Test Ranges and Facilities	06	356,231	390,351	354,227	U
170	0605602A	Army Technical Test Instrumentation and Targets	06	60,170	81,829	49,253	U
171	0605604A	Survivability/Lethality Analysis	06	33,632	36,001	36,389	U
172	0605606A	Aircraft Certification	06	3,319	2,736	2,489	U
173	0605702A	Meteorological Support to RDT&E Activities	06	6,094	6,360	6,689	U
174	0605706A	Materiel Systems Analysis	06	21,233	21,830	21,558	U
175	0605709A	Exploitation of Foreign Items	06	11,168	8,936	13,631	U
176	0605712A	Support of Operational Testing	06	52,280	54,116	55,122	U
177	0605716A	Army Evaluation Center	06	60,474	56,827	65,854	U
178	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	2,423	2,478	2,633	U
179	0605801A	Programwide Activities	06	56,800	84,510	96,589	U
180	0605803A	Technical Information Activities	06	30,434	25,487	26,808	U
181	0605805A	Munitions Standardization, Effectiveness and Safety	06	52,401	55,648	43,042	U
182	0605857A	Environmental Quality Technology Mgmt Support	06	4,489	1,715	1,789	U
183	0605898A	Army Direct Report Headquarters - R&D - MHA	06	53,320	54,564	52,108	U

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184	0606001A	Military Ground-Based CREW Technology	06	2,053			U
185	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06	64,311	68,911	80,952	U
186	0606003A	CounterIntel and Human Intel Modernization	06	2,925	5,200	5,363	U
187	0606105A	Medical Program-Wide Activities	06		19,164	39,041	U
188	0606942A	Assessments and Evaluations Cyber Vulnerabilities	06	4,500	6,496	5,466	U
189	0909999A	Financing for Cancelled Account Adjustments	06	61			U
		Management Support		1,759,840	1,834,218	1,416,698	
190	0603778A	MLRS Product Improvement Program	07	14,014	9,786	12,314	U
191	0605024A	Anti-Tamper Technology Support	07	8,141	8,436	8,868	U
192	0607131A	Weapons and Munitions Product Improvement Programs	07	14,222	19,666	22,828	U
193	0607134A	Long Range Precision Fires (LRPF)	07	149,455	100,146		U
194	0607136A	Blackhawk Product Improvement Program	07	22,502	8,300	4,773	U
195	0607137A	Chinook Product Improvement Program	07	164,820	49,409	52,372	U
196	0607139A	Improved Turbine Engine Program	07	197,941	232,159	275,024	U
197	0607142A	Aviation Rocket System Product Improvement and Development	07	1,847	13,421	12,417	U
198	0607143A	Unmanned Aircraft System Universal Products	07	17,386	19,460	4,594	U
199	0607145A	Apache Future Development	07	5,224	52,502	10,067	U
200	0607148A	AN/TPQ-53 Counterfire Target Acquisition Radar System	07			56,681	U
201	0607150A	Intel Cyber Development	07		14,652	3,611	U
202	0607312A	Army Operational Systems Development	07	45,026	35,851	28,029	U
203	0607313A	Electronic Warfare Development	07			5,673	U

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204	0607665A	Family of Biometrics	07	1,576	1,276	1,178	U
205	0607865A	Patriot Product Improvement	07	83,833	178,984	125,932	U
206	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	45,447	43,060	25,547	U
207	0203735A	Combat Vehicle Improvement Programs	07	266,197	213,728	211,523	U
208	0203743A	155mm Self-Propelled Howitzer Improvements	07	191,076	217,959	213,281	U
209	0203744A	Aircraft Modifications/Product Improvement Programs	07	8,896	11,261		U
210	0203752A	Aircraft Engine Component Improvement Program	07	138	80	132	U
211	0203758A	Digitization	07	4,043	4,351	3,936	U
212	0203801A	Missile/Air Defense Product Improvement Program	07	1,235	1,241	127	U
213	0203802A	Other Missile Product Improvement Programs	07		15,268	10,265	U
214	0205412A	Environmental Quality Technology - Operational System Dev	07	10,000	250	262	U
215	0205456A	Lower Tier Air and Missile Defense (AMD) System	07	93,743		182	U
216	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	112,468	72,817	63,937	U
217	0208053A	Joint Tactical Ground System	07		9,510	13,379	U
219	0303028A	Security and Intelligence Activities	07	26,674	23,367	24,531	U
220	0303140A	Information Systems Security Program	07	25,710	28,270	15,720	U
221	0303141A	Global Combat Support System	07	57,604	70,652	52,739	U
222	0303142A	SATCOM Ground Environment (SPACE)	07		18,002	15,247	U
223	0303150A	WWMCCS/Global Command and Control System	07	1,988			U
226	0305179A	Integrated Broadcast Service (IBS)	07	459	382	5,430	U
227	0305204A	Tactical Unmanned Aerial Vehicles	07	22,147	38,151	8,410	U

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228	0305206A	Airborne Reconnaissance Systems	07	13,177	28,858	24,460	U
229	0305208A	Distributed Common Ground/Surface Systems	07	28,821	40,771		U
230	0305219A	MQ-1C Gray Eagle UAS	07	5,000			U
231	0305232A	RQ-11 UAV	07	3,218			U
232	0305233A	RQ-7 UAV	07	7,817			U
233	0307665A	Biometrics Enabled Intelligence	07	4,350		2,066	U
234	0708045A	End Item Industrial Preparedness Activities	07	105,885	130,785	61,720	U
235	1203142A	SATCOM Ground Environment (SPACE)	07	32,764			U
236	1208053A	Joint Tactical Ground System	07	7,676			U
9999	9999999999	Classified Programs		7,273	3,983	2,993	U
		Operational Systems Development		1,809,793	1,716,794	1,380,248	
237	0608041A	Defensive CYBER - Software Prototype Development	08		56,706	118,811	U
		Software and Digital Technology Pilot Programs			56,706	118,811	
		Total Research, Development, Test & Eval, Army		12,842,958	14,144,856	12,799,645	

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FY 2022 President's Budget
Exhibit R-1 FY 2022 President's Budget
Non RDT&E Title   05 May 2021
(Dollars in Thousands)

Summary Recap of Budget Activities	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request
Research, Development, Test, And Evaluation	890,830	942,493	1,001,231
Total Research, Development, Test & Evaluation	890,830	942,493	1,001,231

Summary Recap of Non-RDT&E Title FYDP Programs			
Central Supply and Maintenance	890,830	942,493	1,001,231
Total Research, Development, Test & Evaluation	890,830	942,493	1,001,231

R-122BAS: FY 2022 President's Budget (Total Base Published Version), as of May 5, 2021 at 15:01:27

Department of the Army
FY 2022 President's Budget
Exhibit R-1 FY 2022 President's Budget
Non RDT&E Title
(Dollars in Thousands)

05 May 2021

Appropriation: 0390D Chem Agents & Munitions Destruction

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
1	0708081D	Chemical Materials Agency	02	6,500	6,494	6,220	U
2	0708083D	Assembled Chemical Weapons Alternatives	02	884,330	935,999	995,011	U
		Research, Development, Test, And Evaluation		890,830	942,493	1,001,231	
		Total Chem Agents & Munitions Destruction		890,830	942,493	1,001,231	

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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 2022 Army | | | | | | | | | | | Date: May 2021 | |

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	PE 0601102A *I Defense Research Sciences*

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
Total Program Element	-	343.481	344.031	297.241	-	297.241	-	-	-	-	-	-
AA1: *ILIR - AMC*	-	10.014	10.780	10.917	-	10.917	-	-	-	-	-	-
AA2: *ILIR - SMDC*	-	0.915	0.965	0.979	-	0.979	-	-	-	-	-	-
AA3: *Single Investigator Basic Research*	-	93.691	100.773	90.542	-	90.542	-	-	-	-	-	-
AA4: *Training and Human Science Research*	-	19.949	21.322	21.781	-	21.781	-	-	-	-	-	-
AA5: *Biotechnology and Systems Biology*	-	5.511	6.042	6.076	-	6.076	-	-	-	-	-	-
AA6: *Robotics and Mobile Energy*	-	20.807	22.353	20.793	-	20.793	-	-	-	-	-	-
AA7: *Mechanics and Ballistics*	-	32.734	35.368	33.359	-	33.359	-	-	-	-	-	-
AA8: *Sensing and Electromagnetics*	-	8.229	9.006	13.611	-	13.611	-	-	-	-	-	-
AA9: *Information and Networking*	-	37.502	40.376	40.540	-	40.540	-	-	-	-	-	-
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	31.269	31.957	37.103	-	37.103	-	-	-	-	-	-
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	16.510	17.089	17.967	-	17.967	-	-	-	-	-	-
CH9: *Advancing Concepts and Technology Forecasting*	-	-	-	3.573	-	3.573	-	-	-	-	-	-
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	66.350	48.000	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This 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). It also

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Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*		**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*

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 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	354.480	303.257	311.641	-	311.641
Current President's Budget	343.481	344.031	297.241	-	297.241
Total Adjustments	-10.999	40.774	-14.400	-	-14.400
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	48.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-10.999	-7.226			
• Adjustments to Budget Years	-	-	-14.400	-	-14.400

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Propulsion Technology*	10.000	-
Congressional Add: *Ballistic and Materials Technology*	10.000	-
Congressional Add: *Flexible LED Lighting*	5.350	-
Congressional Add: *Military Waste Stream Conversion*	5.000	-
Congressional Add: *Multi-layer and dynamically responsive macromolecular composites*	5.000	-
Congressional Add: *Advanced hemostat products*	2.000	-

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Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Congressional Add: *Multi-fuel ignition, chemistry and control strategies for unmanned aircraft systems hybrid propulsion*	9.000	15.000
Congressional Add: *Transmission electron microscope*	20.000	-
Congressional Add: *Program increase*	-	10.000
Congressional Add: *Program increase - explosives and opiods dual-use UV detection*	-	3.000
Congressional Add: *Program increase: Artificial intelligence complex multi?material composites processing*	-	10.000
Congressional Add: *Program Increase: Cell-Free Expression for Biomanufacturing*	-	10.000
Congressional Add Subtotals for Project: T14	66.350	48.000
Congressional Add Totals for all Projects	66.350	48.000

Change Summary Explanation

$4.000 million of FY22 will be realigned to APE 611102AB1 (Basic Research in Infect Dis, Oper Med and Combat Care) from PE 0603002A (Medical Advanced Technology), APE 633002MM9((Tech Base/Enabling Research for Infect Dis Adv Tech)

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	

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 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AA1: *ILIR - AMC*	-	10.014	10.780	10.917	-	10.917	-	-	-	-	-	-

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 2020**	**FY 2021**	**FY 2022**
Title: Edgewood Chemical Biological Center (ECBC)	0.885	1.001	1.008
Description: Basic research in chemistry, biology, biotechnology, toxicology, and aerosols for creating the science base needed for countering improvised explosive devices (IEDs), explosives forensics, obscurants, and defeating targets. *FY 2021 Plans:* Conduct innovative, high-risk, basic research that explores new phenomenology at the boundaries of chemistry, biology, mathematics, and physics. Specifically will conduct fundamental research in novel materials, synthetic biology, novel sensing, molecular toxicology, aerosol sciences, and machine learning. *FY 2022 Plans:* Will conduct basic research that informs Department of Defense Research Priorities and Army Modernization Priorities, focused on the areas of synthetic biology, machine learning for threat detection, novel physical and biological materials for future application of obscuration, protection, and detection, and expanded modeling and simulation in chemical and biological adsorption and deposition. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Armaments Research, Development and Engineering Center (ARDEC)	1.327	1.446	1.485

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
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 2020	FY 2021	FY 2022
Description: Funds basic research in weapons component physics, explosives synthesis/detection, and the fundamental science base of area denial. *FY 2021 Plans:* Conduct innovative basic research that results in powerful explosives for enhanced lethality, novel structural materials for armament system components, novel structural materials for armament system components, physics-based modeling of components and ingredients (e.g., energetics and warheads) in extreme temperature and pressure regimes. *FY 2022 Plans:* Will conduct basic research investigations of airy beams, factors affecting and mechanisms of tube memory, rate constants for gas-phase energetic material decomposition, non-destructive methods for detecting hydrogen embrittlement in steels using plasmonic nanoparticles, thermally induced crack formation mechanisms, new and powerful insensitive explosives with enhanced performance, and novel composite structural materials for light weight armament systems. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Tank Automotive Research, Development and Engineering Center (TARDEC) *Description:* This effort funds basic research in ground vehicle technologies to include power, mobility, and unmanned systems. *FY 2021 Plans:* Conduct competitively selected, basic research to understand Scientific principles in support of Army ground vehicles in areas such as novel control methods for vehicle systems; advanced control of autonomous systems, high fidelity and reduced order modeling and simulation, optimal path planning for autonomous systems, advanced coatings, lightweight materials, additive manufacturing, joining processes, advanced diesel engine heat transfer, and multi-cell battery modeling and control. *FY 2022 Plans:* Will competitively select in-house basic research topic areas to advance fundamental scientific understanding to support ground vehicle systems in: control systems for vehicles, optimal path planning for autonomous systems, advanced coatings, lightweight and composite materials, additive manufacturing, multi-physics battery modeling, hydrodynamic modeling, and internal combustion engine modeling. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	1.118	1.235	1.238
Title: Natick Soldier Research, Development and Engineering Center (NSRDEC)	1.009	1.126	1.158

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021		
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 2020**	**FY 2021**	**FY 2022**
Description: This effort funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection. *FY 2021 Plans:* Conduct basic research to explore the angular dependence and thermal effects of infrared light scattering from patterned microstructure arrays and microparticle-loaded films to enable control of diffuse infrared scattering in order to inform advances in signature management and defense against electromagnetic threats; examine the effects of high altitude exposure on human cognition and gut microbiome to understand the impact of stress on the human gut-brain axis, which influences Soldier performance and decision-making. *FY 2022 Plans:* Will explore techniques for tuning reconfigurability of metamaterials to control activation of multifunctional material properties and inform advancement of high-frequency rectifier materials platforms. Will produce knowledge to support improvements in antenna, communication, data storage, and electromagnetic interference (EMI) shielding technologies. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.					
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts (AMRDEC-MI) *Description:* This effort funds the underlying fundamental science of Lethality and Protection Superiority for guided missile and rocket systems, directed energy weapons, unmanned vehicles, and related components. *FY 2021 Plans:* Investigate the fundamental nature of complex network dynamics for enhanced security communication and sensor systems; research theoretical model of component processes for the generation of entangled microwave photons for quantum-enhanced detection; study the potential use of machine learning to discover novel, high-performance energetic materials; investigate the properties of polaritons based on representations of the electromagnetic field in a linear medium for improved sensors; explore properties of nanoscale materials and metamaterials for optimal energy management, sensor protection, and sensor enhancement. *FY 2022 Plans:* Will develop an experimental system using unclocked Boolean circuits to enable exploration of the fundamental nature of complex dynamics in networks of coupled identical oscillators for secure communications and device protection; will explore compressive sensing techniques based on deep learning methods to augment existing sensor suites and maximize information collected from sensor hardware while reducing size, weight, power, and cost (SWAP-C); will investigate, simulate, and fabricate new proof-of-principle designer devices and artificial materials to enable disruptive opto-electro-plasmonic systems for sensors and devices for			2.327	2.394	2.405

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021	
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 2020**	**FY 2021**	**FY 2022**
sensor protection and masking; will develop proof-of-concept experiments for entanglement generation on a quantum integrated circuit with investigations into quadrature methods for detection to enable quantum radar operation below classical noise limits. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Aviation and Missile Research, Development and Engineering Center: Aviation Efforts (AMRDEC-AV) ***Description:*** This effort funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science. ***FY 2021 Plans:*** Conduct basic research experiments to examine the relationship between surface finish, contact traction coefficient, and micropitting, and how it affects the reliability and life of gears and bearings; investigate machine learning techniques to augment lower-order models using data from high-fidelity computational fluid dynamics models; conduct basic fluid dynamic research in the areas of vorticity dynamics, unsteady flow separation, and flow control to identify fundamental governing principles. ***FY 2022 Plans:*** Will continue basic aerodynamic science research in the areas of vorticity dynamics, bluff body flow separation, and wake interactions; investigate advanced boundary layer flow control phenomenon including fluidic oscillators in the context of hub flows; will develop an uncertainty quantification and sensitivity analysis framework for rotorcraft aeromechanics simulations; will improve automation for setup and execution of rotorcraft aeromechanics simulation; develop high-fidelity surrogate models for rotorcraft aeromechanics simulations in order to dramatically reduce computational run times for these simulations. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	1.227	1.344	1.381
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 2021 Plans:*** Conduct research on performance of Gallium Nitride/Silicon Carbide (GaN/SiC) transistor models at the upper F-Band (130 GHz ? 140 GHz); investigate highly tunable dielectric materials for radar and communication utilizing highly textured films to achieve high tenability and low power loss; study reducing the interfacial resistance between cathode and solid electrolyte through conducting lithium glass to improve contact between the cathode and solid electrolyte; investigate the geometry of inductive coupling coils	2.121	2.234	2.242

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
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 2020**	**FY 2021**	**FY 2022**
for potential applications in high efficiency wireless power transfer; explore non-destructive, in situ metrology to molecular beam epitaxy (MBE) of antimonide-based infrared detector structures, used in advanced infrared focal plane arrays (IRFPAs). *FY 2022 Plans:* Will conduct research in structural excitation based conformal antenna design concepts; will study incoherent Fourier Ptychographic Photography (FPP) optimized with deep neural networks to Army imaging applications including Aided Target Recognition (AiTR) and target identification; will investigate the material properties of vanadium oxide (VOx) for Long-Wavelength Infrared (LWIR) sensor material; will investigate the incorporation and diffusion of Zinc into semiconductor alloys grown by molecular beam epitaxy (MBE); will investigate the reduction of interfacial resistance between cathode and solid electrolyte through conducting glass for solid state lithium ion batteries; will investigate safe polymer electrolytes for use with high voltage electrode materials in lithium-ion batteries. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	10.014	10.780	10.917

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

D. Acquisition Strategy
 N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
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 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AA2: *ILIR - SMDC*	-	0.915	0.965	0.979	-	0.979	-	-	-	-	-	-

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: SMDC In-house Laboratory Independent Research (ILIR)	0.915	0.965	0.979
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 2021 Plans: Perform laser modeling of other atomic transition line parameters to determine if efficient lasing is possible; models laser cavity parameters, and expand laser spectroscopy to include improved plasma parameters; develops new atmospheric turbulence models to better predict turbulence strength and variation as a function of altitude as the boundary layer varies as a function of weather conditions, solar loading, and terrain parameters; investigates new areas of research in laser phenomenology with potential to transition to the next generation of HEL technology such as Ultra Short Pulsed Lasers (USPL).			
FY 2022 Plans:			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA2 / *ILIR - SMDC*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will collect data using the advanced optical turbulence sensor developed in this effort. Will design a lab experiment and implement control algorithms for advanced atmospheric turbulence compensation techniques. Will design and conduct lab experiments for next generation laser technology. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort			
Accomplishments/Planned Programs Subtotals	0.915	0.965	0.979

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

D. Acquisition Strategy
 N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 1					**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*					**Project (Number/Name)** AA3 *I Single Investigator Basic Research*		
COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AA3: *Single Investigator Basic Research*	-	93.691	100.773	90.542	-	90.542	-	-	-	-	-	-

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 2020**	**FY 2021**	**FY 2022**
Title: Basic Research in Life Sciences	11.890	12.102	10.592

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 2021 Plans:
Elucidate empirical guidelines for the design of polyvalent deoxyribonucleic acid (DNA) origami that can bind a target with high selectivity and can interface with electrochemical systems to report binding that in the long term may reveal mechanisms to rapidly detect active viral pathogens at the point of care or in the field; determine how mitochondrial hydrogen sulfide affects health and functional cellular performance that in the long term may enable methods to modulate mitochondrial integrity in the treatment of post-traumatic stress disorder or possibly to extend the time that highly trained experienced warfighters can remain fit for duty;

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	**Project (Number/Name)** AA3 *I Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
define how mechanical stress can alter the assembly and efflux functions of the E. coli tripartite efflux pump that in the long term may enable new mechanisms to protect the warfighter from pathogens or to engineer microorganisms that will synthesize key materials or compounds even in remote locations; combine electrophysiological and mechanical recordings and manipulations to fully determine the forward and reverse coupling between the somatic membrane potential and active mechanical dynamics in Xenopus saccular hair cells that in the long term will elucidate the encoding of information by the auditory system and define new connectivity and modulation rules for noninvasive human-machine interfaces and artificial intelligence, with applications ranging from prosthetics for the wounded warrior to remote autonomous vehicles; investigate the empirical implications of the theoretical synthesis model, which indicate that in segregated groups the focus of collective action shifts from large-scales to local scales, that in the long term may lead to algorithms that accurately predict conflict emergence, particularly in urban environments, characterized by segregated communities, which will in turn enable enhanced mission planning and decision-making. *FY 2022 Plans:* Will identity the biological molecules and mechanisms involved in the selective sequestration of strontium ions from seawater and the control over the single crystal growth of the mineral celestine that if successful, will be a key step toward designing biotechnological approaches to remove toxins to protect the Soldier, and for the use of synthetic biology to assemble structures with non-natural elements, thereby expanding the periodic table accessible to biology; will identify the regulatory mechanisms mediating expression variation in key genes involved in maintaining H2S homeostasis in tolerant and non-tolerant eukaryotic populations that if successful, may lead to new therapeutic methods for combat casualty care and the treatment of traumatic injuries; will employ a machine learning approach wherein a computer vision algorithm is trained to identify bacteria in public-domain images of brain tissue to examine preliminary findings that the brain is not a sterile environment as traditionally thought, which if successful would validate initial findings that brain tissue co-exists with various bacterial species and would fundamentally change the scientific understanding of detecting and treating neurodegenerative diseases and mood disorders that may affect the active and retired Soldier; will conduct systems-level molecular studies on the physiology of slow growth with methanogenic Archaea using anaerobic chemostats with growth rates limited by either catabolic or anabolic substrates, to determine how cellular energy and ribosomal activity is allocated during slow growth, that if completed will provide new routes to harness microorganisms for the synthesis of future compounds of interest ranging from therapeutics to enzymes for inactivating toxic chemicals or warfare agents. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding that supports research in the area of impacts that can alter the assembly and efflux functions of the E. coli tripartite efflux pump was reduced to support the Army Advanced Biological Control Center and Army Advanced Energetics Center in PE 0601104A Project AB7.			
Title: Basic Research in Chemical Sciences	16.515	14.664	11.467
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			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
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 2021 Plans:* Design and assemble a novel photo-capillary reactor in which starting compounds will be mixed and exposed to multiple laser photons, harnessing photochemistry that depends on the wavelengths of the photons, the intensity of the laser pulses, and the time delay between the pulses, which will be used to characterize potential new energetic materials, that in the long term may enable new methods for chemical manufacturing and the creation of optimized energetic materials; synthesize polymers that mimic protein primary structure via a templated step-growth polymerization method that in the long term may lead to the creation of a new class of materials with properties inherent to biological materials, thereby enabling the design of materials that are smart, environmentally responsive, and self-healing; determine the fundamental design rules to access hydrochemically stable metal-organic frameworks with various functionalities and diverse topologies in aqueous media at room temperature, which in the long term may enable/lead to functional materials for more environmentally-benign chemical neutralization methods; generate a hot-electron, low temperature transient pulsed plasma using high voltage nanosecond pulses in the local vicinity of a surface containing Au nanoparticles, and use in situ spectroscopy to determine the reaction pathway, which in the long term may lead to the development of lower-weight power storage and generation. *FY 2022 Plans:* Will assess a new hypothesis for how to design new classes of depolymerizable polymers that are capable of rapid depolymerization in the context of solid materials that if successful, will enable future protective layers for electronics devices and smart coatings for self-healing materials or the controlled release of specialized material layers to protect the Soldier and materiel; design, synthesize, and validate transient, responsive functional nanomaterials that autonomously respond to specific chemical stimuli that if successful will enable new classes of functional materials that can autonomously transform into a different functional configuration according to a preset schedule or stimuli, such as to resist or inactivate a toxic industrial chemical; perform parametric experimental studies as a function of the chemical functionality present at cation-exchange/anion-exchange membranes, coupled with multiscale modeling on length scales from nanometers to hundreds of microns to determine the transport and interfacial effects in bipolar membranes that if successful, will enable the next generation of polymer electrolyte fuel cells to reduce soldier-borne weight; determine the photochemical fate of saxitoxin (which can be from natural or synthetic sources) and its analogues in surface waters by assessing the degradation kinetics and pathways and identifying the major transformation products, that if successful will provide novel tracking and remediation practices to protect the Soldier and Army materiel. *FY 2021 to FY 2022 Increase/Decrease Statement:*			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
In FY 2022, funding that supports research in the area of polymers that mimic protein primary structure was reduced to support the Army Radio-Frequency (RF) Electronics Center and the Army Advanced Energetics Center in PE 0601104A Project AB7.			
Title: Basic Research in Physics *Description:* This effort fosters research in many subfields of physics, including condensed matter physics, optical physics, atomic and molecular physics, and quantum information, with an emphasis on discovering new realms of quantum and optical phenomena. Pursuit of fundamental physics in these subfields provides new opportunities for future developments in superior optics, ultra-sensitive sensors, and novel electronic architectures for classical and quantum computing. *FY 2021 Plans:* Determine the effects of the shape, curvature, and geometry of both one- two- and three dimensional conducting structures such as supersymmetry-enabled optical materials, on electromagnetic wave scattering properties, that in the long term may enable fundamentally-new ways to control light, enabling lighter components and lower power devices, which can lighten the warfighter?s load, as well the possibility of developing totally new functionalities, such as more sensitive detectors or capabilities at new wavelengths; investigate entanglement between trapped polar molecular ions for improving quantum state readout, optimized cooling, and dipolar entanglement that in the long term may enable the precision measurement of molecular transitions which is important for chem/bio detection capability and quantum metrology; co-trap molecular ion (CaH+) with an atomic ion (Ca+) within a selected transition, and then sympathetically cool the molecular ion, followed by performing an entangling operation between Ca+ and CaH+ acting as a qubit, that if successful may lead to future breakthroughs in quantum sensing, quantum spectroscopy, and quantum computing; electrically induce topological superconductivity in a single material system enabling the exploration of the related electronic phases that comprise and enable this possibility, and if successful, study the physics of the topological superconducting state, which in the long term may enable low-power electronics and enhanced applications in communications. *FY 2022 Plans:* Will perform two-photon electron bridge spectroscopy of the 229Th3+ nuclear isomer transition that if successful is expected to enable compact, fieldable, atomic clocks with significantly reduced environmental sensitivity to provide new capabilities in positioning, navigation, and timing; elucidate the nature of magnetic coupling across interfaces between topological materials and magnetic materials to the degree that device concepts based on those couplings can be pursued, that if successful will provide a foundation for new energy efficient electronic technologies that will enable Soldiers and small systems to extend mission length and reduce dependence on extensive portable power systems; will generate and preserve multi-quantum bit entangled states via dynamically-corrected gate operations in silicon spin quantum bits that, if successful, should have a transformative impact on silicon based quantum computing by enabling the implementation of future quantum information processors that will provide new capabilities in command, control, computers, communications, cyber, intelligence, surveillance and reconnaissance; utilize non-Hermitian interaction coupled with quantum gauge theory for active control of chiral light with quantized orbital angular momentum	16.519	11.607	12.065

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
that if successful would provide on-chip information processing and high-powered semiconductor microlaser sources for secure high-speed optical communications. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding reduction reflects planned lifecycle of this effort because research into the study of topological superconducting state has ended.			
Title: Basic Research in Electronics and Photonics ***Description:*** This effort fosters discoveries in electronic sensing, optoelectronics, solid state and high frequency science, electromagnetics, microwaves, and power electronics for situational awareness, communications, information processing, electro-magnetic warfare, and power efficiency. ***FY 2021 Plans:*** Establish the physical limits of biological sensing and signal processing with precision quantum measurements on the nitrogen vacancy embedded in nanodiamonds that in the long-term could enable probing of the intracellular environment to significantly influence soldier medicine and performance; create novel optical responses in magnetic Weyl semimetal and multi-fold fermions that in the long-term could lay a foundation for new spintronic memory devices for high-speed information processing and energy efficient electronics; create efficient long-wave infrared (LWIR) detectors that in the long-term could enhance long-range detection and adaptive optical systems, and even enable free-space laser communications; investigate high efficiency and high-speed nanoscale, subwavelength light emitting diodes that in the long-term could lead to the development of photonic integrated circuits for extremely low energy data communication. ***FY 2022 Plans:*** Will develop bioelectric field imaging techniques and electronic material and device-based interfaces with single cells; will map the relationship between genetic responses and bioelectric networks within cell communities; will develop a hierarchy of simulation tools to analyze wave-propagation effects and electron-transport physics in active electromagnetic structures including the complex coupling of physical equations describing the nonlinear active phenomena with full-wave electromagnetic-wave modelling that captures interactions; will utilize two dimensional materials embedded in microcavities to induce band splitting with optical fields; will assess non-reciprocal effects that may be used in integrated photonic platforms; will explore large refractive index changes in inverted bandgap superlattices for long wavelength infrared optoelectronics including modulation and beam steering. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, funding increased to support additional research into the relationship between genetic responses and bioelectric networks within cell communities.	6.242	10.449	8.852
Title: Basic Research in Materials Sciences	12.209	11.760	11.319

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
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 2021 Plans:* Study fundamental liquid-surface interactions in order to design and create patterned and functionalized surfaces that in the long-term could provide passive water harvesting and novel decontamination devices; explore donor-acceptor charge transfer complexes and develop a series of new co-crystal materials that in the long-term could develop new tunable organic ferroelectric materials for advanced communications and sensing capabilities; investigate a novel colloidal assembly process for complex macrostructures that in the long-term could enable multifunctional materials that could simultaneously provide both structural support and power storage; research a new paradigm for force-responsive polymers based on a molecular ladder structure for an amplified response that in the long-term could enable new structural health monitoring strategies and advanced sensors. *FY 2022 Plans:* Will investigate novel driving forces that influence equilibrium and non-equilibrium self-assembly, including turbulence, light, mechanical stress, or chemical gradients, and use these forces to design self-assembling and reconfigurable soft materials that adapt to their environment and/or serve as artificial neural networks; develop the necessary computational, theoretical, and machine learning methods to enable new data-driven forward and inverse design paradigms for creating self-assembling and reconfigurable soft matter; investigate hetero-epitaxial thin-film growth methods to synthesize a new class of ternary transition metal perovskite chalcogenide in thin film form to understand the influence of strain and dimensionality on the physical properties of these materials; systematically investigate innovative synthesis routes and fundamental physical properties (electronic, optical, magnetic, superconducting as well as topological insulator behavior) of a novel class of crystalline two-dimensional metal-organic frameworks; will develop a computational method for calculating the ideal processing parameters for metallic additive manufacturing (AM) to address the challenges in formulating qualification procedures for AM parts; will explore new material phases in extreme mechanical and thermomechanical environments, to determine if they can actively respond to extreme events by becoming harder and tougher; design robust metamaterials capable of steering mechanical stress waves around critical areas within structures, which could eventually lead to lighter armor for Soldier and vehicle protection. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding that supports research in the area of donor-acceptor charge transfer complexes was reduced to support the Army Radio-Frequency (RF) Electronics Center and the Army Advanced Biological Control Center in PE 0601104A Project AB7.			
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,	6.076	11.188	8.818

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
energy generation and multi-dimensional systems, and solid mechanics especially at high strain rates in composite materials for novel armor and protection systems. *FY 2021 Plans:* Construct an elastic theory of active solids that are far-from-equilibrium that in the long-term could enable dramatically enhanced vibration mitigation and energy generation in military structures; design and investigate novel composites with triply periodic minimal surface structures that in the long-term may lead to unique lightweight structures for mechanical support, thermal conservation and impact shielding; conduct the first ever simultaneous measurements of velocity and temperature, in situ, for a reacting turbulent combustion event that in the long-term may provide critical validation of engine model codes for revolutionary future engine design; and determine the effects of compressibility on the complex flow physics of stability and transition in boundary layers for the transonic flight regime that in the long-term could provide new paradigms for future transonic energy efficient aircraft. *FY 2022 Plans:* Will develop information-theoretic control across different spatio-temporal scales and generalize uncertainties by combining tools from information theory with advances in nonequilibrium statistical mechanics and apply them to the problem of nonlinear stochastic optimal control; will explore the possibility that turbulent fluctuations can be harnessed to de-mix particles and assemble structures; will extend proof-of-concept work in the development of the Ultra-Short Pulse Off-Axis Digital Holography (USPODH) technique for imaging high pressure fuel sprays in the dense spray region; will determine the mechanisms which give rise to nonlinearity in geomaterials, will determine the influence of different periodic arrangements of the microstructures found in geomaterials on wave propagation, and will design meta-materials with controlled wave-propagation based on these microstructural features; will elucidate the role that surface roughness (topography) plays in modulating the spatial and temporal variability of wind, temperature, and passive gases inside the canopy/roughness layer, between and just above the buildings in urban terrain. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding was increased to support additional research in the area of the Ultra-Short Pulse Off-Axis Digital Holography (USPODH) technique proof-of-concept work.			
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 2021 Plans:*	6.199	8.648	6.641

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Create distributed algorithms that are dynamic, flexible and can scale and adapt to the massive degree of heterogeneity present in new and future computer architectures or applications and the massive amount of data that characterize future computing needs; investigate methods based on Bayesian modeling, information theory and information physics to characterize semantic information content in multimodal data; establish new scientific understanding in managing long and short term memory models that enable life-long learning while mitigating the effects of catastrophic forgetting; explore and gain new insights into visual concept reasoning by extending the deep reinforcement learning theory for estimating probabilistic rewards; and developing new graph matching techniques to infer new links between known objects in a dynamic visual environment; establish resilient and robust learning and adaptation techniques for better cyber defense in contested domains where the environment and system characteristics may change rapidly and unpredictably over time due to adversarial manipulations and attacks. *FY 2022 Plans:* Will develop new decentralized planning and learning methods for coordinating multiple agents in uncertain, unstructured domains that address three issues: planning in large continuous spaces, asynchronous learning, and adaptability. This will potentially enable efficient planning and learning methods to accomplish missions such as reconnaissance or resupply; investigate the robustness of existing machine learning systems and the ability to inject adaptively to the associated general methodologies in resource-limited scenarios with potential time-critical contexts, impacting areas such as Intelligence, Surveillance, Reconnaissance (ISR) and robotic perception; build a fully unified framework for Tractable Deep Probabilistic Models (TDPM) which will provided greater efficiency and interpretability compared to current deep neural network approach, benefitting future Army systems that will employ deep neural networks; explore understanding human behavior to be able to create generators and classifiers at the right level of fidelity in a virtual environment; better understand Generative Adversarial Networks (GANs) for data generation, compression, domain transfer, and security, resulting in the ability to design more robust implementations of secure, reliable, and efficient deep neural network artificial intelligence solutions. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding that supports research in the area of learning and adaptation techniques was reduced to support the Army Radio-Frequency (RF) Electronics Center and the Army Advanced Biological Control Center in PE 0601104A Project AB7.			
Title: Basic Research In Network Sciences *Description:* This effort focuses on gaining an understanding of the fundamental aspects of how networks develop, function, and adapt to the environment and the rate of information flow in man-made and naturally occurring networks. This understanding will have a direct impact on net-centric force operations, such as better communication system design and operations, and more efficient logistics or communications support. *FY 2021 Plans:* Design low overhead millimeter-wave (mm-Wave) mobile ad hoc networks (MANETs) for highly-mobile vehicular systems with side information such as position and motion, direction of users, terrain and environment information, and locations of surrounding	12.955	10.807	10.946

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
objects; investigate properties of social networks for graph separator properties, which can then be used to design compositional algorithms for applications such as the problem of processing incredibly large graphs (millions to billions of nodes and edges) to identify small portions of it that are important in the context of understanding societies -- e.g., small adversarial groups embedded in large urban population; study brain structure (i) to analyze time-varying synchronization patterns in brain networks with new theories and tools aimed at characterizing how localized perturbations may have their network-wide effects and (ii) to discover optimal information transmission (and possibly control) of brain networks by exploiting the geometric structure of interconnection patterns for well-defined cognitive processing tasks; investigate a theoretical framework for an Intelligent Trust Modulation (ITM) system for Human-Agent Teams that uses multimodal sensors to measure human, machine, and team ?states? relating to trust, and intelligently selects real-time adaptations of system components to optimize team trust dynamics and team effectiveness. *FY 2022 Plans:* Will develop theory and system of network-wide radio context attestation that is capable of capturing the continuous dynamic change of radio contexts of individual devices while protecting the confidentiality of the operational parameters of those devices against untrusted network components, leading to the next generation of remote verification properties for military radios; develop a unified framework for geometric factorization for community mining, with particular focus on the challenges faced by homeland security and military intelligence operations such as network scenarios with many hidden links, small-footprint outliers, and outlying communities, that will address the current challenges associated with modeling the complexity of social networks; will develop an efficient computational method for the synthesis of optimal distributed controllers, particularly a new mathematical foundation for the design of optimal decentralized/distributed controllers that can be deployed for a wide range of real-world applications such as communication networks, electrical power systems, aerospace systems, large-space flexible structures, traffic systems, wireless sensor networks, and various multi-agent systems; will explore the use of online reinforcement learning across multiple concurrent agents to enable cross-layer optimization in tactical networks to support more efficient usage of resources in a dynamic and resource constrained environment. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding reduction reflects planned lifecycle of this effort because research into an Intelligent Trust Modulation (ITM) system has ended.			
Title: Basic Research in Mathematical Sciences *Description:* This effort fosters the creation of new mathematical tools and methods for performing complex, multi-system analysis and modeling to enhance Soldier and weapon-system performance. More specifically, the focus is on creating mathematical principles and practical algorithms for stochastic analysis and control, analysis and control of biological systems, numerical computation of infinite-dimensional systems, and modeling of irregular geometric and social phenomena. *FY 2021 Plans:*	5.086	9.548	7.342

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Create new mathematical tools and methods for performing complex, multi-system analysis and modeling to enhance soldier and weapon-system performance, including investigation of mathematical principles and algorithms for rapid/reliable statistical inference, computational capability for new scientific understanding and advanced design, analysis and control of biological systems, and modeling of complex systems; model brain circuitry with realistic dynamics, combined with information processing and learning, through multiscale, multiphysics properties of the brain combined with biologically realistic learning rules to train the models to generate purposeful behavior, that will enable development of better biologically-inspired AI applications that can more transparently interact with humans in a closed loop, improving human-agent teaming; expand machine learning techniques beyond optimal functions on a single data set that is then extrapolated to others, to instead find many good functions on a data set and extrapolate them in a way to generate many predictions which can be used to establish a level of confidence in the prediction; study mathematical language tools to manipulate both physical process and analytic properties together in a potentially arbitrary number of dimensions, which physicists could use as basis for new quantum information science capability; investigate mathematical tools (statistical hypothesis testing, modeling of geometric flows over networks) to enable logistics planners to account for task organization, scheme of maneuver, and environment in generating forecasted logistical demand by priority and to optimize the flow of sustainment through the logistics network. *FY 2022 Plans:* Will investigate and develop the increasing mathematical network of interlocking analogies between physics, topology, logic, and computer science, and their common overlap as the possible beginnings of a new science in the general science of mathematical systems and processes bringing together mathematical ideas within the context of Category theory, including in the contexts of algorithms, complexity, and error correction, such as are present in quantum information; gain an understanding of how electrical stimulation affects the behavior of active neuronal networks, focusing on creating and implementing new modeling techniques for simulations of large-scale biologically realistic cortical networks subjected to electrical stimulation, potentially leading to significantly improve the efficacy of existing electrical stimulation therapies across multiple domains and will be useful for future device/therapy design for neural dysfunctions such as movement disorders, tinnitus, traumatic brain injury, and pain and could potentially be used for restoration of motor function or sensation as well as for improvements in memory performance; will construct better optimization algorithms by uncovering the geometric structure of the model's landscape as a function of its parameters to better enable the fitting of statistical and probability models (i.e., finding good parameter values) which will lead to knowing the landscape's geometry aiding in finding a collection of nearly optimal points to allow analysts to see which features they agree (giving us more confidence in the inference) or disagree (giving us less confidence). This could enable more accurate modeling and simulation of future Army systems; develop an entirely new approach to Topological Data Analysis (TDA), bridging the important gap between traditional TDA output and practical applications of it using statistical inference and machine learning, and developing TDA output that is more stable with respect to initial data than the standard TDA output (e.g. persistence diagrams) which could enable the development of tools to search very large sets of data for anomalies and threats and to provide visualizations that may be used by humans to obtain actionable intelligence. *FY 2021 to FY 2022 Increase/Decrease Statement:*			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
In FY 2022, funding increased to support additional research in the area of a mathematical network of interlocking analogies between physics, topology, logic, and computer science.			
Title: HBCU/MI Single Investigator	-	-	2.500
Description: This effort supports extramural basic research to create and exploit new scientific discoveries from Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) that will improve the Army's transformational capabilities. Areas of interest include chemical sciences, computing sciences, electronics and photonics, life sciences, material sciences, mathematical sciences, mechanical sciences, network sciences, and physics. *FY 2022 Plans:* Will identify and support competitively-selected extramural research conducted at HBCU/MI institutions to provide increased knowledge and understanding in fields related to long-term future force needs; support faculty immersion program where HBCU/MI faculty are aligned with Research 1 (R-1) universities and Army research laboratories in order to contribute research in support of long-term Army modernization priority needs. *FY 2021 to FY 2022 Increase/Decrease Statement:* in FY 2022, funding realigned from Basic Research in Life Sciences, Basic Research in Chemical Sciences, Basic Research in Physics, Basic Research in Electronics and Photonics, Basic Research in Materials Sciences, Basic Research in Mechanical Sciences, Basic Research in Computing Sciences, Basic Research in Network Sciences, and Basic Research in Mathematical Sciences within this Project to support HBCU/MI institution extramural research in the areas of chemical sciences, computing sciences, electronics and photonics, life sciences, material sciences, mathematical sciences, mechanical sciences, network sciences, and physics.			
Accomplishments/Planned Programs Subtotals	93.691	100.773	90.542

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 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AA4: *Training and Human Science Research*	-	19.949	21.322	21.781	-	21.781	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

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

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

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Translational Neuroscience	3.646	3.964	3.998
Description: This effort integrates neuroscience with traditional approaches to understanding Soldier behavior to enable system designs that maximize Soldier performance. ***FY 2021 Plans:*** Examine the relationship between arousal and visual search accuracy in degraded visual environments; investigate network methods to understand rapid neural dynamics that predict future behavior; establish methods to determine the role of environmental context on visual target detection and identification. ***FY 2022 Plans:*** Will identify relationships between ocular and neural signals to understand visual search behavior in virtual and augmented environments; will investigate methods to augment the brain and predict neural behavior in real-world contexts including social interactions; will create initial neural models of the brain's spatial reasoning system. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Human System Integration	5.203	5.200	5.290
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 2021 Plans:*** Generate novel approaches to predict fluctuations in marksmanship accuracy to enhance the performance of closed-loop systems; create generalized models using machine learning methods that improve signal detection robust to time and environment changes; investigate algorithms to integrate information over multiple timescales from hybrid teams for improved situational awareness; identify metrics to improve adaptive human-autonomy joint decision making in crew station scenarios. ***FY 2022 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will develop models to predict decisions by human users interacting with autonomous systems using multi-modal sensor measurements; generate initial, real-world physiological tracking of human state to drive optimal human-agent mutual adaptation; will create models for optimizing individual decision making under uncertainty for future technology integration; will generate initial methodologies to analyze brain signals using topological data analysis. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***Description:*** This effort investigates technologies that provide the foundation for future Army systems to adapt to individual Soldier states, behaviors, and intentions in real-time. Enable high fidelity, continuous prediction that can account for continuous changes in Soldier physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. ***FY 2021 Plans:*** Investigate approaches for modeling how individual differences impact team dynamics; investigate heart-based metrics that can robustly predict changes in task performance; research methods to continuously measure and assess social interactions, physical activity, and task dynamics in real-world contexts. ***FY 2022 Plans:*** Will examine multi-modal and multi-timescale models of human dynamics to improve understanding of variability over unimodal or short timescale models; will conduct research to validate models predicting performance on military-relevant tasks, incorporating multi-timescale features; will explore adaptive algorithms using multi-timescale approaches for real-time prediction of task performance on specific, laboratory based tasks. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	4.055	4.162	4.395
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. ***FY 2021 Plans:***	1.070	1.336	1.342

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Identify methods to utilize immersive technologies and individual differences to improve training for spatial tasks and efficient navigation. ***FY 2022 Plans:*** Will identify training approaches that utilize immersive technologies and individual differences to improve decision-making and adaptability under complexity and uncertainty. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
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 2021 Plans:*** Study techniques to reduce data requirements for autonomous systems by incorporating knowledge from humans using natural interactions. ***FY 2022 Plans:*** Will develop techniques to incorporate multimodal sensing to improve autonomous system performance under dynamic environments to improve human/intelligent agent joint performance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	0.760	0.999	0.981
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 2021 Plans:*** Conducting research to identify individual contribution to performance within a group; conducting research to develop new integrative framework of implicit personality; conducting research in psychometric models for sensor data sources (e.g., data streams). ***FY 2022 Plans:***	2.658	1.887	1.968

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will conduct research to develop new scoring approaches to improve measurement precision; will continue research to develop integrated frameworks of implicit-explicit personality; will continue research to identify individual contribution to team performance; develop collective and individual measures of performance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** N/A			
Title: Context of Behavior in Military Environments ***Description:*** This basic research effort develops an integrative theory to understand and model the contextual drivers of individual and group performance. ***FY 2021 Plans:*** Conducting research studying a theory of event-based leadership and identify contextual factors impacting individual and group decision making. ***FY 2022 Plans:*** Will conduct research to develop integrative multi-disciplinary frameworks of organizational context; will conduct research to develop theory to understand cross-echelon influence of leadership on performance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	-	0.899	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 2021 Plans:*** Conducting research on mathematical algorithms for composing teams and assessing team performance; conducting research to understand and model social contagion of motivation within groups. (e.g., how does motivation spread among group members). ***FY 2022 Plans:*** Will conduct research to develop computational approaches to model impact of organizational structure on team performance; will conduct research to develop frameworks to understand multi-team processes.	2.557	1.888	1.888
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.	-	0.987	0.987

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2021 Plans: Conducting research on adaptive performance to identify predictors and barriers to behavior change and learning; conducting research to develop an integrated framework of self-regulated learning behaviors, motivation, and attitudes related to individual and group informal learning. *FY 2022 Plans:* Will conduct research to develop approaches to understand and model longitudinal developmental processes of personnel; will conduct research to develop frameworks for building constructive learning environments.			
Accomplishments/Planned Programs Subtotals	19.949	21.322	21.781

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 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
AA5: *Biotechnology and Systems Biology*	-	5.511	6.042	6.076	-	6.076	-	-	-	-	-	-

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 2020	FY 2021	FY 2022
Title: Engineered Biotechnology (previously titled: Biological and Bio-derived Materials and Devices)	2.326	2.572	2.577
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 2021 Plans:** Utilize established bioprospecting, bio-panning and high throughput screening capabilities to identify potential individual microbes and communities for materials degradation; investigate modeling and experimental techniques to design and build microbial communities; investigate the role of microbial / material interfaces in degradation and assembly processes for tunable adhesion to control optical/electronic properties. **FY 2022 Plans:** Will conduct targeted bioprospecting, bio-panning, and expand high throughput study of biological control mechanisms to identify material specific microbes and communities for material degradation; understand the behavior of micro-environment of degrading material through analytical and computational techniques to inform predictive community models; will investigate			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
genetic engineering strategies to tune microbial interactions and adhesion to material interfaces for dynamic microbial/material interactions to identify candidates for degradation and assembly process. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Synthetic Biology for Dynamic Materials ***Description:*** This effort researches the concept of responsive materials imparting living functions for operation in Army-relevant environments to enable disruptive capabilities, such as self-healing, adaptation, protection, and situational awareness. Perform research to enable design and synthesis of materials both enabled by and including biological entities to provide these living functions. ***FY 2021 Plans:*** Identify discovery tools to bridge gaps in foundational understanding of materials production and harnessing of indigenous biology in military environments; identify materials and biologically derived assembly techniques for tuning material and system performance; research tools for manipulation and control of Army relevant organisms enabling access to targeted material production and operational environments, investigate synthetic biology derived sense and respond circuits for biological microorganisms; identify tools to link bioinformatics and materials informatics for high throughput data analysis. ***FY 2022 Plans:*** Will explore new control strategies for harnessing indigenous biology in military environments; continue to examine materials and biologically derived assembly techniques for systems and materials performance; will develop high through-put technology for study of control mechanisms and/or parts in novel organisms; will identify orthogonal tools to allow for organism engineering agility to pivot for Army needs for material production and operational environment; will develop strategy to link high throughput data analysis of bioinformatics and material informatics to bulk material analytics. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	3.185	3.470	3.499
Accomplishments/Planned Programs Subtotals	5.511	6.042	6.076

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

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D. Acquisition Strategy

  N/A

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COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AA6: *Robotics and Mobile Energy*	-	20.807	22.353	20.793	-	20.793	-	-	-	-	-	-

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 Research Centers).

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Vehicle Propulsion and Power Research	0.864	1.225	1.395
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 2021 Plans: Investigate ultra-high temperature materials and coatings in a high temperature continuous combustion environment to enable the development of future Army propulsion systems with higher power density.			
FY 2022 Plans:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will validate coupled fluid structure interaction models for dynamic contact angle for molten particulates in hot turbine components; assess emissivity characteristics of oxide/oxide ceramic matrix composites for engine applications; characterize thermo-mechanical behavior of ultra-high temperature composites. **FY 2021 to FY 2022 Increase/Decrease Statement:** In FY 2022, funding increased to support additional research in the area of coupled fluid structure interaction models.			
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 2021 Plans:** Investigate ignition chemistry of novel aviation fuel blends determine the ignition map formulation for wide-range ignition models to support robust engine control schemes; investigate novel tribological materials to enable reliable low viscosity fuel delivery from storage to the site of energy conversion; investigate advanced lightweight aluminum alloys for application under extreme thermomechanical dynamic stresses to enable the development of reliable engine components with reduced weight. **FY 2022 Plans:** Will expand aviation fuel models for robust engine control to include gasoline and other highly volatile fuels; determine fuel property sensing method to differentiate fuel ignition quality; explore ignition behavior at cost start and altitude relight conditions in small gas turbine engine; investigate industrial processing conditions and alloying additions on microstructural evolution of advanced aluminum alloys for high thermomechanical applications; will produce and record lab scale mechanical properties of aluminum alloys with varying microstructures and at varying temperatures; will determine microstructural changes in novel tribological materials that lead to scuffing and coating delamination failures in fuel-lubricated mechanical interfaces in simple and complex geometries. **FY 2021 to FY 2022 Increase/Decrease Statement:** In FY 2022, funding decrease reflects planned reduction in research in the area of novel tribological materials.	3.827	3.696	3.354
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 materials for topological insulators for energy conversion, and new designs for solar cells.	1.051	1.235	0.930

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Investigate the process of nuclear excitation by electron capture (NEEC) as a means of releasing energy stored in nuclear isomers for a potential disruptive power source; investigate aqueous battery chemistries involving multi-valent cations (e.g., Zinc and Magnesium)) and the protection of anode surface low potential materials (e.g., graphite and Lithium metal); study the electrochemical and catalytic processes with advanced infrared spectroscopic methods to explore novel approaches to improve the stability and performance of battery and other electrochemical energy storage/conversion devices. **FY 2022 Plans:** Will study isomer energy release utilizing nuclear excitation by electron capture or other processes, with the goal of testing a non-implantation approach to an isomer power source; will study charge and energy transfer pathways of light absorbing and catalytic electrochemical systems for energy storage chemical reactions using ultrafast spectroscopy and electrochemical characterization. **FY 2021 to FY 2022 Increase/Decrease Statement:** In FY 2022, funding was reduced in this effort because research into aqueous battery chemistries ended.			
Title: Materials, Structures, and Analytics for Enduring Platform Operations **Description:** Basic research to establish fundamental understanding in structural damage tracking methods, novel material/structures, and prognostic and diagnostic techniques to improve vehicle performance and capability. This includes the advancement of machine learning algorithms for deep learning, and the exploration of novel lightweight, durable, self-sensing structures for improved maneuver and reduced maintenance. **FY 2021 Plans:** Investigate novel approaches of combining material informatics, artificial intelligence/machine learning, and classical mechanics to achieve new mechanics to predict materials behavior and structural properties to enhance the performance and resilience of advanced air vehicle structures. **FY 2021 to FY 2022 Increase/Decrease Statement:** In FY22, funding is realigned to PE 0601601A (Artificial Intelligence Basic Research) / Project CL3 (AI/ML Basic Research Hub) to focus on advanced efforts in Artificial Intelligence, as part of the Program Evaluation Groups (PEG) efficiency drill	1.225	1.538	-
Title: Reconfigurable Platform Mechanics and Propulsion **Description:** Basic research in reconfigurable platform mechanics and propulsion science to investigate technologies to enable subsystem configuration concepts for efficient hover and high-speed/range Vertical Take-Off and Landing (VTOL) aircraft. **FY 2021 Plans:**	0.826	0.999	0.981

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Investigate and design robust, reconfigurable vehicle structures that will enable future air vehicles to function efficiently and adapt to several operational modes; investigate novel approaches to synthesize bio-inspired material systems capable of mimicking distributed energy mechanisms, to enable complex motions for stability, robustness, and compliance in dynamic platforms. *FY 2022 Plans:* Will investigate reconfigurable platform mechanics (materials, structures, actuators, aeromechanics) and technologies to enable subsystem configuration concepts (mechanical, electrical, power, and information interfaces) for efficient high-speed, range, and payload vertical take-off/landing (VTOL) aircraft; will explore interdisciplinary materials research to inform on the viability of engineering materials at the molecular level to achieve highly reconfigurable, mechanically relevant structures; will develop a sizing methodology and performance models for the assessment of advanced unmanned aerial system (UAS) concepts with adaptive structures. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Robotics Autonomy and Human Robotic Interface Research *Description:* Basic research focused on enabling robust autonomous mobility for small and human-scale robotic systems, including autonomous teaming behavior with hybrid human-robotic teams. Enablers for robust autonomous mobility include planning, behaviors, energy efficient maneuver, and the interface of manipulation technologies to support manned-unmanned teaming constructs. *FY 2021 Plans:* Investigate methods to enhance intelligent robotic performance and reduce algorithmic brittleness in a mission-relevant and hybrid teaming context; determine mechanisms to enhance resilience of robotic performance; establish methods to increase robotic operational tempo under supervised and unsupervised autonomous operating conditions; explore impacts and methods to mitigate sporadic network connectivity. *FY 2022 Plans:* Will investigate novel methods for energy prediction and energy awareness for heterogeneous unmanned systems; develop algorithms that enable autonomous power distribution between ground and air vehicles for sustained increase in operational duration; investigate optimized vehicle route planning among robot teams under constraints of energy availability and mission demands; develop methods for alternative energy in the form of heat engines for power distribution among robotic teams. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding increased in this effort to support additional research into autonomous power distribution between ground and air vehicles.	1.201	1.513	1.632
Title: Intelligent Systems	6.059	5.884	6.166

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
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 2021 Plans:* Conduct fundamental research to extend the techniques of transfer learning, reasoning, and reinforcement outside of simulation to live environments; investigate previous work in intelligence architecture frameworks across distributed heterogeneous agents to include distributed world models and shared representations. *FY 2022 Plans:* Will conduct fundamental research on navigation algorithms capable of assessing route options using limited resources while assessing multiple courses of action over long planning horizons; develop algorithms that allow automated tuning of low level control parameters with limited human feedback; will extend shared representations techniques to enable planning across multiple platforms. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change 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 2021 Plans:* Investigate new experimental aeromechanics approaches for characterizing and optimizing efficiency, speed, and maneuverability for novel advanced vehicle configurations; investigate the effects of interactional aerodynamics associated with the transition from vertical flight to forward flight for novel vertical lift unmanned air vehicle concepts; research methods to capture human agents, enemy behavior, and human-agent interaction in multi-agent simulation framework; investigate fluid-structure interaction models to inform the structural design of an adaptive Unmanned Aerial Ssystem with enhanced aerodynamic performance. *FY 2022 Plans:*	2.827	2.997	3.019

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will combine aeromechanics models, artificial intelligence/machine learning, and classical mechanics to achieve embodied intelligence to creatively machine design platforms to enhance the performance and resilience of advanced air vehicle structures; develop computationally efficient methods and functional models of aerodynamic interactions for near real-time flight dynamics in virtual environments; acquire wind tunnel and experimental flight data on multi-rotor configurations to enable analytical and computational models for vehicle design methods, explore novel active flow control technologies and measurement methodologies, and assess novel numerical techniques; develop approaches for on-board sensing of airflow and vehicle orientation for automated flight transitions. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
Title: Air Mobility **Description:** Create robust experimental and computational approaches for understanding, modeling, and predicting the complex fluid flow and aerodynamics of next generation rotorcraft concepts. This research includes innovative numerical methods for capturing the details of steady state and non-steady state aerodynamics and acoustics occurring with multi-rotor, rotor-propeller, and rotor hub configurations; and associated experimental techniques needed to verify modeling results. ***FY 2021 Plans:*** Conduct experimental and computational investigations to better understand interactional aerodynamics of multi-rotor configurations by exploring pioneering flow measurement techniques and novel numerical algorithms/methods; conduct computational aero-science investigations using numerical methods including work on validating the physical assumptions forming the building blocks of the underlying theory. ***FY 2022 Plans:*** Will conduct computational aerodynamics and structural dynamics research aimed to develop novel numerical methods to solve rotary-wing aeromechanics problems including hover and high-speed forward flight; continue to conduct experimental and computational investigations in order to identify, explain, and predict the interactional aerodynamics of multi-rotor configurations by developing pioneering flow measurement techniques and novel numerical algorithms/methods. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	2.333	2.504	2.576
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	0.594	0.762	0.740

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
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 2020**	**FY 2021**	**FY 2022**
directed at understanding advanced mathematical and computational methodologies using state-of-the-art analytical and empirical procedures. *FY 2021 Plans:* Continue to review and quantify the effectiveness and efficiency of the multi-scale computational algorithms for modeling a military ground vehicle traversing over fine soil particles; apply deep learning algorithms for generating Go/NoGo maps to other geographic regions; continue to expand human cognitive models based on use cases and human roles for integration into autonomy modeling; explore intelligent autonomous mobility technologies integrating minimal sensor configurations, deep-learning based terrain identification, high-fidelity mobility simulations, robust path planning and control, all on-board and in real time; investigate a terrain deoxyribonucleic acid concept that correlates to distinct mobility performances. *FY 2022 Plans:* Will expand investigative research into quantum computing approaches for computationally expensive multi-scale algorithms for modeling a military ground vehicle interaction with terrain / soft soil; research assured mobility with cyber implications; research gaming engine algorithms for autonomous vehicle off-road mobility; conduct explorative research in intelligent autonomous mobility technologies integrating minimal sensor configurations; research deep learning based terrain identification; research and develop robust path planning and control, all on-board and in real time; continue researching the application of deep learning algorithms for generating Go/NoGo maps to other geographic regions. *FY 2021 to FY 2022 Increase/Decrease Statement:* N/A			
Accomplishments/Planned Programs Subtotals	20.807	22.353	20.793

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

D. Acquisition Strategy
 N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
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 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AA7: Mechanics and Ballistics	-	32.734	35.368	33.359	-	33.359	-	-	-	-	-	-

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); 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 2020	FY 2021	FY 2022
Title: Protection Sciences	5.284	5.000	5.394
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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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA7 / *Mechanics and Ballistics*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
mechanisms through increased understanding of wave propagation through tissue, and the resulting deformation and damage of tissue during ballistic and blast events. *FY 2021 Plans:* Investigate computational methods and perform ballistic experiments on lightweight metal alloys and brittle materials to capture multiple deformation and failure mechanisms occurring simultaneously under ballistic and blast loading conditions; perform novel experiments to probe and quantify high-rate deformation mechanisms at small length scales to improve multi-scale computations; investigate a human-derived thorax model for measuring and relating the human structural and injury response in ballistic impacts to produce substantiated design parameters for personal protection systems. *FY 2022 Plans:* Will initiate micro-mechanical dynamic response experiments on heterogeneous ceramics and MAX phase material; conduct transverse indentation studies to establish the response of Tensylon to impact loading relevant to ballistic environments and use meso-scale validated computational models to obtain the evolution of the stress-state; perform macroscale fracture studies at quasi-static and dynamic strain rates using in-situ x-ray imaging and diffraction techniques to improve computational failure models; investigate a stable and accurate finite element model for ballistic impacts to the human thorax in order to improve personal protective equipment. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Microscopic/Nanostructural Materials *Description:* This effort explores new materials and creates new computational capabilities based upon fundamental concepts derived from studies of structure, process, and property relationships at the microscopic and nanostructural levels. Research includes synthesis, processing, characterization, and modeling of novel metal alloys and armor ceramics, including control and manipulation of nanostructural features, grain boundaries, texture, and other nano-to-microscale structure. *FY 2021 Plans:* Investigate nanostructured materials properties achieved through novel processing routes for potential use in and transition to vehicle armor and lethality applications. *FY 2022 Plans:* Will investigate the quasi-static and high-rate properties of nanostructured materials (iron-based and copper-based) determined to be important to the behavior needed in vehicle armor and lethality applications; investigate novel particulate consolidation methods that preserve the nanostructure at elevated processing temperatures and provide the unique properties needed to be successful; provide a correlation of the processing parameters to the properties observed; continued the development of high	2.971	3.245	3.307

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	**Project (Number/Name)** AA7 *I Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
diamond content composite ceramic materials to include large enough specimens for sub-scale ballistic assessments for high-rate and resultant microstructural characterization. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: High Deformation Rate Materials ***Description:*** This research addresses Army-unique issues in fundamental materials research involving the performance of advanced materials at high deformation rates for applications including armor and armaments. Fundamental understanding is developed to enable design, processing, and characterization of materials specifically intended for high loading-rate applications, including improved physics based models, methods to characterize materials microstructure, interfaces, and defects and their role on materials response, and the determination of rate-dependent constitutive and failure/fracture behavior of materials. ***FY 2021 Plans:*** Investigate material mechanisms in metals, ceramics and polymers which contribute to novel behaviors at high rates of loading, making them suitable for lethality and protection applications. ***FY 2022 Plans:*** Will integrate metals, ceramics, and polymers with unique high rate behaviors into prototype composite armor and composite weapon systems/sub-systems and investigate the influence on the composite response to extreme mechanical loading. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	3.096	3.386	3.410
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 2021 Plans:*** Investigate the use of field-based processing methods to influence microstructural control, phase transformation, and texturing behavior in various materials systems. For metals, processing under magnetic fields will lead to the determination of mechanisms and development of descriptive models to enable enhanced diffusion control and expansion of manufacturing process space, particularly in additive manufacturing. For ceramics, field-based parameters and conditions are investigated to develop an intelligent processing capability that incorporates in-situ characterization, modeling, and real-time processing controls to fabricate consistent, high performance materials. ***FY 2022 Plans:***	2.254	2.478	2.488

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will identify alloy compositions which maximize response under a magnetic field for additive manufacturing alloy design and determine appropriate processing conditions which improve printability and carburization in aluminum and steel systems respectively through the application of descriptive models that incorporate magnetic field based diffusion mechanisms; optimize processing methodology to produce samples large enough to conduct ballistic testing to assess if new material meets performance requirements. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: One Dimensional (1D) and Two Dimensional (2D) Materials and Processing Research ***Description:*** Discover novel building block materials that provide disruptive protection mechanisms. Research includes synthesis, processing, characterization, and modeling to discover new 1D and 2D building block materials and associated assembly into protective membranes, smart fibers and films, and other molecular composite architectures. ***FY 2021 Plans:*** Explore synthetic methods to produce novel 2D polymer molecules and examine the assembly of platelets into ensemble films; explore structure-property relationships of 2D films, in an attempt to assess their mechanical properties for ballistic applications. ***FY 2022 Plans:*** Will explore expanding the palette of available 2D polymer chemistries to tune properties for a range of applications, guided in part by artificial intelligence and machine learning (AI/ML) design methodologies; identify processing science advances to enhance the quality, properties, and scalability of 2D polymer films. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	1.286	1.690	1.663
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 2021 Plans:*** Investigate the biological synthesis of inorganic materials, biopolymers, and composites for scalable integration and processing with an emphasis on materials for electro-optic, electromagnetic, and sensing applications; investigate strategies for scalable integration that are compatible with large scale polymer and industrial processes; explore synthetic high throughput biology routes	1.523	1.815	1.811

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			**Date:** May 2021		
Appropriation/Budget Activity 2040 / 1		**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
to engineer biological systems for tunable material properties such as elemental doping of structures and creation of tunable scaffolding; explore integration strategies for living/responsive function that can leverage microorganism response to external triggers. *FY 2022 Plans:* Will down-select candidate materials, biopolymers, and composites and study functional behavior after scalable integration and processing; tune biopolymer properties for improvements to control meso-scale assembly and identify structure/function and/or sequence-defined function properties; investigate compatibility of biological materials and organisms and material scaffolds and uncover mechanisms for controlling precision placement and integration of biological and composite material behavior. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles *Description:* Improve the fundamental understanding of the mechanisms controlling the launch and flight of gun-launched projectiles and missiles, and understand the interaction of these weapons with armored targets. *FY 2021 Plans:* Investigate computational tools for coupling of thermal-fluids and structural mechanics with analysis of high-speed munitions; explore the feasibility of adding chemistry to tools for propulsion and/or plasma applications; research munition control technologies (e.g., flight control algorithms, control mechanisms) to improve maneuverability of small munitions in extreme mechanical and thermal environments and gain further understanding using advanced coupled mechanics computations; understand basic phenomena (e.g., shock interactions, thermal loading) associated with high speed munition flight using computational tools and experimental data; formulate basic estimation theory for multiple agents with constrained sensors and actuators; research estimation algorithm and image processing frameworks which combine model-based and data-driven approaches. *FY 2022 Plans:* Will perform studies to examine the aero-thermodynamics of Army-relevant shapes flying at hypersonic speeds and compare computational predictions, wind tunnel measurements, and ballistic free-flight experiments; extend theories of multi-agent perception and control for constrained, high-speed aerial systems. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	2.846	3.192	3.214
Title: Energetic Materials Research	3.350	3.648	3.621

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 1		**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*		**Project (Number/Name)** AA7 *I Mechanics and Ballistics*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
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 2021 Plans:* Continue synthesis of new energetic ingredients and polymers for use in gun propellants; refine new melt cast ingredients and formulations identified in FY20; analyze performance characteristics of disruptive-type materials (e.g. extended solids and fast reacting metals) and structural reactive materials; validate and verify response to dynamic compression of ingredients developed in FY20; continue numerical simulations that aide in understanding the kinetic rates of newly developed propellants and propulsion technologies. *FY 2022 Plans:* Will synthesize, characterize, and explore novel high energy density nanometals and extended solids, building off of FY21 successes; transition grain scale dynamic modeling techniques and solid state kinetics methodologies developed in FY21 to large scale efforts for verification and validation; develop fundamental models to aide in the design of newly developed propulsion concepts. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Theory in Atmospheric Characterization, Sensing, and Modeling *Description:* New algorithms and methods are developed to account for a variety of complex-terrain physical processes in microscale models. Novel instrumentation and observational methods are developed to advance the understanding of physical processes in the atmosphere. Employ optical techniques to advance detection methods for chemical/biological agents mixed in with atmospheric constituents. Data from high-resolution instrumentation arrays are used to advance and verify evolving atmospheric characterization theory focused on complex terrain and dense urban areas. *FY 2021 Plans:* Continue to research urban land surface energy budget and radiative transfer processes using data collected at the MSA testbed and apply machine learning techniques to MSA data to identify previously unknown complex terrain and urban processes and for anomaly detection; conduct laboratory investigation of aerodynamics of vertical takeoff and landing Unmanned Aircraft Systems, and integration of environmental sensors to facilitate environmental awareness essential for autonomous flight; research thermal and momentum flux of sloping surface under stratification to better treat physical processes in complex and urban terrain, and adequately express the uncertainty for decision support tools; couple a newly-developed radiative transfer code with the Atmospheric Boundary Layer Environment-Lattice Boltzmann Method (ABLE-LBM) forecast model and conduct initial simulations of idealized, radiatively-forced boundary layers; evaluate the performance of emerging acoustic vector sensing hardware/data as applied to beam forming (source-localization) and atmospheric acoustic tomography; assess the viability of multi-aperture	3.846	3.900	4.162

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
remote sensing capability for atmospheric aerosol, wind, and temperature retrieval; characterize, quantify, and assess the impact of atmospheric conditions on aerosols using optical characterization techniques (e.g., elastic and inelastic scattering) in the laboratory and the field. *FY 2022 Plans:* Will apply machine learning techniques to the Dense Urban Area Meteorological Sensor Array (MSA) data to identify previously unknown complex terrain and climatic processes building from research on complex land surface energy budget, water cycle processes, and radiative transfer processes using data collected at the MSA testbed; explore both short timeframe and longer timeframe environmental processes in urban domains; identify additional sensing modalities that could be integrated onto an unmanned aerial system (UAS) platform to facilitate environmental awareness essential for autonomous flight; continue research to quantify thermal and momentum flux of sloping surfaces under stratification to better treat physical processes in complex and urban terrain; study the application of lattice-Boltzmann methods to simulate radiative transfer in the urban environment; explore and devise new/improved methods to characterize and assess the impact of atmospheric environment on aerosols; explore methods of heterogeneous sensing modalities to both characterize the environment and assess the impact of the environment on electro-optic, radio frequency (RF), and acoustic signals. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Multiscale Modeling for Novel Materials *Description:* Explore and develop multi-scale modeling techniques to support fundamental studies of electronic and structural material properties from the atomistic to the continuum. Resulting models will be used to design and develop materials for more efficient, longer lifetime sensors and power and energy devices, and lighter materials for vehicle and soldier protection. This effort includes coupled research with two 5-year Collaborative Research Alliances (CRAs): the Materials in Extreme Dynamic Environments CRA and the Multi-scale/Multidisciplinary Modeling of Electronic Materials CRA. These CRAs are funded under PE 0601104A (University and Industry Research Centers) / Project AB7 (Army Collaborative Research and Tech Alliances). *FY 2021 Plans:* Incorporate uncertainty model predictions and a basic set of non-deterministic aspects of microstructure and it?s evolution into numerical methods for computer models of materials; assess predictive capabilities of selected new at-scale models for simple material systems; enable ?on-the-fly? delta-machine learning approaches for lower-accuracy models, yielding full resolution Density Functional Theory (DFT) accuracy at near classical computational speed or cost; investigate electro-optical vertical transport models for real devices; investigate hydrodynamic transport modeling to topological materials to understand and validate physics within material and devices. *FY 2021 to FY 2022 Increase/Decrease Statement:*	3.262	3.546	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 **/** 1	**R-1 Program Element (Number/Name)** PE 0601102A **/** *Defense Research Sciences*	**Project (Number/Name)** AA7 **/** *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
In FY 2022, funding was realigned from this effort to Terminal Ballistic Design and Evaluation for Next Generation Materials within this Project and to support Physics-Informed Machine Learning for Complex Phenomena in PE 0601102A Project AA8.			
Title: Environmental Quality	0.859	1.107	1.109
Description: This effort conducts research on innovative environmentally-friendly technologies that support the warfighter focusing on pollution prevention technologies. *FY 2021 Plans:* Perform basic research to understand and reduce the environmental impact of energetic compounds, their chemical pre-cursors, and solvents used during their processing and formation; characterize and synthesize novel, nanoparticles for easier chemical detection of trace compounds; study controlled electrodeposition techniques from ionic liquids for the synthesis of new class of layered coatings for corrosion protection of materials used in armament systems; research a statistical method for the screening of alternative solvents for energetic materials to reduce the environmental impact of energetic material synthesis; study the mechanism for adhesion and colonization of the primary colonizing fungi on composites reduce fungi growth on materials. *FY 2022 Plans:* Will conduct innovative basic research in the systematic study of new innovative environmentally friendly energetics through the study of fundamental aspects of compounds and precursors and bench scale synthesis including experimental research; conduct modeling and simulation of various compounds and the study of alternative solvents and processes to reduce the hazards associated with the manufacturing of energetics; research new green coatings through the study of various shaped and sized nanoparticles to replace hazardous chemicals for a variety of armament and energetic materials, enhancing coloration while reducing toxicity; conduct research on innovative methods to replace toxic chemicals in the coating of metals for corrosion inhibition. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Surface Science Research	2.157	2.361	2.386
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 2021 Plans:* Continue studies to understand and characterize chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces, to include transport, binding energy, deposition, chemical reactivity, and interactions between these			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	**Project (Number/Name)** AA7 *I Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
processes; conduct basic research to understand effects of surface structure, morphology, and surface group properties; and continue to study the theory and investigate models of processes at complex surfaces. *FY 2022 Plans:* Will conduct research and studies focused on chemical and biological interactions on solid surfaces including interfaces between materials and the surface. Areas of interest include transport, deposition, reactivity, and removal of biological and chemical compounds of interest, material interactions and properties arising from physical or biological synthetic processes, and enabling models and theory of interfacial interactions or processes that may relate to bulk properties. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Terminal Ballistic Design and Evaluation for Next Generation Materials *Description:* Research will focus on novel terminal ballistic designs utilizing engineered materials to provide lightweight protection and low-energy penetrator solutions for combat-relevant threats. Specific architecture materials will be identified and utilized based on high-throughput material synthesis and characterization, and data-driven physics based modeling approaches. *FY 2022 Plans:* Will develop analysis methods for penetration mechanics of non-homogeneous materials for Army applications; develop a canonical experiment approach to relate lab-scale material properties to ballistic response. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding realigned from Multiscale Modeling for Novel Materials effort within this Project.	-	-	0.794
Accomplishments/Planned Programs Subtotals	32.734	35.368	33.359

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 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AA8: *Sensing and Electromagnetics*	-	8.229	9.006	13.611	-	13.611	-	-	-	-	-	-

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 2020**	**FY 2021**	**FY 2022**
Title: Photonic Materials and Device Research *Description:* Conduct research into novel material and device structures operable throughout the electromagnetic spectrum from long wave infrared (LWIR) to ultraviolet (UV) including sources, detectors, and integrated photonic devices to increase situational awareness in open and complex terrains; allow assured communication, improved target detection, identification, and discrimination; and create new device functionalities while reducing size, weight, and power requirements. *FY 2021 Plans:* Explore fundamental issues limiting extraction efficiency and injection efficiency in deep ultraviolet emitters; investigate the use of III-Nitride semi-polar planes to increase light extraction in light emitting diodes operating in the solar-blind region; examine carrier transport in these structures through experiment and modelling. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding realigned to HEL Materials and Thermal Management in this Project.	0.886	0.999	-
Title: Advanced Materials Research *Description:* This effort conducts research in modeling, fabrication, and characterization of semiconductor materials and structures that leads to revolutionary device functionality in sensing, low power electronics, quantum networks, and power generation. This effort investigates novel complex crystal structures that can lead to devices with performance beyond normal	2.675	2.699	3.465

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army				Date: May 2021		
Appropriation/Budget Activity 2040 **/** 1			**R-1 Program Element (Number/Name)** PE 0601102A **/** *Defense Research Sciences*	**Project (Number/Name)** AA8 **/** *Sensing and Electromagnetics*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
semiconductor transistors, including neuromorphic computing structures and topological insulator based heterostructure with low operating voltage. *FY 2021 Plans:* Understand and optimize growth conditions of topological crystalline materials to achieve the necessary properties to create proof of concept device structures; investigate, characterize, and model interface physics between semiconductors exhibiting topological properties and ferromagnetic materials to optimize predicted low power switching capabilities; investigate methodologies to achieve desired topological device effects that can be achieved under real-world conditions (e.g., at or near room temperature); study diamond interface devices based on single crystal diamond and transition metal oxides with the objective of using superior thermal properties of diamond for high power radio frequency (RF) applications. *FY 2022 Plans:* Will optimize topological insulator materials for use in topological enhanced devices for atta joule computing at the edge; develop methodologies and algorithms to demonstrate basic arithmetic operations based on specialized arrays needed for realizing neuromorphic computing; study the electrical properties of silicon terminated diamond surfaces with the objective of operative transfer doping at higher temperatures. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding realigned from Materials Science for Army Power and Communications within this Project to support additional research in diamond material properties for radio frequency and power electronic devices.			
Title: Distributed Sensor Research *Description:* This effort creates more survivable and secure sensors and displays, investigates new acoustic, seismic, magnetic- and electric-field sensor technologies for personnel, activity, vehicle, and weapon-fire, and develops means to correlate, fuse, and interpret data from diverse sensors. This effort investigates novel algorithms and electromagnetic models to better understand radio frequency (RF) propagation and exploitation in complex clutter environments for improved RF and radar sensing. *FY 2021 Plans:* Research methods to improve the speed and utility of full-wave electromagnetic scalar and vector Helmholtz solvers for extremely large (up to a trillion elements) quasistatic-, magnetic- and electric-field sensing problems with distributed processing; study multi-function, acoustic particle-velocity-based, multi-target algorithms; investigate robust, inexpensive, multi-axis vector sensors for airborne and terrestrial mechanical wave exploitation; research robust methods to enhance perception of targets from onboard Size, Weight and Power (SWaP) constrained platforms; understand and create new radar data. *FY 2022 Plans:* Will investigate novel RF sensing modes for tactical Army applications; investigate and develop algorithms to enable the coherent integration of synthetic aperture radar (SAR) data across an aperture generated by sensor platform forward motion; research and	1.543	1.716	1.742

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Appropriation/Budget Activity 2040 **/** 1		**R-1 Program Element (Number/Name)** PE 0601102A **/** *Defense Research Sciences*	**Project (Number/Name)** AA8 **/** *Sensing and Electromagnetics*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
develop low complexity signal processing for RF sensors detecting and tracking personnel in complex multi-path backgrounds; investigate cross-modality geophysical interactions and coupling between 3D low-frequency electromagnetic fields, acoustic particle velocity, and torsional seismic waves. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
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 2021 Plans:*** Examine fundamental issues leading to high leakage currents in wide band gap, silicon carbide (SiC) diode structures under bias conditions resulting in internal electric fields; fabricate p-i-n diode structures to identify sources of leakage current; explore impact of modifying trap states on leakage currents in the diode structures through deep level transient spectroscopy, ultra-fast time resolved spectroscopy, and leakage current measurements; conduct multiscale modeling of the hybrid aqueous electrolytes to assist design of safe batteries with an improved energy density and fast charge; study methods to improve ion transport prediction accuracy to within 15% of the experimentally measured values; conduct multiscale modeling of selective ionic transport and energy conversion during electrochemical redox under dynamic field changes. ***FY 2022 Plans:*** Will validate previously developed models of impact ionization effects through experimental studies on appropriate structures; investigate how leakage currents are effected by lateral versus vertical structures; investigate interfacial interactions of adsorbed chemical species and excited states in plasmonic, electrocatalytic, and photoelectrocatalytic systems; identify causes of high leakage currents in wide band gap, silicon carbide (SiC) diode structures. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding realigned to Advanced Materials Research within this Project in FY 2022.	1.500	1.664	1.177
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 Global Positioning System (GPS)-denied, actively jammed, or austere environments.	0.535	0.709	0.729

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Appropriation/Budget Activity 2040 / 1		R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA8 / *Sensing and Electromagnetics*		

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Fabricate and perform experimental analysis of environmentally stable (i.e., temperature, vibration) electro-optic air-ring resonator using specialized indium tin oxide materials deposited on a silicon metamaterial structure. ***FY 2022 Plans:*** Will investigate the optical properties and its environmental dependence of the permittivity near zero metamaterial based air-ring resonator; develop a new tuning method for the soliton based micro-optical-frequency-comb and explore the locking mechanism to lock the optical frequency comb to the environmental-insensitive resonator for long-term stability. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Functional Materials ***Description:*** This effort supports basic research in polymer science and textile technology, nano and biotechnology, and multifunctional materials to achieve technologies that support the Soldier of the future through multi-functional materials with clothing/protective equipment functionality that also embody electronic functionality. ***FY 2021 Plans:*** Measure reaction rates of metal oxide photoelectrode materials and characterize the interaction mechanisms of metal oxides with aqueous toxic chemical solutions to inform future advancements in water remediation and decontamination; conduct experiments to gain mechanistic understanding of the impact of transcranial electrical stimulation on muscle output (i.e., isokinetic and whole-body kinematic performance) to inform development of future systems intended to moderate neuronal activity to enhance cognitive and motor performance. ***FY 2022 Plans:*** Will explore fabrication and characterization of novel materials with unique compositions and structures that result in tunable optical and electromagnetic properties; study human physiological responses to blue light exposure to understand the impact on sleep attributes and alertness. Knowledge gained will support optimization of Soldier performance, as well as inform design and usage of visual displays, such as in integrated headborne systems. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	1.090	1.219	1.233
Title: 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	-	-	1.290

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
transients to reduce the size and weight of thermal management components while increasing the energy magazine of systems operating in burst modes. ***FY 2022 Plans:*** Will explore new classes of passive and active phase change materials and processing methods to improve transient thermal management; investigate methods to tune and characterize thermal properties such as thermal conductivity and specific energy storage; investigate innovative techniques of reliable measurement of thermal resistivity for novel gain materials and innovative fiber designs; conduct laser experiments utilizing improved transient thermal management based on new active phase change materials; investigate thermal interfaces and thermal transport in phase change materials; explore controlled crystallization of all-glass, low nonlinearity fibers as well as thermo-optic tailoring of novel, low-nonlinearity glasses. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, funding realigned from Electro-Optic Materials Research within this Project, and from all the Projects in Basic Research portfolio as part of the Program Evaluation Groups (PEG) efficiency drill.			
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 radio frequency (RF) applications. ***FY 2022 Plans:*** Will investigate deficiencies of existing machine-learning approaches when applied to modeling of physical systems; validate the use of existing machine-learning techniques to construct models of physical systems; examine existing methods for incorporating physical constraints into machine-learning models of physical systems; conduct research into assimilation of multiple-fidelity data into machine-learning models of physical systems; explore techniques for uncertainty quantification of machine-learning models. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, funding realigned from Multiscale Modeling Novel Materials in PE 0601102A Project AA7.	-	-	3.275
Title: Semiconductor Modeling for Advanced Electronics ***Description:*** 3D numerical modeling basic research activities are scattered and insular, not effectively leveraging the combined capabilities of Government, Academia, and Industry. The problems are diverse and complicated, and need a focused and multi-disciplinary approach to gain fundamental understanding. This effort will build an ecosystem for foundational modeling and research in semiconductor materials and devices that leverages the broad combined knowledge base from academia,	-	-	0.700

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
industry, and government laboratories to develop new and advanced semiconductor materials and devices for sensors, emitters, neuromorphic, and topological device applications. *FY 2022 Plans:* Will investigate recombination mechanisms in Type-II Long Wave Infrared (LWIR) and Medium Wave Infrared (MWIR) strained layer superlattices (SLS) to develop understanding for improving transport and efficiency in these materials for sensing; investigate methodologies for mitigation strategies for optimal device design for sensing; investigate the interface properties between a topological insulator (TI) and a ferromagnetic and antiferromagnetic layers, which is needed for realizing low power switching electronic devices. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding realigned from all the Projects in Basic Research portfolio as part of the Program Evaluation Groups (PEG) efficiency drill.			
Accomplishments/Planned Programs Subtotals	8.229	9.006	13.611

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 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
AA9: *Information and Networking*	-	37.502	40.376	40.540	-	40.540	-	-	-	-	-	-

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 (Networks 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 2020	FY 2021	FY 2022
Title: Communications in Complex Dynamic Networks	5.532	5.475	5.337
Description: Perform research to provide communications capability for a fully-mobile, fully-communicating, and situationally-aware force operating in a highly dynamic, wireless, mobile networking environment populated by hundreds to thousands of networked nodes. This research includes techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldier information needs, modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber-attacks. Also to be considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Research methods for the control of social, information, and communication networks (and composite networks thereof) that enable enhanced operation in complex dynamic tactical environment through, e.g., software configurability, incorporation of the operational context of information within the network(s), scalable energy-efficient protocols, and/or the augmentation with unconventional communication and networking modalities; conduct simulation, emulation, and experimentation of such networks accounting for requirements on heterogeneity and scalability, and will utilize results to investigate novel improvements to network control methods; explore and characterize the performance of communication and networking methods that address adversarial physical and cyber threats to the network through, for example, the adaptive use of low-probability-of-detection techniques. **FY 2022 Plans:** Will conduct research on network models that jointly characterize combinations of the environment, network topology, communication technology diversity, computational resources, and/or mission objectives; develop and analyze multi-layer network protocols for optimizing network performance given technological, objective diversity, operational, and environmental constraints; explore novel network emulation approaches to support the development of future networks featuring vast scale and complexity; conduct emulation and physical experiments that characterize the performance of novel networking control protocols for intelligent, adaptive, and/or distributed operation. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.			
Title: Data to Knowledge to Support Decision Making (Information Mediation) **Description:** Research a laboratory-scale common information processing infrastructure, inclusive of cloud computing, for networking processes that aids the transformation of data into actionable intelligence to support decision-making under uncertainty. Perform research to utilize real-time, tactical, Soldier-centric information for improved decision-making and situational awareness. Perform research in support of rapidly enhancing long-duration, complex, dynamic decision-making capabilities of individual Warfighters and units through the integration of cognitive augmentation and course of action recommender technologies. **FY 2021 Plans:** Explore fundamental understanding of, and theories for, decision making phenomena in immersive environments and massive amounts of Joint, Coalition, and/or multi-domain data; research theories and methods that deliver accelerated decision making for tactical and military intelligence, through the use of virtualization and machine learning augmented autonomous and human information interaction techniques; investigate fundamental issues in defining an enhanced event ontology for multimodal event representation with support for causal and temporal reasoning by intelligent systems that augment Solder decision-making; define annotation approaches for situated training data, conduct investigation of statistical, rule-based, and other algorithmic approaches for information transformation to create an abstract semantic representation for multi-domain data from heterogeneous information	4.850	5.221	4.228

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
sources; create theoretical models of the features and characteristics in military artifacts that are the most relevant to course of action generation and disposition; study knowledge elicitation techniques and conduct human-in-the-loop empirical studies of tactical operations to define knowledge representation models optimized for inferencing and real-time situational awareness. *FY 2022 Plans:* Will investigate models and approaches to enable autonomous systems to transform information to facilitate increased comprehension, decreased ambiguity, and maintain effective op-tempo decision making and responsive situational awareness; explore human-in-the-loop and human-on-the-loop machine learning strategies for interoperability and rapid autonomous mediation of inter and cross-domain data from heterogeneous sources; investigate computational models, novel training corpora, and algorithms that enable automated computer systems to understand and interpret information content from multimedia data and construct knowledge networks for concept recognition, explanation, and inferences for downstream analytics to support collaborative decision making. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, a portion of the funding has been realigned to support Machine Learning for Intelligent Agent and Human Decision Making within this Project.			
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 2021 Plans:* Investigate secure communication protocols that can be practically implemented in tactical (resource-constrained) environments by featuring the adaptability of theoretical guarantees on the level of security as a function of the finite available (e.g., computational, energy, and/or communication bandwidth) resources and that optimize for broadcast and network security (not just for point-to-point links); model and characterize the effect of communication channels and networking devices on the transfer and use of quantum entanglement and create protocols to mitigate deleterious effects; research methods on intrusion detections, malware defense, data modeling, game theory, autonomy and resilience for military systems on both tactical and enterprise networks and provide resilience in robust and austere environments; research new algorithms and methodologies for deceiving attackers; explore tradeoffs between machine learning-enabled deception and information capacity for contested tactical networks in efficiently conveying battlefield environment awareness. *FY 2022 Plans:* Will advance the use of machine learning in cyber security, with minimal need for subject matter experts, to counter swift attacks in a constrained environment; pursue innovative intelligent countermeasures against adversarial machine learning attacks that reduces burden on the defender and increases the cost to the adversary; investigate techniques to predict adversary tactics, techniques, and procedures (TTPs) for proactive network defense and to support honeynet generation which is situation-aware	4.610	4.742	5.086

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
and realistic enough to attract and mislead an intelligent adversary; using machine learning and computational game theory, develop modeling approaches with the following features: (a) prediction of frequency and occurrence of network attacks by type for effectively implementing adaptive honeynets and (b) analysis of impact of software defined networks (SDN) for mobile network architectures; study and analyze the performance alternative methods of entanglement creation and distribution to mitigate entanglement degradation; explore and characterize the performance of fundamental quantum networking elements such as switches and interfaces. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Naturalistic Behavior for Shared Understanding and Explanation with Intelligent Systems ***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of-the-art techniques in machine translation and natural language processing. ***FY 2021 Plans:*** Define computational approaches for incorporating natural language into human-robot interaction to create dialog management system software capable of semantic comprehension of ambiguities, lack of specificity, and op-tempo communication for future application to Soldiers in the field conducting route reconnaissance, intelligence preparation of the battlefield, and multi-domain operations; explore neural machine translation approaches for document exploitation to identify fundamental issues in information transformation that maintains context, intent, and linguistic accuracy given data-driven machine learning techniques. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, funding and research realigned from this effort to Machine Learning for Intelligent Agent and Human Decision Making within this Project.	0.890	1.226	-
Title: Advanced Computing Architectures and Algorithms ***Description:*** Investigate advanced computing and high performance computing (HPC) networking architectures, memory/ storage architectures, processing algorithms, and visualization techniques to support advanced battle command applications for Command, Control, Communications, Computers, and Intelligence (C4I) systems. ***FY 2021 Plans:*** Investigate and create novel approaches for enhanced computing by optimizing for size, weight, and power of computational resources; investigate new approaches using reconfigurable computing for machine learning using convolutional neural networks that will fit in memory-constrained deployed platforms; research new methods to categorize computing capacity of deployed devices to facilitate processor selection and assignment to required computing task; study training of decentralized reinforcement	3.502	3.891	3.910

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
learning agents to optimize a diverse set of properties (e.g., security, efficiency, etc.) while maintaining communication integrity in mobile networks. *FY 2022 Plans:* Will study protocols and algorithms to enable sets of decentralized and distributed heterogeneous computing systems; research energy efficient algorithms for coordination and consensus; explore methodology and algorithms to enable information processing scaled across heterogeneous computing hardware; investigate both high performance processing capabilities, scalable to heterogeneous hardware platforms, and novel approaches to enable ingesting, extracting, translating, processing, and analyzing heterogeneous data. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
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 techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. *FY 2021 Plans:* Research methods for the identification and detection of structure, dynamics, and/or traffic in social, information, and communication networks that correlate with network performance, and will create protocols for adapting network formation and/or operation based on such identification/detection; create and characterize methods for obscuring pertinent features of network operation from adversarial interpretation, and identify and characterize potential vulnerabilities and exploits (and corresponding mitigation strategies) of machine-learning-based network protocols; research Intrusion Detection Systems (IDS) using Machine Learning (ML) linear classification; investigate theories to defend against ML based IDS that have been compromised by adversarial ML techniques; create methods for construction of surrogate models of battlefield environments to expedite uncertainty quantification; create grounding theory and machine learning algorithms that measure and automate information interoperability, quantify information/model uncertainty, and aggregate information; investigate algorithmic approaches to uncertainty quantification in machine learning models and formal theories for network/system state estimation under adversarial machine learning conditions; research theories algorithms to identify, characterize, and exploit the value of information from sensor and other information assets for information dissemination and mediation. *FY 2022 Plans:*	5.753	6.000	6.331

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will investigate and assess algorithms enabling intelligent intrusion detection and threat categorization; explore techniques for automated network forensics and analytics, and integrate with Machine Learning techniques to lay foundations for incorporating autonomous agents and decision making; conduct research on low-complexity, distributed, and/or robust cyber techniques based on machine learning for proactive evading, detecting, and responding to adversarial activity; develop rigorous mathematical frameworks and analyses of adaptive and responsive friendly and adversarial cyber protocols; continue to examine theories and algorithmic methods that measure information interoperability, quantify information/model uncertainty, and optimize information synthesis; investigate algorithmic approaches that quantifies the predictive uncertainty of automated decisions under adversarial computational-equivalency and conditions; validate algorithms which infer value of information characteristics from sensor and other information assets in information dissemination and mediation contexts; explore stochastic-process-based models of physical systems to incorporate random-field approaches; investigate methods for incorporating uncertainty into decision-making processes leveraging complex physical behaviors. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, funding increased to support additional research in the area of low-complexity, distributed and robust cyber techniques.			
Title: Machine Learning for Intelligent Agent and Human Decision Making ***Description:*** This effort researches methodologies and algorithms for machine learning with incomplete, unstructured, potentially deceptive, and heterogeneous information, enabling joint decision making for Intelligent Agent-Human teams which adapt to unknown environments and missions. Research includes methods for learning and decision making that occur under short time frames and constrained resources (e.g., computation, power, spectrum, and networks). ***FY 2021 Plans:*** Investigate and evaluate algorithms enabling intelligent sharing of system control between humans and autonomous artificial agents and machine learning techniques that can learn from real-time interaction with humans via demonstration, intervention, and feedback modalities; explore methods to address challenges of online learning over streaming data and reasoning over incomplete semantic data to predict, rank, and recommend courses-of-action for autonomous and human-collaborative decision makers; investigate theories and machine learning algorithms that automate reasoning, learn and predict information requirements and preference, and minimize information search for the purposes of accelerating autonomous and non-autonomous decision making; explore neural network and machine learning methods to create custom acoustic models for future application to adaptable automated speech recognition components that can rapidly adapt to sub-population language, military domain terminology, and task-specific communication between coalition partners and during joint human-agent collaboration; research methods for Cyber situational awareness & threat classification methods; research active defense algorithms and risk assessment for vulnerability exploitation. ***FY 2022 Plans:***	3.600	3.981	5.758

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will develop models and algorithms for predicting impacts of diversification strategies on system assets, including network, applications and cybersecurity, to provide decision support to defenders, operators, and commanders on the battlefield; conduct empirical analysis of models and algorithms when pinned against malware and other intrusions; enable repeatable experimentation focused on systematic automation that will realize continuous model refinement; explore techniques that allow for reasoning over incomplete semantic data to draw inferences about semantic observations and introduce greater contextual richness into a shared world model; investigate multi-agent coordination techniques that facilitate the development of tactical behaviors across small teams of autonomous agents; extend distributed world model by investigating intelligent sharing of salient data streams based on operational context; identify, define, and explore computational models, novel training corpora, and machine learning approaches that enable intelligent systems to recognize shared and contrastive content in multiple forms of text, video, acoustic, and other modes of information sharing and multimodal communications; define algorithms, models, and machine learning techniques to enable intelligent systems to automatically identify context and intent to construct, generate, or transform relevant representations of information for enhanced situational awareness and decision-making. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY22, funding has been realigned from Naturalistic Behavior for Shared Understanding and Explanation with Intelligent Systems, and Data to Knowledge to Support Decision Making (Information Mediation) to this effort to support additional research in tactical behaviors of intelligent systems.			
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 2021 Plans:* Create artificial intelligence/machine learning algorithms for real-time scene understanding and situational awareness from multimodal imaging sensors on distributed heterogeneous aerial and ground, manned and unmanned, platforms for potential application to mobility and maneuver engagement scenarios; identify point-of-need image data exploitation methods capable of real-time inference on size, weight, and power-limited computing architectures at the edge; research synthetic data generation methods to augment limited availability of real-world data to enhance algorithm training and effectiveness; investigate computational vision approaches for enhanced scene understanding in visually degraded environments. *FY 2022 Plans:* Will investigate artificial intelligence/machine learning methods for assessing value of targets in unstructured scenes; develop deep reinforcement learning approaches for scene understanding to feed rapid strategic decision making for Command and Control in complex Multi Domain Operation (MDO) environments; investigate domain transfer approaches for effective training of machine learning algorithms for scene understanding with synthetic data; investigate algorithm optimization approaches for scene	1.874	2.231	2.235

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B. Accomplishments/Planned Programs ($ in Millions)			FY 2020	FY 2021	FY 2022
understanding performance retention in resource constrained computation environments such as low size, weight, and power (SWaP) processors onboard unmanned air and ground vehicles.					
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.					
Title: Fundamentals for Energy Efficient Electronic & Photonic Components			1.635	1.947	1.948
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 2021 Plans:
Better understand charge transfer mechanisms from hydrogen terminated diamond surfaces to suitable electron acceptor layers; conduct research on the growth of topological materials and fabricate heterostructures of topological crystalline materials along with ferromagnetic insulator thin films; investigate and optimize the interplay between a topological material and the ferromagnetic insulator to understand the device characteristics of the topological heterostructures and determine if theoretical predictions can be realized under real-life conditions; investigate radiation tolerance of wide-band-gap semiconductors for betavoltaic energy conversion and quantify the measured performance degradation using 1-200keV electron beams.

FY 2022 Plans:
Will investigate mechanism of energy deposition and transfer through ultra-wide bandgap materials through the use of time-dependent pulsed beam stimulation and repetitive photoluminescence (PL) and cathode luminescent (CL) measurement of charge carrier kinetics; investigate ferroelectric and anti-ferroelectric materials in nanoscale 3D scaffolding for high energy density capacitors for rapid recharge applications; explore materials and fabrication techniques for devices needed for through metal wireless power transfer and wearable, stretchable wireless power; research ultra-wide bandgap material structures based on Diamond/Boron Nitride technology for high efficiency radio frequency (RF) components; investigate mechanisms for detection of circular polarized light in several topological materials through growth and characterization for efficient communications.

FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort. | | | | | |
| Title: Quantum Information Sciences | | | 5.256 | 5.662 | 5.707 |
| 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 | | | | | |

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
matter interfaces, including optical cavities, nanophotonics, and high density atomic systems. This effort also explores quantum algorithms for entanglement distribution. *FY 2021 Plans:* Conduct research to achieve a broad understanding of strong interactions between light and quantum systems for ultrasecure communications and enhanced sensors; study quantum information storage in atomic ensembles and how to multiplex read/write quantum operations; investigate limits of Rydberg atomic systems for radio frequency and microwave sensing and communications for novel communications schemes; explore interactions between nanophotonic systems with cold atoms; research silicon-carbide growth capabilities for high-quality solid-state defects as qubits and sensors; and identify entanglement-enhanced measurement and sensing in cold ion systems. *FY 2022 Plans:* Will investigate optimal approaches for storing and manipulating quantum information in physical platforms of atoms, ions, and material systems for entanglement-enhanced sensing and communications; investigate multiplexed quantum memory in cold-atom systems; investigate schemes for efficient readout of Rydberg sensor information; extend atom-atom interaction distance through optical nanofibers for distributing entanglement; explore charge-state dynamics of solid-state defect materials for optimization of sensor capabilities and magnetometers; explore frequency conversion in ion trap systems for long-range entanglement through optical fiber. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	37.502	40.376	40.540

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

D. Acquisition Strategy
 N/A

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 1					**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*					**Project (Number/Name)** AB1 *I Basic Res in infect Dis, Oper Med and Combat Care*		

COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	31.269	31.957	37.103	-	37.103	-	-	-	-	-	-

Note
 In FY 2022 this Project funding was realigned from:

 PE 0602787A (Medical Technology)
 *Project MM4 (Cbt Casualty Care Applied Rsch Technology)
 *Project MK4 (Warfigher Health Applied Rsch Technology)

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.

 FY20 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Damage Control Resuscitation	1.573	1.640	-
Description: This effort conducts studies to define and identify cellular processes and metabolic (biochemical activity) mechanisms associated with blood clotting to understand the relationships between the human immune processes and bleeding in trauma. *FY 2021 Plans:* Identify candidate key additives for improving platelet and whole blood storage that delay or inhibit the biochemical processes leading to platelet death during storage; expand on previous stem cell studies to include feasibility for use to treat traumatic hemorrhage; conclude cell culture screening of drugs that protect cells from the effects of blood loss and oxygen deprivation;			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
perform basic research studies to identify candidate components for engineered plasma to reverse impaired blood clotting that occurs subsequent to severe trauma. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project AB1 (Hemorrhage, Shock, Coagulopathy of Trauma).			
Title: Combat Trauma Therapies *Description:* This effort conducts studies of trauma to tissues and organs, including dental (facial and oral) injuries, extremity wounds and fractures, and burns, and ways to mitigate and/or repair this damage. *FY 2021 Plans:* Study new conceptual approaches to accelerate healing of severe burn wounds; perform studies to better understand the human immune response to skin grafts; perform basic research to better understand stem cell use as means to reduce inflammation and organ injury following severe burns. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project AB1 (Burn Injury, Expeditionary Medicine).	1.410	0.664	-
Title: Pre-hospital tactical Combat Casualty Care *Description:* This effort conducts basic science studies to determine physiological responses to trauma and aid in development of life-saving interventions. *FY 2021 Plans:* Perform conceptual studies to guide development of animal models to assess novel agents that protect the kidney during hemorrhage with and without resuscitation, and to assess effects of blast injury on the ability to survive hemorrhage as well as the effect of hemorrhage on neural damage induced by blast injury; perform conceptual studies to support minimally invasive control of non-compressible hemorrhage; characterize cellular effects of crush injury. *FY 2022 Plans:* Will perform feasibility study to support development of an extremity tourniquet prototype able to provide guidance to operators of all skill levels on its proper application, optimal placement, and maximum time to be left on and management, and decrease complications associated with prolonged use. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project AB1 (Endovascular Hemorrhage Control).	1.258	1.411	0.909
Title: Traumatic Brain Injury	1.300	1.356	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	**Project (Number/Name)** AB1 *I Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort conducts basic research in poly-trauma (multiple injuries)/Traumatic Brain Injury (TBI) model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI *FY 2021 Plans:* Perform conceptual studies to guide animal model development for assessment of novel treatments for severe traumatic brain injury that may be administered by combat medical personnel at the point of injury. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project AB1 (TBI Neurotrauma/Brain Dysfunction).			
Title: Prolonged Field Care *Description:* This effort performs basic research to study the physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties. *FY 2021 Plans:* Characterize changes that occur within the cells that line the arteries when oxygen-carrying blood substitute drugs are introduced into the body; explore novel approaches to treat lung injury; examine feasibility of possible new treatments for sepsis (life-threatening complication of an infection) following trauma; characterize ability of stem cells to mitigate organ failure following traumatic injury in rodent models; perform conceptual studies to identify new approaches to accelerate healing of orthopedic injuries; utilize computer modeling simulations to characterize biological changes to the pain system following traumatic injury; identify novel pain therapeutic targets based on computer models, and investigate these targets in both currently utilized and newly developed animal models of traumatic injury; investigate newly identified targets as potential biomarkers for pain and analgesic efficacy. *FY 2022 Plans:* Will perform In vitro and in vivo efficacy studies of medical treatments for burn in environments contaminated with nerve agent. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project AB1 (Biology of Operational Pain).	0.814	2.729	2.418
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) injury. Also includes the characterization of ocular injury pathways resulting from blast exposure in small animal models.	2.166	2.519	2.545

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Characterize bone injury predictive biomarkers that identify increased risk for musculoskeletal injury during BCT; down-select the most relevant genetic and physiological markers associated with injury risk; research and refine whole body blast animal and human based injury models that can inform blast injury criteria for next generation bomb suit and blast exposure health hazard assessment criteria.			
FY 2022 Plans: Will further the characterization of cellular and physiological pathways responsible for bone adaptation after strenuous exercise and characterize normal and abnormal pathways responsible when using non-steroidal anti-inflammatory drugs. Will develop scaling and correlations of bio mechanical and injury perturbations across multiple species to develop injury criteria for blast over pressure exposure resulting from improvised explosive devices.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned life cycle of this effort.			
Title: Physiological Health	5.152	4.926	3.965
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 2021 Plans:*** Define the role of nutrition support for metabolic recovery from military activity; understand CNS correlates of chronic sleep restriction and recovery; understand field-based impact of sleep on operational performance; investigate non-invasive brain and peripheral nervous system (outside the brain and spinal cord) stimulation for enhancing operational performance; study relationship between underlying brain characteristics (e.g., density of neural synapses, glymphatic flow, and cortical thickness) to Soldier military performance; discover indices of brain dysfunction and repair related to Soldier job-related awakedness and recovery following sleep; investigate biomedical mechanisms of inter-individual differences in vulnerability to cognitive performance and attention related to time-on-task. ***FY 2022 Plans:*** Will continue to define the role of nutrition support for metabolic recovery from military activity. Will continue to understand field-based impact of sleep on operational performance. Will continue to investigate basic mechanisms of non-invasive brain and peripheral nervous system (outside the brain and spinal cord) stimulation for enhancing operational performance Will investigate physiologic, metabolic and genetic biomarkers of resilience to military stressors. ***FY 2021 to FY 2022 Increase/Decrease Statement:***			

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

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funds realigned to other efforts within Project AB1 (Soldier Performance Augmentation).			
Title: Environmental Health	1.088	1.089	1.119
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 2021 Plans: Research animal models for basic mechanisms of injuries from exposure to heat that degrade health and performance and those factors that accelerate improved recovery; establish screening methods to determine the underlying molecular mechanisms for degraded physical and behavioral performance of susceptible individuals in extreme respiratory-challenging dense urban and subterranean environments.			
FY 2022 Plans: Will research animal models for basic mechanisms of injuries from heat exposure and those factors that accelerate improved recovery; will establish screening methods to determine the underlying molecular mechanisms for degraded physical and behavioral performance of susceptible individuals in challenging dense urban and subterranean environments.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned life cycle of this effort.			
Title: Psychological Health and Resilience	1.898	1.717	0.808
Description: This effort conducts research into the basic mechanisms of the ability to overcome traumatic events including determination of underlying neurobiological mechanisms (nervous system control of cellular and molecular processes) related to Post-Traumatic Stress Disorder (PTSD) and depression.			
FY 2021 Plans: Design biomedical research strategies to overcome technological barriers for research on physiological and psychological factors limiting Warfighter effectiveness and will research methods for characterizing health hazards generated by military systems and resulting from military operations; research militarily relevant aspects of the neurobehavioral aspects of stress.			
FY 2022 Plans: Will identify new candidate therapeutic targets to promote resilience to stressors using a novel evidence-synthetic receptor-based strategy, to speed the process of drug discovery. Will identify new compounds and pharmacologics for rapid recovery from acute stress reactions using preclinical experiments and will identify molecular markers of recovery from acute stress symptoms after intervention (pharmacological and non-pharmacological). Will research candidate pharmacological solutions for their ability			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
to provide rapid recovery from acute stress symptoms by enhancing Soldier resilience to recover from high-stress events with minimal side effects using preclinical testing. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project AB1 (Soldier Performance Augmentation).			
Title: Basic Research on Drugs and Vaccines Against Parasitic Diseases (previously titled: Basic Research to Prevent Parasitic Diseases) ***Description:*** Discover and identify new chemical compounds for further characterization and optimization as potential drug leads against malaria. Discover and identify new antigens, virulence factors and adjuvants that will lead to the development of effective malaria vaccines, develop approaches for multivalent vaccines that achieve protective efficacy across genetically diverse malaria parasites and identify correlates of protection in animal models and in humans. ***FY 2021 Plans:*** Identify and discover new chemical entities for treatment and prevention and treatment of malaria; research assays and platforms for assessment and prioritization of new compounds; discover, identify, and characterize: new substances that induce an immune response in the body; molecules produced by microorganisms that help them attach, evade host responses and allow spread; and substances that enhance the body's immune response; generate, characterize, and evaluate proteins produced in response to and against malaria; characterize malaria parasites to inform future development of prophylactics against malaria. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project AB1 (Medical Readiness ? Infectious Diseases).	6.050	5.835	-
Title: Bacterial Disease Threats ***Description:*** Discover and identify new antigens, virulence factors and adjuvants that will lead to the development of effective diarrheal vaccines against Enterotoxigenic Escherichia Coli (ETEC), Shigella and Campylobacter. Identify approaches to develop multivalent vaccines that achieve protective efficacy across several bacterial serotypes and species, as well as identify correlates of protection from bacterial diarrheal disease in animal models and in humans. ***FY 2021 Plans:*** Discover, identify, and characterize the following for treatment and prevention of bacterial diarrheal diseases: new substances that induce an immune response in the body; molecules produced by microorganisms that help them attach, evade host responses and allow spread; and substances that enhance the body's immune response; generate, characterize, and evaluate proteins	1.527	1.721	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
produced in response to and against bacterial diarrheal diseases; characterize diarrhea-associated bacteria to inform future development of prophylactics against bacterial diarrheal diseases. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project AB1 (Prolonged Field Care ? Infectious Diseases).			
Title: Viral Threats Research ***Description:*** Discover and identify new antigens, virulence factors and adjuvants that will lead to the development of effective vaccines against hemorrhagic fever viruses (e.g. dengue and Hantaviruses). Identify approaches to develop multivalent vaccines that achieve protective efficacy across all dengue serotypes, and discover and identify correlates of protection from viral diseases in animal models and in humans. ***FY 2021 Plans:*** Discover, identify, and characterize the following for treatment and prevention of viral diseases: new substances that induce an immune response in the body; molecules produced by microorganisms that help them attach, evade host responses and allow spread; and substances that enhance the body's immune response; generate, characterize, and evaluate proteins produced in response to and against viral diseases; characterize viruses to inform development of prophylactics against viral diseases. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project AB1 (Prolonged Field Care ? Infectious Diseases).	1.632	1.700	-
Title: Insect Vector Basic Research ***Description:*** Identify and characterize specific populations of vectors that may carry and transmit infectious disease, inform vector control countermeasures, and develop detection assays for vectors and vector-borne pathogens. ***FY 2021 Plans:*** Identify unique biological markers (e.g., proteins, genes) and technologies/platforms that can be used to produce improved identification and detection tools; identify and characterize vector populations and the pathogens they transmit to inform vector control countermeasures and develop risk assessment tools. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project AB1 (Prolonged Field Care ? Infectious Diseases).	1.529	1.594	-
Title: Clinical and Rehabilitative Medicine	0.943	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort conducts basic studies of mechanisms of tissue growth and traumatic injury to gain an understanding that will assist or facilitate the healing or transplantation process. The focus is placed on severe blast trauma to the limbs, head, face (including eye), genitalia (organs of reproduction), and abdomen.			
Title: Network Sciences Initiative **Description:** This effort uses mathematical models and algorithms to extract medical information from large-scale datasets (generated from the study of cellular genetic makeup, protein structures and function, wearables, and whole organism responses) to improve understanding, prevention, diagnostics, and treatments of those injuries and diseases that pose a threat to Warfighter readiness: e.g., musculoskeletal injury, PTSD, uncontrolled bleeding, infectious diseases, hard-to-diagnose pulmonary disease, and exposure to environmental stressors and hazards. **FY 2021 Plans:** Research three-dimensional computational capabilities to accurately simulate blood-clotting processes to identify promising strategies to improve clot formation following trauma; conduct research on individualized algorithms that predict the risk of musculoskeletal stress-fracture injury in Warfighters during basic combat training; conduct research on a systematic, computational approach that determines what antibody sequences are associated with vaccine protection and how these antibodies are generated under different conditions; study artificial intelligence (AI) algorithms to predict biomarkers indicative of toxic chemical exposure and organ damage; identify mechanisms of malaria parasite drug resistance, and validate their involvement in mitigating resistance against a new antimalarial drug; research AI models to identify brain activity during sleep that may be indicative of PTSD and enhance resilience of healthy Soldiers to sleep deprivation **FY 2021 to FY 2022 Increase/Decrease Statement:** Funds realigned to other efforts within Project AB1 (Injury Prevention & Readiness and Medical Computational Modeling).	2.929	3.056	-
Title: Biology of Operational Pain **Description:** This effort performs basic research to support development of novel, non-opioid drugs to treat pain in the austere battlefield environment with minimal side effects. **FY 2022 Plans:** Understand the mechanisms that contribute to the transition from acute to chronic pain and identifying novel drug therapy targets to alleviate pain. **FY 2021 to FY 2022 Increase/Decrease Statement:**	-	-	1.131

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funds realigned from other efforts within Project AB1 (Prolonged Field Care).			
Title: Extremity Trauma ***Description:*** This effort performs basic research to support development of treatments to preserve tissues and function of severely mangled limbs. ***FY 2022 Plans:*** Will perform basic research of cellular metabolism in injured limb tissues to support identification of potential means to protect injured, viable tissues from further damage during the period from time of injury until definitive care is made available. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project AB1 (Combat Trauma Therapies).	-	-	0.580
Title: Expeditionary Medicine ***Description:*** This effort performs basic research to support development of treatments to protect non-injured and injured, but viable, tissues from oxygen deprivation, metabolic disruption, and further injury following severe trauma. ***FY 2022 Plans:*** Will perform basic research to support development of new technologies to improve provision of critical care in forward, austere and logistically restricted areas of the battlefield). ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project AB1 (Combat Trauma Therapies).	-	-	0.499
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. ***FY 2022 Plans:*** Will perform conceptual studies to support design, development, and optimization of a diagnostic tool that can predict overall hemostatic efficiency of an injured casualty. Will perform hemostatic functional assays of a novel dried whole blood product. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project AB1 (Damage Control Resuscitation).	-	-	1.684
Title: Endovascular Hemorrhage Control	-	-	0.479

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort performs basic research to support development of devices that when introduced into arteries or veins may be used to stop internal bleeding. **FY 2022 Plans:** Will conceptualize and evaluate synthetic and animal models in which to test feasibility of novel vascular access approaches. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funds realigned from other efforts within Project AB1 (Pre-Hospital Tactical Combat Casualty Care).			
Title: Burn Injury **Description:** This effort performs basic research to support development of treatment and clinical management tools for severe burns. **FY 2022 Plans:** Will perform In vitro and in vivo efficacy studies of medical treatments for burn in environments contaminated with nerve agent in order to examine the effects of the chemical agent and decontamination agents on the burn wound and surrounding viable tissues, and to examine the effects of acute burn wound treatment on decontamination. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funds realigned from other efforts within Project AB1 (Combat Trauma Therapies).	-	-	2.861
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. **FY 2022 Plans:** Will evaluate efficacy of Tactical Combat Casualty Care blood product resuscitation strategies in a swine model of penetrating TBI and polytrauma. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funds realigned from other efforts within Project AB1 (Traumatic Brain Injury).	-	-	1.425
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.	-	-	1.921

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2022 Plans: Will study relationship between underlying brain characteristics (e.g., density of neural synapses, glymphatic flow, and cortical thickness) to Soldier military performance. Will discover indices of brain dysfunction and repair related to Soldier job-related awakedness and recovery following sleep. Will investigate biomedical mechanisms of inter-individual differences in vulnerability to cognitive performance and attention related to time-on-task. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project AB1 (Psychological Health and Resilience and Physiological Health).			
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 animal models and in humans. ***FY 2022 Plans:*** Will discover, identify, and characterize the following for prevention and treatment of combat wound infections and sepsis in a prolonged field care environment: new substances that induce an immune response in the body; molecules produced by microorganisms that help them attach, evade host responses and allow spread; and substances that enhance the body's immune response; generate, characterize, and evaluate proteins produced in response to and against combat wound infections; characterize combat wound infections to inform development of prophylactics and treatments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project AB1 (Bacterial Diseases, Vector Control, Viral Disease).	-	-	4.561
Title: Medical Readiness - Infectious Diseases ***Description:*** Discover and identify new prophylactics and treatment (antibodies, drugs and biologics) approaches that will lead to the development of effective prevention and treatment strategies for endemic bacterial and viral infectious diseases. Identify approaches to develop antibodies, drugs and biologics that achieve protective efficacy and discover and identify correlates of protection from endemic diseases in animal models and in humans. ***FY 2022 Plans:*** Will discover, identify, and characterize the following for the prevention and treatment of endemic bacterial and viral infectious diseases: new substances that induce an immune response in the body; molecules produced by microorganisms that help them attach, evade host responses and allow spread; and substances that enhance the body's immune response; generate,	-	-	7.067

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
characterize, and evaluate proteins produced in response to and against endemic bacterial and viral infectious diseases; characterize endemic bacterial and viral infectious diseases to inform development of prophylactics and treatments. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned from other efforts within Project AB1 (Parasitic Diseases).			
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, PTSD, heat stress, and infectious diseases. *FY 2022 Plans:* Will design algorithms to identify the impact of load carriage and stride-length on the risk of stress-related bone fracture in Warfighters during basic combat training. Will develop and refine computational strategies that allow us to use Artificial Neural Network and Machine Learning methods to solve military biomedical problems even when the sample sizes are small. Will quantitatively compare existing cooling strategies currently recommended by the U.S. Army and identify the most efficacious ones in reducing core body and organ temperatures following exposure to specific heat-stress conditions. Will identify genes and mechanisms of drug resistance in the malaria parasite, as a model organism, and validate their involvement in mitigating resistance against new antimalarial drugs. Will use a mathematical skeletal-muscle model based on biophysical principles to identify and assess interventions that delay muscle fatigue, reduce injury, and prolong optimal performance. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned from other efforts within Project AB1 (Network Sciences Initiatives).	-	-	3.131
Accomplishments/Planned Programs Subtotals	31.269	31.957	37.103

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 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
AB2: *Protection, Maneuver,* *Geospatial, Natural Sciences*	-	16.510	17.089	17.967	-	17.967	-	-	-	-	-	-

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Mapping, remote sensing, signature physics and terrain state **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 2021 Plans:** Investigates a novel approach for rapidly observing the spatial variation of key parameters affecting the optical transmissivity and reflectivity of falling and blowing snow. Fundamental research also validates computational models to infer mechanisms of collective motion that initiate social contagion. **FY 2022 Plans:** Will investigate signal processing algorithms for automatic target recognition. Basic research will also characterize urban noise fields at ground level, for both acoustic and electromagnetic waves, relevant to military operations. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.	3.738	3.868	3.964
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.	4.261	4.700	4.815

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Explore the effects of nano-crystalline grains on high-rate deformation mechanisms and plastic flow of alloys for structural materials; investigate the mechanical response and damage evolution of high-strength cementitious materials under confined dynamic loading to enhance new structural material development.			
FY 2022 Plans: Will investigate physical drivers of currents in the littoral swash zone to inform the geo-environmental conditions of autonomous vehicles; will study thermal conductivity in cold environments to understand the electrical performance limitations of crystalline materials; will determine the mechanisms that enable tunability of specific materials for novel unconventional countermeasures and survivability applications.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Fundamental Infrastructure Sciences	1.650	1.817	1.864
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 2021 Plans: Investigate the interfacial transition zone (ITZ) chemical and mechanical properties of concrete materials with the inclusion of biomimetic adhesive polymer inspired by marine organisms; explore polymer functionality that gives rise to stimulus-responsive reactions.			
FY 2022 Plans: Will explore the potential of resonance energy transfer as a light harvesting mechanism to inform future development of advanced materials; will investigate the structure-function relationship in compartmentalized nanoreactors for future application in on-demand chemical reactions and real time monitoring.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Biological, Chemical and Physical Sciences	6.861	6.704	7.324
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.			

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
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 2020	FY 2021	FY 2022
FY 2021 Plans: Investigate the fundamental processes and phenomena involved in infrared (IR) reflectance of biological materials; explore the properties of bio-inspired nanomaterials for future novel Army functionalities; investigate foundational knowledge for multilayer reflector mechanisms that enable color and reflectance switching.			
FY 2022 Plans: Will investigate mechanisms in cold-dwelling bacteria (psychrophiles) and frozen media to support future development of cold-specific Army technologies; will explore how synthetic biology can be combined with new materials to allow manipulation of materials on demand.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding increase in FY22 will support increased investigation of novel materials and processes.			
Accomplishments/Planned Programs Subtotals	16.510	17.089	17.967

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

D. Acquisition Strategy
 N/A

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 1					**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*				**Project (Number/Name)** CH9 *I Advancing Concepts and Technology Forecasting*		

COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
CH9: *Advancing Concepts and Technology Forecasting*	-	-	-	3.573	-	3.573	-	-	-	-	-	-

Note

This is a new start in FY 2022.

This is a new start for FY 2022.

A. Mission Description and Budget Item Justification

Advancing Concepts 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. Perform long-range technology forecasts of Army-relevant basic research topics to enable informed decision making for the deep 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 in this Project is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advancing Concepts and Technology Forecasting	-	-	3.573
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. Provides long-range, scientifically grounded technology forecasts of basic research topics to enable informed decision-making. *FY 2022 Plans:*			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	**Project (Number/Name)** CH9 *I Advancing Concepts and Technology Forecasting*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will perform initial integration of basic scientific research outcomes with a priority focus on far-term Maneuver, Fires, and Mission Command Army Warfighting Concepts; perform long-range technology forecasts of Army Priority Basic Research Areas, including Synthetic Biology, Artificial Intelligence, and Disruptive Energetics. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, funding realigned from multiple sources within the Army Futures Command basic research portfolio to support far-term basic scientific research integration with Army Warfighting Concepts, as well as long-term technology basic research-driven forecasts that will inform the Future Operational Environment.			
Accomplishments/Planned Programs Subtotals	-	-	3.573

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

D. Acquisition Strategy
 N/A

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 1				**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*						**Project (Number/Name)** T14 *I BASIC RESEARCH INITIATIVES - AMC (CA)*		
COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	66.350	48.000	-	-	-	-	-	-	-	-	-

Note
Congressional Interest Item funding provided for Defense Research Sciences.

A. Mission Description and Budget Item Justification
Congressional Interest Item funding provided for Defense Research Sciences.

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Congressional Add: Propulsion Technology	10.000	-
FY 2020 Accomplishments: Program Increase to support basic research on propulsion Technologies Work executed by Army Futures Command.		
Congressional Add: Ballistic and Materials Technology	10.000	-
FY 2020 Accomplishments: Program Increase to support basic research on ballistic and materials technology Work executed by Army Futures Command.		
Congressional Add: Flexible LED Lighting	5.350	-
FY 2020 Accomplishments: Program Increase to support basic research on Flexible LED Lighting Work executed under the direction of the Army Futures Command.		
Congressional Add: Military Waste Stream Conversion	5.000	-
FY 2020 Accomplishments: Program Increase to support basic research on military waste stream conversion Work executed under the direction of the Army Futures Command.		
Congressional Add: Multi-layer and dynamically responsive macromolecular composites	5.000	-

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
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 2020	FY 2021
FY 2020 Accomplishments: Program Increase to support multi-layer and dynamically responsive macromolecular composites Work executed under the direction of the Army Futures Command.		
Congressional Add: Advanced hemostat products	2.000	-
FY 2020 Accomplishments: Program Increase to support basic research on advanced hemostat products Work executed under the direction of the Army Futures Command.		
Congressional Add: Multi-fuel ignition, chemistry and control strategies for unmanned aircraft systems hybrid propulsion	9.000	15.000
FY 2020 Accomplishments: Program increase to support multi-fuel ignition, chemistry and control strategies for unmanned aircraft systems hybrid propulsion Work executed under the direction of the Army Futures Command.		
FY 2021 Plans: Program Increase supported basic research on Multi-Fuel Ignition, Chemistry, and Control Strategies for Unmanned Aircraft Systems Hybrid Propulsion. Work executed by Army Futures Command.		
Congressional Add: Transmission electron microscope	20.000	-
FY 2020 Accomplishments: Program increase for transmission electron microscope equipment in support of basic research. Work executed under the direction of the Army Futures Command.		
Congressional Add: Program increase	-	10.000
FY 2021 Plans: Program Increase supported basic research on Defense Research Services. Work executed by Army Futures Command.		
Congressional Add: Program increase - explosives and opiods dual-use UV detection	-	3.000
FY 2021 Plans: Program Increase supported basic research on Explosives and Opiods Dual-Use UV Detection.		

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601102A *I Defense Research Sciences*	**Project (Number/Name)** T14 *I BASIC RESEARCH INITIATIVES - AMC (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed by Army Futures Command.		
Congressional Add: Program increase: Artificial intelligence complex multi?material composites processing	-	10.000
FY 2021 Plans: Program Increase supported basic research on Artificial Intelligence Complex Multi-Material Composites Processing. Work executed by Army Futures Command.		
Congressional Add: Program Increase: Cell-Free Expression for Biomanufacturing	-	10.000
FY 2021 Plans: Program Increase supported basic research on Cell-Free Expression for Biomanufacturing. Work executed by Army Futures Command.		
Congressional Adds Subtotals	66.350	48.000

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

D. Acquisition Strategy
 N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army											**Date:** May 2021	

Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*						R-1 Program Element (Number/Name) PE 0601103A *I University Research Initiatives*						

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
Total Program Element	-	85.148	84.697	66.981	-	66.981	-	-	-	-	-	-
AB3: *MURI/PECASE/DURIP*	-	63.148	64.697	66.981	-	66.981	-	-	-	-	-	-
D55: *University Research Initiative*	-	22.000	-	-	-	-	-	-	-	-	-	-
D58: *URI ACTIVITIES (CA)*	-	-	20.000	-	-	-	-	-	-	-	-	-

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 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Previous President's Budget	87.858	67.148	68.487	-	68.487
Current President's Budget	85.148	84.697	66.981	-	66.981
Total Adjustments	-2.710	17.549	-1.506	-	-1.506
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	20.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.710	-2.451			
• Adjustments to Budget Years	-	-	-1.506	-	-1.506

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Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103A *I University Research Initiatives*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Project: D58: *URI ACTIVITIES (CA)*		
Congressional Add: *Program increase*	-	20.000
Congressional Add Subtotals for Project: D58	-	20.000
Congressional Add Totals for all Projects	-	20.000

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	

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 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AB3: *MURI/PECASE/DURIP*	-	63.148	64.697	66.981	-	66.981	-	-	-	-	-	-

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 2020**	**FY 2021**	**FY 2022**
Title: Multidisciplinary University Research Initiative	52.839	52.117	54.345

Description: The 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 5 years in length at a cost of $1.25 million each per year.

FY 2021 Plans:
Provide continued support for MURI awards made in prior years and initiate six to eight new FY21 MURI efforts that will enable advances in select interdisciplinary basic science and/or engineering research areas determined to be of critical importance to national defense.

FY 2022 Plans:
Will provide support for MURI awards made in prior years and assess and initiate six to eight FY 2022 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 2021 to FY 2022 Increase/Decrease Statement:

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601103A *I University Research Initiatives*	**Project (Number/Name)** AB3 *I MURI/PECASE/DURIP*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding change reflects planned lifecycle of this effort.			
Title: Presidential Early Career Awards for Scientists and Engineers	1.503	4.686	4.735
Description: Supports PECASE investigators started in prior years as well as new award recipients. *FY 2021 Plans:* Evaluate and award competitive grants for new award recipients to conduct world class research and enhance educational capabilities critical to Army transformation. *FY 2022 Plans:* Will support prior year awardees and assess and recommend four new PECASE candidates. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Defense University Research Instrumentation Program	8.806	7.894	7.901
Description: Supports basic research through competitive grants for research instrumentation. *FY 2021 Plans:* Evaluate and award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research and enhance educational capabilities critical to Army transformation. *FY 2022 Plans:* Will assess and award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research and enhance educational capabilities critical to Army transformation and modernization. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	63.148	64.697	66.981

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

D. Acquisition Strategy
 N/A

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 / 1				**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*					**Project (Number/Name)** D55 / *University Research Initiative*			
COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
D55: *University Research Initiative*	-	22.000	-	-	-	-	-	-	-	-	-	-

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

FY20 realignments are due to financial restructuring in support of Army 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 2020**	**FY 2021**	**FY 2022**
Title: Basic Research Program Increase	22.000	-	-
Accomplishments/Planned Programs Subtotals	22.000	-	-

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

D. Acquisition Strategy
N/A

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 1				**R-1 Program Element (Number/Name)** PE 0601103A *I University Research Initiatives*						**Project (Number/Name)** D58 *I URI ACTIVITIES (CA)*		
COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
D58: *URI ACTIVITIES (CA)*	-	-	20.000	-	-	-	-	-	-	-	-	-

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 2020**	**FY 2021**
Congressional Add: Program increase	-	20.000
FY 2021 Plans: Congressional Increase. Basic research to support University Research Initiatives.		
Congressional Adds Subtotals	-	20.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army											Date: May 2021	

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 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
Total Program Element	-	123.654	118.716	94.003	-	94.003	-	-	-	-	-	-
AB4: *Army Research Centers*	-	25.075	22.425	23.204	-	23.204	-	-	-	-	-	-
AB7: *Army Collaborative Research and Tech Alliances*	-	41.100	45.147	52.832	-	52.832	-	-	-	-	-	-
AB8: *Army Educational Outreach Program*	-	10.035	10.275	10.641	-	10.641	-	-	-	-	-	-
AC6: *International Science and Technology*	-	6.444	6.869	6.951	-	6.951	-	-	-	-	-	-
CI9: *Strategic University Basic Research Alliance*	-	-	-	0.375	-	0.375	-	-	-	-	-	-
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	41.000	34.000	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This 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.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army		Date: May 2021
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*

FY20 adjustments align program financial structure to Army Modernization Priorities in support of the National Defense Strategy.

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 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Previous President's Budget	127.164	87.877	89.591	-	89.591
Current President's Budget	123.654	118.716	94.003	-	94.003
Total Adjustments	-3.510	30.839	4.412	-	4.412
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	34.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.011	-			
• SBIR/STTR Transfer	-3.499	-3.161			
• Adjustments to Budget Years	-	-	4.412	-	4.412

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Project: J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*		
Congressional Add: *Congressional Program Increase - University and Industry Research Centers - Army Artificial Intelligence Innovation Institute*	20.000	-
Congressional Add: *Congressional Program Increase - University and Industry Research Centers - Bioenabled Materials*	4.000	-
Congressional Add: *Congressional Program increase - Materials in Extreme Dynamic Environments*	5.000	10.000
Congressional Add: *Congressional Program Increase - university assisted hypervelocity testing*	2.000	-
Congressional Add: *Catalyst*	10.000	-
Congressional Add: *Program increase - biotechnology development*	-	4.000
Congressional Add: *Program increase - Army artificial intelligence innovation*	-	20.000
Congressional Add Subtotals for Project: J13	41.000	34.000
Congressional Add Totals for all Projects	41.000	34.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army	**Date:** May 2021
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*

Change Summary Explanation

Project AB7 (Army Collaborative Research and Tech Alliances) experienced increase of $18M in FY22 for the creation of three Army Centers (Army Advanced Biological Control Center, Army Advanced Energetics Center and Army Radio-Frequency (RF) Electronics Center).

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
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COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
AB4: *Army Research Centers*	-	25.075	22.425	23.204	-	23.204	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

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

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

The third is the Army Centers of Excellence (COEs). The COEs focus on expanding the frontiers of knowledge in research areas where the Army has enduring needs, and couples state-of-the-art research programs at academic institutions with broad-based graduate education programs to increase the supply of scientists and engineers in automotive and rotary wing technology.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Centers of Excellence for Battlefield Capability Enhancements (BCE)	1.431	1.669	1.685
Description: The focus of the PRI Program is to advance innovative basic research leading to potential technology development in areas of strategic importance to the Army by bringing competitively selected HBCUs and MIs research teams into existing Army Futures Command CRAs and CTAs. The CRAs and CTAs are large collaborative centers focused on developing and transitioning research in Army critical areas. **FY 2021 Plans:**			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
The PRI Program continues in its second multi-year phase, supporting Army's research partnerships with HBCU/MI via collaborations with UARCs. ***FY 2022 Plans:*** Will support three competitively-selected HBCU/MI-led collaborative research centers in the areas of information, engineering, and physical sciences that were competitively-selected and awarded in FY 2021. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Institute for Collaborative Biotechnologies *Description:* This effort performs sustained multidisciplinary basic research supporting technologies that provide the Army with bio-inspired materials and biomolecular sensor platforms. ***FY 2021 Plans:*** Create a new generalizable platform using synthetic biology to engineer materials with novel optical and electronic properties that are impossible to produce using non-biological routes; create a platform to build genetic circuits in Magnetospirillum and G. hansenii to control the primary structure and spatial arrangement of composite nanomaterials; investigate control of the shape, composition, and supermolecular assembly of composite metal nanocrystals integrated into silica structures and investigate organic polymers as conductors. In the long term, these efforts are expected to translate solutions from biological systems into high-performance technologies, materials, and systems for the Army. ***FY 2022 Plans:*** Will develop innovative platforms by using the tools of synthetic and systems biology, genetic circuitry, biocatalytic enzymes, and directed evolution to design and engineer new types of multi-functional materials with novel properties; design and assess enabled functionalities that include optical signature management, solar-to-electrochemical energy conversion, mechanical and thermal robustness, self-assembly and healing, highly selective chemical reactivity, sense-and-respond properties, and logging of environmental signals and events. These basic research efforts will combine state-of-the-art methods in synthetic and systems biology with advanced materials synthesis and characterization to provide unique biologically-derived material solutions for the Army?s future challenges. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	5.146	4.565	4.783
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,	6.484	4.506	4.737

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
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 2021 Plans:* Explore deep learning in the context of creating virtual assistants and immersive environments for synthetic training; automatically create 3-D models of humans from a few photographs, currently an arduous manual task, as well as realistic behavioral models of humans, such as speaking patterns and behavioral gestures, when interacting in groups; conduct studies to understand human intent and state of mind from video for potential applications in coaching and after-action reports; investigate explainable models of Reinforcement Learning that could form the basis of transparent artificial intelligent systems. *FY 2022 Plans:* Will explore understanding human behavior to be able to create generators and classifiers at the right level of fidelity in a virtual environment; research Artificial Intelligence-based systems that make it easy to author Army training systems; advance scientific understanding on how technology can assist the performance of individuals within tasks that are assumed to require social and emotional intelligence within a virtual environment; assess whether the effect of the virtual environment itself (e.g., poor vs. affluent neighborhood) on responses during the training or simulation (e.g., training outcomes, stress, impressions of virtual human (VH) characters in the environment, etc.) is significant (i.e., reliable) for simulations with different content (e.g., wayfinding, active shooter simulation, negotiation); build a theoretical and end-to-end framework based on 3D deep learning to enable AI-driven synthesis of dynamic 3D objects from 2D views. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Institute for Soldier Nanotechnologies	5.800	5.196	4.954

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort investigates Nanomaterials and Nanotechnologies for Soldier applications focused on light-weight, multifunctional nanostructured fibers and materials. *FY 2021 Plans:* Determine if packed granular particles of shape memory ceramic materials can dissipate energy through inter-particle friction and intra-particle martensitic phase transformations for application to vibrational damping, and synthesis of novel mechano-optic, electro-optic, and thermo-optic fibers. In the long term, this work may enable high bandwidth communications and reflectivity management of Soldier clothing and platforms. *FY 2022 Plans:* Will design a novel, durable, shape-stable metamaterial composite for future high-temperature high Mach Number hypersonic applications; design superelastic granular materials to enable novel ductile (as opposed to current brittle) ceramic plates for greatly improved Soldier armor; design low-power on-chip beam-steering capabilities by exploiting a Luneburg lens design in a nanophotonic platform, to enable efficient directed Soldier comms that cannot be adversary-detected; design rapid and effective treatment of incompressible and internal wounds by systemically injectable hemostasis, based on nanoparticles crosslinked through bio-orthogonal click chemistry, designed to hone-in to location of bleeding even if location cannot be identified. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding was realigned to Program Element (PE) 0601601A / CL3 Artificial Intelligence Basic Research Hub which is reduction in energy dissipation research.			
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, Structures, Flight Dynamics and Control, Rotorcraft Design and Concepts, Vibration and Noise Control, Propulsion, Affordability, Safety and Survivability, and Naval Operations. *FY 2021 Plans:* Complete the final year of the current VLRCOE technology interchange agreements with the Georgia Institute of Technology, the Penn State University, and the University of Maryland; conduct fundamental experimental measurements and analysis of Future Vertical Lift relevant configurations such as coaxial rotors and winged compound; identify new research thrust areas of interest to Army Aviation, such as autonomy and teaming; solicit proposals for a new Center of Excellence program that provides a robust experimental and analytic basic research program coupled with a vertical lift focused education program. *FY 2022 Plans:*	3.051	3.190	3.349

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will kick-off a new, five year program combining graduate education and university research to explore frontier areas relevant to Future Vertical Lift; assess proposals based on a combination of criteria that requires a critical mass of expertise to form an inter-disciplinary research and education center; individual research tasks will be selected predominantly based on their scientific merit and relevance to Army Science and Technology (S&T) goals; conduct multi-disciplinary experimental, computational, and analytical basic research tasks in vertical lift technology disciplines spanning aeromechanics, structures and materials, flight dynamics and control, Vertical Take-Off and Landing (VTOL) concepts and design, vibration and noise control, propulsion, affordability, and safety and survivability. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Automotive Research Center (ARC) ***Description:*** The ARC is an U.S. 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 2021 Plans:*** Continue to conduct advanced modeling and simulation research for ground vehicles focusing on autonomy and mobility problems. Topics include: teleoperated, semi-, fully-, and multiple autonomous vehicle operation and control, high fidelity operational evaluations of autonomy-related technologies, perception in degraded sensor environments, machine learning, robotic trust, high performance terramechanics models, ground vehicle power generation, storage, and distribution models, and the usage of modeling and simulation techniques to shorten the vehicle/technology/capabilities development for future combat vehicles. ***FY 2022 Plans:*** Will enhance modeling and simulation (M&S) capabilities for ground systems with a concerted effort in autonomous vehicle off-road mobility M&S in harsh terrains and contested environments; other major ground system M&S focus areas for enhancements include: Vehicle-Level Sensing, Perception and Acting for autonomous vehicles in different situational and teaming environments; Communication, Trust and Cognition between humans and conventional/autonomous vehicles; Intelligence, Off-Road, Resilience for vehicle structures and large-scale computational methods; Adaptability and Self-Awareness for power systems; Fleet Dynamics, Decision-Making, and System of Systems. Will research usage of operational data-driven techniques to analytics models to improve prediction accuracy and efficiency. ***FY 2021 to FY 2022 Increase/Decrease Statement:***	3.163	3.299	3.696

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding realigned from all the Projects in Basic Research portfolio as part of the Program Evaluation Groups (PEG) efficiency drill.			
Accomplishments/Planned Programs Subtotals	25.075	22.425	23.204

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

D. Acquisition Strategy
 N/A

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Appropriation/Budget Activity 2040 *I* 1				**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*				**Project (Number/Name)** AB7 *I Army Collaborative Research and Tech Alliances*			

COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
AB7: *Army Collaborative Research and Tech Alliances*	-	41.100	45.147	52.832	-	52.832	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding realigned from Program Element (PE) 0601102A / Defense Research Sciences/ Project AA3 / Single Investigator Basic Research for the following efforts:
Army Advanced Biological Control Center, Army Advanced Energetics Center, Army Radio-Frequency (RF) Electronics Center and Army Advanced Energetics Center

In Fiscal Year (FY) 2022, funding realigned to Program Element (PE) 0601601A/ CL3 Artificial Intelligence Basic Research.

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, 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 2020**	**FY 2021**	**FY 2022**
Title: Internet of Battlefield Things CTA (IoBT CTA)	5.804	5.856	2.921
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 2021 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Investigate methods for Dynamic and Autonomous Composition that enable automatic and transparent cooperation between intelligent devices through Deep Learning and Satisfiability Modulo Convex (SMC) optimizations; explore computational methods provide artificial intelligence algorithmic bounding and guarantees, as well as provide resilience to threats and adversarial activities through quantified machine learning (ML) such as deep learning algorithms that provide quantified uncertainty in responses for use in automated processes; create theories and methods for distributed learning and inference that can support collective intelligence through progressive machine learning and continuous learning, such as Zero Shot algorithms that combine deep learning with classifiers and semantic projection. *FY 2022 Plans:* Will explore foundational theories and methods for quantifying uncertainty in data and predictive or classifying algorithms given highly heterogeneous and pervasive intelligent systems; create approaches that quantitatively improve the overall dependability/stability of complex, smart command and control systems-of-systems; investigate algorithms that capitalize on ubiquitous sensor/actuators and the ability to derive information outside of their intended/advertised use; investigate theories and algorithms that enable agile composite systems to have self-awareness and autonomy to reconfigure/react to adversarial battlefield environment and information dynamics. *FY 2021 to FY 2022 Increase/Decrease Statement:* Partial funding realigned in FY 2022 to support artificial intelligence advancements by the Army Artificial Intelligence Task Force.			
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 2021 Plans:* Investigate theories, models, and techniques for content-based software defined networking, policy-based secure coalition information infrastructures, composability of adaptive distributed coalition data services, dynamic context-aware information processing services, distributed processing and analytics to derive situational understanding, and complex adaptive human systems in the context of ad-hoc coalition operations at the tactical-edge. *FY 2022 Plans:* Will investigate theories, models, and techniques for distributed control of policy-enabled dynamic infrastructures, federated policy learning and management, federated learning for coalition analytics, interpretability of neural networks in distributed and contested coalition environments, understanding internal group behavior and dynamics in complex multi-domain environments, and learning	3.935	4.074	2.734

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
and inferencing for uncertainty-aware human-machine situational understanding, in the context of ad-hoc coalition operations at the tactical-edge. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Partial funding realigned in FY 2022 to Program Element (PE) 0601601A / CL3 Artificial Intelligence Basic Research in support of artificial intelligence advancements			
Title: Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Material CRA ***Description:*** Research will focus on two-way multiscale modeling for predicting performance and designing materials; investigating analytical and theoretical analyses to effectively define the interface physics across length scales; advancing experimental capabilities for verification and validation of multiscale physics; and modeling and strategies for the synthesis of high loading rate tolerant materials. The multiscale modeling capability will be applied across multiple disciplines to facilitate revolutionary advances in materials for coupled environments (electromagnetic, high rate, high pressure, and other extreme environments). ***FY 2021 Plans:*** Conduct iterative research through the materials-by-design paradigm to create newly designed metal, ceramic and composites systems for armor applications; continue to investigate multiscale models to enable the transition of software codes and tools to improve armor design codes for the selected material systems; study integrative multi-mechanism models using canonical experiments; use synthesis and processing to control the critical mechanisms which determine the material performance in high strain rate extreme environments; generalize the integrative models based on these mechanisms, thus enabling the materials-by-design paradigm to be applied to other materials within the same class; investigate physics-informed machine learning for multiscale/multi-physics modeling for the advancement of electrochemical and electro-optical materials devices for sensing, energy and power applications; study extending multiscale modeling to optoelectronic and electrochemical materials and devices to explore physics based materials by design. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, funding realigned to support Tactical Behaviors for Autonomous Maneuver and Materials Discovery for Extreme Environments within this Project during a planned change in scope for Materials in extreme environments.	8.522	8.363	-
Title: Distributed Collaborative Intelligent Systems Technology CTA ***Description:*** Establish the underpinning science to extend the reach, situational awareness, and operational effectiveness of intelligent system and Soldier teams against dynamic threats in complex and contested environments and provide technical and operational superiority through fast, intelligent, resilient, and collaborative behaviors. Research efforts will enable distributed	5.914	6.059	6.295

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
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 2021 Plans:* Conduct fundamental research to investigate scalable methods for heterogeneous multi-agent autonomous maneuver through complex environments; explore methods for resource-constrained coordination and local and global situational awareness and understanding between multi-agent heterogeneous team members; investigate techniques for increased resiliency of multi-agent teams to adapt to large changes in state and situational understanding; investigate approaches that will enable multi-agent heterogeneous teams to react to and adapt to adversarial behaviors and operations in contested environments; conduct research to increase understanding of team formation, tasking, and control in collaborative heterogeneous human/multi-agent teams. *FY 2022 Plans:* Will conduct fundamental research in heterogeneous multi-agent situational awareness to explore how a heterogeneous team can collaborate to build shared situational awareness while moving through a contested environment and perform collaborative decision making over long timescales with high operational tempo in complex, dynamic environments; explore dynamic teaming operations, heterogeneous team control and strategy, and synthesis and adaptation of team behaviors with high operational tempo; establish resource aware communication required for coordination and collaboration amongst team members and increase distributed resilience in the team response. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects 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 2021 Plans:* Identify neural biomarkers that correspond to individual differences in spatial and navigational abilities, thereby testing specific predictions about the structural and functional correlates of different skills; investigate training paradigms to improve navigational abilities, testing the hypothesis that training involving making explicit predictions about upcoming locations when learning a novel environment will improve performance; determine how brain structure and function changes with training, testing the hypothesis that prediction training will increase intrinsic connectivity between prefrontal cortex and hippocampus and will lead to structural changes in white matter and diffusivity. If successful, these studies may enable new training techniques to enhance navigational skills. *FY 2022 Plans:*	0.438	0.629	0.626

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will employ state-of-the-art techniques in neuroscience to develop and test neural biomarkers associated with human cognition that track with directed attention, modes of planning and problem solving, memory-guided decision-making, and visual search; characterize the influence of arousal, fatigue, stress, and other demands on cognitive states and their neural biomarkers; assess the potential for biomarkers to inform human-machine interfaces, to accelerate learning, and to enhance integrated human-artificial intelligence system performance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Center for Exploitation of Quantum Effects ***Description:*** This work supports needed quantum information science basic research for next generation capabilities in security, decision aids, sensing, and position, navigation, and timing (PNT) for Army dominance on the future battlefield. ***FY 2021 Plans:*** Investigate, through experiment and theory: approaches for manipulating quantum systems with strong atom-light interaction; nanophotonic materials that protect quantum information from perturbations; optimization techniques for quantum algorithms and non-classical measurement that beats classical limits. Identify solid-state materials and excitation pathways in atoms that optimize response to electric and magnetic fields. ***FY 2022 Plans:*** Will investigate approaches to solid-state sensing of magnetic fields using Nitrogen-Vacancy (NV) diamond and Silicon Carbide (SiC) defects in solids; investigate long-range atom-atom interactions through optical fiber and solid-state emitters near integrated waveguides; investigate topological light sources for low-loss routing of entangled photon pairs; explore distributed sensing using ion traps; explore methods for using telecom-compatible energy levels in ytterbium (Yb) ions for long-range entanglement distribution. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	2.784	2.888	2.926
Title: Neuroergonomics CTA ***Description:*** By utilizing fundamental principles that underlie Soldier neurocognitive performance, this effort provides individualized and adaptive technologies that enhance Soldier-agent interaction.	1.084	-	-
Title: Identification and characterization of team-level processes for enhancing performance of heterogeneous Soldier-Agent teams CRA	3.314	4.758	4.931

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
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 2021 Plans:* Execute multiple focused lines of research prioritizing discovery and operationalization of the relationships between individual dynamics and team-level states and processes in human-autonomy teams; investigate novel metrics of team-level states and processes in human-autonomy teams that impact team effectiveness, accounting for specific roles and characteristics of humans and intelligent agents cooperatively performing complex tasks; and explore advancements in dynamic models linking individual and team states. *FY 2022 Plans:* Will characterize and model critical individual processes and dynamics in relation to team-level emergence in military-relevant team tasks involving multiple humans and multiple intelligent agents; extend and validate human-based theories of team effectiveness incorporating micro, meso, and macro signatures of emergence to human-agent teams; explore team emergent responses to perturbations; incorporate agent-based learning from humans to improve dynamic teaming. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects 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 2021 Plans:* Further investigate the underpinning science to extend the reach, situational awareness, and operational effectiveness of Intelligent System/Soldier teams against dynamic threats in complex and contested environments; research will work to explain	9.305	7.202	7.537

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
how diverse, embodied agents collectively sense, infer, reason, plan, and execute in collaboration with Soldiers and in the face of a peer adversary. *FY 2022 Plans:* Will assess current research and combine, re-direct, or initiate efforts to meet progressively harder challenge problems through experimentation and physics based criteria; transition most promising results and models to Army specific applications enabling rapid improvement of ML techniques; increase database accessibility and tools to provide an array of software and processing capabilities to academic, industry, and other Department of Defense partners; provide access to curated, labeled dataset covering a large variety of applications to meet Army requirements. *FY 2021 to FY 2022 Increase/Decrease Statement:* Partial funding realigned in FY 2022 to support artificial intelligence advancements by the Army Artificial Intelligence Task Force.			
Title: Artificial Intelligence Hub *Description:* The AI Hub is located at Carnegie Mellon University as a consortium of industry, government, and academia focused on building and optimizing the Army's AI and ML initiatives with the goal of accelerating the fielding of capability. The AI Hub will utilize the A2I2 data and AI/ML algorithms and software tools to investigate AI and ML capabilities to address the Army's unique problems. The AI Hub will focus on research into AI technologies for future application to Army-relevant areas such as predictive maintenance, operations for intelligence in support of Long Range Precision Fires, human relations/talent management; and autonomous threat recognition. *FY 2021 Plans:* Investigate AI and ML models for: identifying emerging trends in helicopter maintenance records and/or on-board flight and/or vibration data; autonomous collection, integration, and analysis of information from myriad sensors/systems to rapidly produce actionable intelligence and facilitate targeting; branching models which align Army personnel talent with branch needs; AI that raises the level and number of tasks that can be executed autonomously or semi-autonomously by vehicles in the fleet. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding realigned in FY 2022 to Program Element (PE) 0601601A / CL3 Artificial Intelligence Basic Research which is a new PE/Project to show visibility of the strategic partnerships of the AI Task Force Center in support of artificial intelligence advancements	-	5.318	-
Title: Army Radio-Frequency (RF) Electronics Center *Description:* The Army Radio-Frequency (RF) Electronics Center will develop ultra-wide bandgap (UWBG) materials and device concepts designed to enable next generation RF semiconductor technology for the Army. This research will enable advanced, robust, high-power RF electronics for radars, comms, directed energy, and electronic warfare (EW). The resulting robust high	-	-	4.892

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 I 1	R-1 Program Element (Number/Name) PE 0601104A I *University and Industry Research Centers*	Project (Number/Name) AB7 I *Army Collaborative Research and Tech Alliances*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
power operation will provide longer ranges for sensing and effect-on-target under adverse conditions and improved sized, weight, and power (SWaP) will give small systems (Unmanned Aerial Vehicles, countermeasures, etc.) new capabilities. *FY 2022 Plans:* Will implement a combination of approaches designed to create a basic research paradigm in UWBG semiconductor materials using data-driven physics informed computer science approaches; undertake research that will understand materials/device physics and performance limits under extreme conditions; create innovative device concepts and circuit architectures to realize or overcome these limits. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding realigned from Basic Research in Chemical Sciences; Basic Research in Computing Sciences; Basic Research in Materials Sciences; Basic Research in Electronics and Photonics; and Basic Research in Mathematical Sciences in PE 0601102A Project AA3.			
Title: Army Advanced Biological Control Center *Description:* The Army Advanced Biological Control Center will develop a fundamental knowledge base for precise, reliable control of engineered biological systems for functional effect during military operations. By exploiting fundamental relationships governing the functions and properties of biological systems, the Center will develop advanced control schemes using synthetic biology targeting two key areas: 1) Genetic Control of Material Properties and 2) Biological Control in Competitive Environments. *FY 2022 Plans:* Will initiate concepts for a comprehensive information pipeline for the creation of new algorithms and scalable computational models that extract the critical genetic parameters driving material properties; develop robust predictive models to inform genetic manipulation using synthetic biology for precision material synthesis with targeted properties across scales; design and assess experimental approaches to measure interactions of engineered microorganisms with the biological, chemical, and physical parameters of the microenvironment and bulk environment compared to naturally occurring microorganisms. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding realigned from Basic Research in Mathematical Sciences; Basic Research in Computing Sciences; Basic Research in Electronics and Photonics; Basic Research in Life Sciences; and Basic Research in Materials Sciences in PE 0601102A Project AA3.	-	-	4.892
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	-	-	4.892

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** AB7 *I Army Collaborative Research and Tech Alliances*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
current programs. This research focuses on high through-put synthesis and rapid characterization to accelerate discovery of next, next generation materials to enable Army domination of the future battlefield. *FY 2022 Plans:* Will develop concepts around future energetic materials for tailorable effects which enable increased lethality of warhead fragments and enable new concepts for shape charge weapons; develop energetic materials with higher energy density and enable lighter, smaller, more lethal warheads for smart munitions; design materials for high specific impulse propellants, enable increased range of munition systems, and enable reduced time-of-flight, increased munitions survivability, and end-game maneuverability to avoid threat countermeasures. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding realigned from Basic Research in Life Sciences; Basic Research in Mechanical Sciences; and Basic Research in Chemical Sciences in PE 0601102A Project AA3.			
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 2022 Plans:* Will conduct fundamental research on planning algorithms that can passively learn tactics from observed data in constrained terrains using limited resources, and predict positions of advantage for area reconnaissance based on external observations. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding realigned from Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Material CRA within this Project to support this effort.	-	-	2.425
Title: Materials Discovery for Extreme Environments *Description:* Research will focus on material discovery for next-generation ballistic materials by using accelerated material-by-design approach to include consideration of nonhomogeneous, anisotropic, and hierarchical material systems. A data-driven material design approach will be developed utilizing high-throughput material processing and characterization, multi-scale modeling, and machine intelligence to produce leap-ahead material solutions. *FY 2022 Plans:* Will conduct research in data-driven and machine intelligence approaches to correlate material structure, property, and requirements for multiple harsh military environments such as launch and flight, high-temperature and high ablation, and impacts at unprecedented velocity; enable rapid screening of high dimensional material datasets; establish parameter space and methods	-	-	6.255

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
for synthesis and high-throughput characterization of material classes suitable for high rate applications to produce large variations in properties. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, funding realigned from Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Material CRA within this Project to support 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 2022 Plans:*** Will investigate foundational approaches to light-matter interfaces to understand how to efficiently store, retrieve, and distribute quantum information between atoms and ions. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding realigned from all the Projects in Basic Research portfolio as part of the Program Evaluation Groups (PEG) efficiency drill.	-	-	0.506
Title: Convergent Manufacturing for High Performance Material Interfaces ***Description:*** This research will address novel additive deposition, high fidelity subtractive methods, and high resolution directed energy processes to investigate complex, non-discrete, high performance, multi-material interfaces with improved adhesion, gradual coefficient of thermal expansion changes, and gradual wavespeed changes to enable high performance under extreme ballistic and thermal conditions. ***FY 2022 Plans:*** Will develop a basic convergent manufacturing platform that is capable of depositing two classes of materials (i.e., polymers, metals, or ceramics) and transform those materials into their desired morphology independently; investigate a complex interface, such as a gradient, composed of two classes of materials using convergent processing. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding realigned from all the Projects in Basic Research portfolio as part of the Program Evaluation Groups (PEG) efficiency drill.	-	-	1.000
Accomplishments/Planned Programs Subtotals	41.100	45.147	52.832

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

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** AB7 *I Army Collaborative Research and Tech Alliances*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy
  N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 1				**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*					**Project (Number/Name)** AB8 *I Army Educational Outreach Program*		

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
AB8: *Army Educational Outreach Program*	-	10.035	10.275	10.641	-	10.641	-	-	-	-	-	-

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 careers. AEOP increases interest and involvement of students and teachers across the nation in STEM at all proficiency levels and backgrounds to include under-represented 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.

FY20 realignments are due to financial restructuring in support of Army Modernization Priorities and the Office of Science and Technology Policy (OSPT) Federal Coordination efforts outlined by the American's Strategy for STEM Education Report.

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 2020	FY 2021	FY 2022
Title: AEOP Coop Agreement	9.725	9.975	10.641
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 2021 Plans:*			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
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 will perform annual comprehensive reviews and educational assessments to support future decisions and best practices. *FY 2022 Plans:* Will continue Army sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive reviews and educational 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 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort			
Title: West Point Cadet Program *Description:* The West Point Cadet Research Program provides West Point Cadets an opportunity to work on Army research projects alongside Army and industry scientists and engineers during the summer. *FY 2021 Plans:* Conducts West Point cadet research internship program to enhance cadet training through field experience in Army research labs and engineering centers. Between 40 and 60 cadets will intern for a period of 3 to 6 weeks. *FY 2021 to FY 2022 Increase/Decrease Statement:* Efforts and funding are realigned to the AEOP Cooperative Agreement effort within this Project.	0.310	0.300	-
Accomplishments/Planned Programs Subtotals	10.035	10.275	10.641

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

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
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D. Acquisition Strategy

 N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 1					**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*				**Project (Number/Name)** AC6 *I International Science and Technology*		

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
AC6: *International Science and Technology*	-	6.444	6.869	6.951	-	6.951	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project funds the Combat Capabilities Development Command's (CCDC) International Basic Research Mission, the CCDC International Technology Centers (ITCs), and 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 U.S. Army's Science and Technology (S&T) strategy. The nine 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 S&T investments of our international partners. The CCDC ITCs and CCDC's Army Research Laboratory Army Research Office (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. ITC 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 2020	FY 2021	FY 2022
Title: International Technology Centers	4.319	4.469	4.531
Description: The nine 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 Science and Technology (S&T) investments 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. The international basic research mission exploits new scientific discoveries and technology breakthroughs from international universities that have the potential to deliver future Army transformational capabilities. Highly promising 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.			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** AC6 *I International Science and Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Continue to seek out promising foreign science and technology solutions within geographic areas of responsibility that may have interest and applicability to the U.S. Army?s research and development efforts in support of the Army?s Modernization Priorities. In accordance with the Army S&T Strategy and the Combat Capabilities Development Command (CCDC) Global Engagement Plan, the ITCs will seek-out and connect foreign researchers with U.S. Army scientists and engineers, with the explicit intent to fund promising and relevant research through a grant, contract, or cooperative agreement. Will also continue to enhance and refine technology search capabilities using customer feedback to focus on mid- and long-term capabilities. *FY 2022 Plans:* Will continue to continue to seek out promising foreign Science and Technology (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 CCDC Global Engagement Plan (GEP), continue to seek -out and connect foreign researchers with United States Army scientists and engineers, with the explicit intent to fund promising and relevant research through a contract or cooperative agreement; continue to enhance and refine technology search capabilities using customer feedback to focus on mid- and long-term capabilities. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Foreign Technology (& Science) Assessment Support *Description:* The FTAS program serves as a catalyst for the US Army Futures Command to assess potentially game-changing technologies discovered in friendly foreign nations by the US 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 2021 Plans:* Solicit proposals and assess scientific quality of candidate projects by utilizing U.S. Army Senior Scientist Corps expertise. Provide seed funding for approved proposals to U.S. Army laboratories to develop and/or assess technology areas identified by the Army?s ITCs. *FY 2022 Plans:*	2.125	2.400	2.420

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Research Centers*	**Project (Number/Name)** AC6 *I International Science and Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will solicit proposals and assess scientific quality of candidate projects by utilizing United States Army scientific expertise; continue to provide funding for approved proposals to United States Army Science and Technology (S&T) centers and laboratories to develop and/or assess technology areas identified by the ITCs and S&T community and ARO personnel. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	6.444	6.869	6.951

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

D. Acquisition Strategy
 N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 1				**R-1 Program Element (Number/Name)** PE 0601104A *I University and Industry Re search Centers*						**Project (Number/Name)** CI9 *I Strategic University Basic Research Alliance*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CI9: *Strategic University Basic Research Alliance*	-	-	-	0.375	-	0.375	-	-	-	-	-	-

Note

This is a new start in FY 2022.

In Fiscal Year (FY) 2022, this Project is a New Start.

A. Mission Description and Budget Item Justification

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: University Basic Research Strategic Partnerships	-	-	0.375
Description: Conducts basic research leading to potential emerging technologies in areas of strategic importance to the Army by bringing competitively selected Universities with research teams into strategic alliances. Investigates novel principles, ideas, and theories potentially leading to novel technologies in collaboration with academic entities that might not otherwise collaborate with the DoD, with the end goal of accelerating the adoption of cutting-edge technology for the warfighter.			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** CI9 / *Strategic University Basic Research Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2022 Plans: Will conduct fundamental research employing a multidisciplinary research strategy to advance new capabilities in such areas as autonomy, artificial intelligence, machine learning, robotics, all terrain navigation/routing, and novel materials and sensing modalities; discover novel methods for seamless cooperation between intelligent agents and humans; and investigate network resiliency. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** New start in FY22 to develop strategic partnerships with the academic community to deliver world class science in support of the Army's Modernization Priorities. Funding realigned from Program Element 0601102/AB4.			
Accomplishments/Planned Programs Subtotals	-	-	0.375

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

D. Acquisition Strategy
 N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
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 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	41.000	34.000	-	-	-	-	-	-	-	-	-

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 2020**	**FY 2021**
Congressional Add: Congressional Program Increase - University and Industry Research Centers - Army Artificial Intelligence Innovation Institute ***FY 2020 Accomplishments:*** Congressional Increase. Basic research to support artificial intelligence algorithm development and evaluation.	20.000	-
Congressional Add: Congressional Program Increase - University and Industry Research Centers - Bioenabled Materials ***FY 2020 Accomplishments:*** Congressional increase. Basic research to harnes biotechnology advancements.	4.000	-
Congressional Add: Congressional Program increase - Materials in Extreme Dynamic Environments ***FY 2020 Accomplishments:*** Congressional increase: Accelerating basic research on materials in extreme dynamic environments. ***FY 2021 Plans:*** Congressional increase: Accelerating basic research on materials in extreme dynamic environments.	5.000	10.000
Congressional Add: Congressional Program Increase - university assisted hypervelocity testing ***FY 2020 Accomplishments:*** Congressional increase. Basic Research on university assisted hypervelocity testing	2.000	-
Congressional Add: Catalyst	10.000	-

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
FY 2020 Accomplishments: Program Increase to support Catalyst - Soldier Inspired Solutions. Work will be done to mature, integrate, and demonstrate soldier-centric design technology solutions through partnering with academia and industry. Work will be executed by Army Futures Command.		
Congressional Add: Program increase - biotechnology development	-	4.000
FY 2021 Plans: Congressional increase: Accelerating basic research on biotechnology development.		
Congressional Add: Program increase - Army artificial intelligence innovation	-	20.000
FY 2021 Plans: Congressional Increase: Basic Research to support Army Artificial Intelligence Innovation.		
Congressional Adds Subtotals	41.000	34.000

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

D. Acquisition Strategy
 N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					**R-1 Program Element (Number/Name)** PE 0601121A *I Cyber Collaborative Research Alliance*							
COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
Total Program Element	-	4.982	5.077	5.067	-	5.067	-	-	-	-	-	-
CB5: *Cyber Collaborative Research Alliance*	-	4.982	5.077	5.067	-	5.067	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This 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.

All FY20 adjustments align program financial structure to Army Modernization Priorities in support of the National Defense Strategy.

B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	4.982	5.077	5.181	-	5.181
Current President's Budget	4.982	5.077	5.067	-	5.067
Total Adjustments	0.000	0.000	-0.114	-	-0.114
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	-0.114	-	-0.114

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	

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 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CB5: *Cyber Collaborative Research Alliance*	-	4.982	5.077	5.067	-	5.067	-	-	-	-	-	-

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 2020	FY 2021	FY 2022
Title: Cyber Security Collaborative Research Alliance *Description:* The CSEC CRA supports basic research to enable capabilities for rapid development and adaptation of cyber tools for dynamically assessing cyber risks, detecting hostile activities on friendly networks, and supporting agile maneuver in cyber space in spite of the emergence of novel threats. *FY 2021 Plans:* Investigate theories and models for reasoning about adversarial intent, defeating enemy Artificial Intelligence (AI), and employing deception to protect networks and forces; create techniques for autonomous planning and control of cyber maneuvers to deceive adversaries and protect networks; study methods for intelligent cyber threat detection and recognition in complex, adversarial and uncertain environments. *FY 2022 Plans:*	4.982	5.077	5.067

PE 0601121A: *Cyber Collaborative Research Alliance*
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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
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 2020	FY 2021	FY 2022
Will investigate theories and models that study fundamental properties and capabilities of adaptive, scalable, and robust cyber threat detection techniques; investigate methods for planning, assessing, and directing autonomous cyber maneuvers; research fundamental properties and capabilities of adaptive deception techniques for cyber defense, mission resilience, and counter-adversarial machine learning, in congested and contested tactical environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	4.982	5.077	5.067

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

D. Acquisition Strategy
 N/A

PE 0601121A: *Cyber Collaborative Research Alliance*
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Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army											**Date:** May 2021	
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 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
Total Program Element	-	-	-	10.183	-	10.183	-	-	-	-	-	-
CL3: *AI/ML Basic Research Hub*	-	-	-	10.183	-	10.183	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this Program Element (PE) is created to focus on basic research efforts in the Army portfolio pertaining to Artificial Intelligence (AI) and Machine Learning (ML) coordinated by the Army's Artificial Intelligence Integration Center (AI2C); with funding realigned from:
PE 0601102A Defense Research Sciences
AA1 ILIR - AMC
AA2 ILIR - SMDC
AA6 Robotics and Mobile Energy
AA7 Mechanics and Ballistics
AA8 Sensing and Electromagnetics
AB1 Basic Res in Infect Dis, Oper Med and Combat Care
AB2 Protection, Maneuver, Geospatial, Natural Sciences
AB4 Army Research Centers
AC6 International Science and Technology
PE 0601104A University and Industry Research Centers / AB7 Army Collaborative Research and Tech Alliances,
This was a part of the Program Evaluation Groups (PEG) efficiency drill.

A. Mission Description and Budget Item Justification

This 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).

PE 0601601A: *Artificial Intelligence and Machine Lear...*
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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2022 Army	**Date:** May 2021
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*

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

B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	0.000	0.000	0.000	-	0.000
Current President's Budget	0.000	0.000	10.183	-	10.183
Total Adjustments	0.000	0.000	10.183	-	10.183
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	10.183	-	10.183

Change Summary Explanation

In FY2022, this is a new PE with one new FY22 Project funded by realignments from Program Element (PE) 0601104A University and Industry Research Centers, AB7 Army Collaborative Research and Tech Alliances to align Artificial Intelligence efforts, and from PE 0601102A Defense Research Sciences as a part of the Program Evaluation Group (PEG) efficiency drill.

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Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	

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 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CL3: *AI/ML Basic Research Hub*	-	-	-	10.183	-	10.183	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this is a New Project realigned from:
* PE 0601104A University and Industry Research Centers / AB7 Army Collaborative Research and Tech Alliances
and from all the Projects in Basic Research portfolio as part of the Program Evaluation Groups (PEG) efficiency drill.

A. Mission Description and Budget Item Justification

The 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 PE is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Intelligence support to Operations	-	-	1.500
Description: Research Artificial Intelligence (AI) / Machine Learning (ML) methodologies to perform object detection on imagery to augment operations and to better understand the enemy?s capabilities and projected lethality. 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 area of intelligence support for operations in support of long range precision fires. *FY 2022 Plans:*			

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Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601601A *I Artificial Intelligence and Machine Learning Basic Research*	**Project (Number/Name)** CL3 *I AI/ML Basic Research Hub*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will research the ability to model, animate, and render synthetic data to train algorithms using a high-altitude electro-optical (EO) imagery training set comprised of synthetic data created from open source imagery and limited real-world data. Will also research new low-shot object detection and recognition techniques for small sample learning, and unsupervised computer vision approaches to improve battlespace awareness.			
FY 2021 to FY 2022 Increase/Decrease Statement: In FY2022, this is a new effort for use of AI/ML methodologies in support of Intelligence Operations			
Title: Artificial Intelligence Hub ***Description:*** The AI Hub is located at Carnegie Mellon University as a consortium of industry, government, and academia focused on building and optimizing the Army's AI and ML initiatives with the goal of accelerating the fielding of capability. The AI Hub will utilize the Army Artificial Intelligence Innovation Institute (A2I2) data and AI/ML algorithms and software tools to investigate AI and ML capabilities to address the Army's unique problems. The AI Hub will focus on research into AI technologies for future application to Army-relevant areas such as, but not limited to, replication of tactical behaviors to enable autonomous capabilities for maneuver, robotics, predictive maintenance, multi-domain Command, Control, Communications, and Computers (C4), network resiliency and cybersecurity, AI-enhanced common operating picture (CoP), intelligent business and process automation, decision support, AI-enabled collaborative data infrastructure platform, medical support and force protection. ***FY 2022 Plans:*** Will investigate new ways of streamlining collaborative AI development with approaches that improve developer productivity and application robustness; research AI-enabled cyber security methodologies in adversarial AI/counter AI, cyber intrusion, and ML-based anomaly detection with counter-actions that are robust to enemy deception; research into safe manned-unmanned vehicle teaming to improve system performance; research to improve the understanding and use of reinforcement learning for studying strategic and cooperative interactions in multi-agent systems and improve decision support. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding and the work for this effort is administratively realigned from PE 0601104A University and Industry Research Centers / AB7 Army Collaborative Research and Tech Alliances	-	-	5.555
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.	-	-	3.128

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 1	**R-1 Program Element (Number/Name)** PE 0601601A *I Artificial Intelligence and Machine Learning Basic Research*	**Project (Number/Name)** CL3 *I AI/ML Basic Research Hub*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2022 Plans: Will research emerging AI-based, multi-system ground and air vehicle-based object recognition strategies based on autonomous collection, integration, and analysis of information from myriad sensors/systems; will further investigate AI methods that raise the level and number of tasks that can be executed autonomously or semi-autonomously by vehicles in the fleet; will perform research into advanced algorithms for autonomous ground and air platform movement with obstacle detection/avoidance in GPS-denied, dense urban and low/no- light environments; will research AI-enabled tactical maneuver of ground platforms by using terrain and vegetation to avoid enemy detection. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY2022, this is a new effort for use of Mobile Cooperative and autonomous sensors.			
Accomplishments/Planned Programs Subtotals	-	-	10.183

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

D. Acquisition Strategy
 N/A

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