Department of Defense
Fiscal Year (FY) 2022 Budget Estimates

May 2021

Army

Justification Book Volume 1b of 1

Research, Development, Test & Evaluation, Army

RDT&E − Volume I, Budget Activity 2

Army • Budget Estimates FY 2022 • RDT&E Program

Volume 1b 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
----

	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request
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

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

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			
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)

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			
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 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

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
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

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   05 May 2021
(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
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

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
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

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   05 May 2021
(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
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

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   05 May 2021
(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
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

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   05 May 2021
(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
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

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   05 May 2021
(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
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

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   05 May 2021
(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
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

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
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

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   05 May 2021
(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2020 Actual*	FY 2021 Enacted**	FY 2022 Request	Sec
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	

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

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	

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

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

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

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 2040: *Research, Development, Test & Evaluation, Army I* BA 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602115A *I Biomedical 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**
Total Program Element	-	-	11.403	11.925	-	11.925	-	-	-	-	-	-
EB2: *HIV Biomedical Technology*	-	-	11.403	11.925	-	11.925	-	-	-	-	-	-

Note

 This Program Element (PE) is a New Start for Fiscal Year 2021 (FY21).

A. Mission Description and Budget Item Justification

 This PE funds the Military Human Immunodeficiency Virus (HIV) Research Program and the Combatting Antimicrobial Resistant Bacteria (CARB) projects. The goal of the Military HIV Research Program is to refine identification methods for determining genetic diversity of the virus, to conduct preclinical work in laboratory animals including non-human primates to identify candidates for global HIV-1 vaccine, and to evaluate and prepare overseas sites for clinical trials with these vaccine candidates. For the CARB program, funding provides for the development of strategies to prevent, mitigate, and treat antibiotic resistant bacteria in wounds through the CARB - Walter Reed Army Institute of Research (WRAIR) Discovery and Wound Program.

 In FY21 these programs were transferred from the Defense Health Agency to the United States Army.

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	11.835	12.072	-	12.072
Current President's Budget	0.000	11.403	11.925	-	11.925
Total Adjustments	0.000	-0.432	-0.147	-	-0.147
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-0.432			
• Adjustments to Budget Years	-	-	-0.147	-	-0.147

PE 0602115A: *Biomedical Technology*
Army

UNCLASSIFIED
Page 1 of 4

R-1 Line #6

Volume 1b - 1

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

Appropriation/Budget Activity 2040 / 2				R-1 Program Element (Number/Name) PE 0602115A / *Biomedical Technology*					Project (Number/Name) EB2 / *HIV Biomedical 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
EB2: *HIV Biomedical Technology*	-	-	11.403	11.925	-	11.925	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

The Military Human Immunodeficiency Virus (HIV) Research Program conducts research on HIV, which causes acquired immunodeficiency syndrome (AIDS). Work in this area includes refining improved identification methods to determine genetic diversity of the virus and evaluating and preparing overseas sites for clinical trials with global vaccine candidates. Additional activities include refining candidate vaccines for preventing HIV and undertaking preclinical studies (studies required before testing in humans) to assess vaccine for potential to protect and/or manage the disease in infected individuals. This project is jointly managed through an Interagency Agreement between U.S. Army Medical Research and Development Command (USAMRDC) and the National Institute of Allergy and Infectious Diseases (NIAID) of the National Institutes of Health.

The Combatting Antimicrobial Resistant Bacteria (CARB) research program was established in response to Presidential direction in late 2013 to create a National Strategy to address the critical issue of antimicrobial resistance. This effort's focus is on the development of new/novel antibiotics, especially those targeting the most resistant and worrisome Gram negative bacterial pathogens, using existing expertise at the Walter Reed Army Institute of Research (WRAIR), and leveraging other WRAIR capabilities to evaluate viable candidate targets for advanced discovery. This project supports (both directly and indirectly) Global Health Security Agenda priorities to respond rapidly and effectively to biological threats of international concern.

The cited work is also consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology focus areas, and supports the principal area of Military Relevant Infectious Diseases to include HIV.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: HIV Biomedical Technology	-	9.631	9.956

Description: The Military HIV Research Program conducts research on HIV, which causes AIDS. Work in this area includes refining improved identification methods to determine genetic diversity of the virus and evaluating and preparing overseas sites for future vaccine trials. Additional activities include refining candidate vaccines for preventing HIV and undertaking preclinical studies (studies required before testing in humans) to assess vaccine for potential to protect and/or manage the disease in infected individuals.

FY 2021 Plans:
The Military HIV Research Program produce and characterize new vaccine candidates for use in pre-clinical and clinical testing. Vaccine candidates are evaluated to assess their ability to invoke an immune response in non-human primates by using novel delivery systems containing a diverse mixture of antigens (substance that induces an immune response) for HIV subtypes A, B, C, D and E. The program develops and optimizes methods of large scale production of new vaccine candidates for testing in Africa and Asia to assess candidate vaccines against diverse HIV subtypes. Efforts continue to identify and develop new clinical trial

PE 0602115A: *Biomedical Technology*
Army

UNCLASSIFIED
Page 2 of 4

R-1 Line #6

Volume 1b - 2

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602115A / Biomedical Technology	Project (Number/Name) EB2 / HIV Biomedical Technology

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
sites in Europe, Southeast Africa, Asia and the US in order to allow scientists the opportunity to test future vaccine candidates against predominant HIV subtypes circulating around the world. *FY 2022 Plans:* In FY22 Military HIV Research Program will continue to characterize next generation HIV vaccines and evaluate their capability to induce protective immune responses. The Military HIV Research Program will elucidate mechanisms by which different Army-owned adjuvants contribute to vaccine protection in monkeys. The program will leverage animal models of HIV remission to test novel treatments, including immune therapies (therapeutic vaccines and monoclonal antibodies). The program will continue to assess the HIV threat due to evolving virus genes around the world and continue to track rates of new HIV infections at likely future clinical trial sites. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Combatting Antimicrobial Resistant Bacteria *Description:* The Combating Antimicrobial Resistant Bacteria (CARB) research program focus is to establish in-house capabilities for an antibacterial drug discovery program directed toward military relevant drug-resistant bacteria that a) encompasses assessment of external products/candidates/leads that may meet DoD requirements, b) opens active intramural based discovery efforts of new potential products/candidates/leads for development, and c) fosters partnerships with external collaborators to develop/co-develop new potential antibacterial treatment therapeutics. *FY 2021 Plans:* The CARB program continues its research efforts to evaluate viable small molecule candidate antibacterial agents for planned development for the Department of Defense (DoD) and Public Health benefit. In addition, the program continues its market analysis of established, non-DoD antibiotic programs to identify other promising compounds that could potentially treat military relevant resistant bacteria, establishing partnership and intellectual property rights agreements where necessary. These promising compounds are screened against military relevant strains and biofilms (microorganisms in which cells stick to each other on a surface) in order to select compounds for continued development. Specifically designed novel drugs are synthesized to support lead optimization efforts, exploiting established in vivo (living organism) model standards to treat military relevant resistant bacteria. *FY 2022 Plans:* The CARB program will continue to evaluate and progress viable small molecule candidate antibacterial agents by: investigating powerful front line treatments for wound infections sustained on the battlefield for combat medics to maximally increase the golden hour in support of the MDO concept; fund research to progress established, non-DoD antibiotic programs for utility against priority pathogens identified as threats to the Warfighter and design an Integrated Product Team (IPT) in order to support product maturation toward clinical development; design clinical trials to expand indications of approved or mature investigational antibiotics	-	1.772	1.969

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602115A *I Biomedical Technology*	**Project (Number/Name)** EB2 *I HIV Biomedical Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
to treat wound infections and/or sepsis; internally investigate an additional prototype series to lead optimization and down-select one development candidate. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	-	11.403	11.925

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

D. Acquisition Strategy
 N/A

PE 0602115A: *Biomedical Technology*
Army
UNCLASSIFIED
Page 4 of 4
R-1 Line #6
Volume 1b - 4

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 2: *Applied Research*					PE 0602134A *I Counter Improvised-Threat Advanced Studies*							

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	-	-	1.927	1.976	-	1.976	-	-	-	-	-	-
CD2: *Counter Improvised-Threat Advanced Studies*	-	-	1.927	1.976	-	1.976	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) executes applied research into novel methods for detecting and defeating Improvised Explosive Devices (IED) through the application of emerging technologies as well as research into emerging IED threats to evaluate potential methods of defeat. The goal of this research is to increase the ability of deployed forces to positively identify IEDs with minimal false alarms and positively neutralize or mitigate the effects of IEDs with minimal collateral damage through the systematic identification and maturation of technologies capable of defeating IEDs.

This PE is executed by the Army Futures Command (AFC) in coordination with the Under Secretary of Defense for Research and Engineering (USD/R&E) and the Defense Threat Reduction Agency (DTRA).

Work in this PE was previously conducted under PE 0602134BR, Improvised Threat Reduction Applied Research.

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	2.000	2.000	-	2.000
Current President's Budget	0.000	1.927	1.976	-	1.976
Total Adjustments	0.000	-0.073	-0.024	-	-0.024
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-0.073			
• Adjustments to Budget Years	-	-	-0.024	-	-0.024

PE 0602134A: *Counter Improvised-Threat Advanced Studi...*
Army

UNCLASSIFIED
Page 1 of 3

R-1 Line #7

Volume 1b - 5

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602134A I *Counter Improvised-Threat Advanced Studies*						**Project (Number/Name)** CD2 I *Counter Improvised-Threat Advanced Studies*	
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**
CD2: *Counter Improvised-Threat Advanced Studies*	-	-	1.927	1.976	-	1.976	-	-	-	-	-	-

Note
 This Project is a New Start for Fiscal Year 2021 (FY21).

A. Mission Description and Budget Item Justification
 This Project researches novel methods for detecting and defeating improvised explosive devices (IED) as well as research into emerging IED threats to evaluate potential methods of defeat of the same.

 This Project is executed by the Army Futures Command (AFC) in coordination with the Under Secretary of Defense for Research and Engineering (USD/R&E) and the Defense Threat Reduction Agency (DTRA).

 Work in this Project was previously conducted under PE 0602134BR, Improvised Threat Reduction Applied Research.

 Work in this Project is related to, and fully coordinated with, PE 0603134A Counter Improvised-Threat Simulation
 .

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Counter IED Emerging Technologies	-	1.927	1.976
Description: This effort investigates emerging technologies to include physics, chemistry, biology and computer science to identify applications to detect current and emerging IED threats and defeat their critical components. This effort investigates novel methods and technology solutions for the detection and defeat of IEDs through the systematic identification and maturation of technologies capable of defeating these threats. The goals include increasing the distance for standoff detection, improving the probability of positive identification and reducing the rate of false indications. This effort is informed by technology trends across the Department of Defense and by analysis of IED threats encountered in operational scenarios. *FY 2021 Plans:* Investigate emerging technologies to include physics, chemistry, biology and computer science to identify novel techniques to detect current and emerging IED threats and defeat their critical components. Evaluate multiple technologies to assess			

PE 0602134A: *Counter Improvised-Threat Advanced Studi...*
Army

UNCLASSIFIED
Page 2 of 3

R-1 Line #7

| Volume 1b - 6 |

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602134A *I Counter Improvised-Threat Advanced Studies*	**Project (Number/Name)** CD2 *I Counter Improvised-Threat Advanced Studies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
their ability to counter IED threats in laboratory environments and transition promising technologies to PE 0603134BR Counter Improvised-Threat Simulation, Project CD3 Counter Improvised-Threat Simulation. ***FY 2022 Plans:*** Will investigate novel radio frequency (RF), electromagnetic (EM), electro-optical and infrared (EOIR), neutron-based sensing, and other emerging technologies and technology components. Will continue to investigate and develop multiple technologies to assess their ability to counter IED threats in laboratory environments and transition promising technologies to the sister Project, PE 0603134A Counter Improvised-Threat Simulation, Project CD3 Counter Improvised-Threat Simulation. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	-	1.927	1.976

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality 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**
Total Program Element	-	68.852	117.484	64.126	-	64.126	-	-	-	-	-	-
AH5: *Projectile and Multi-Function Warhead Technologies*	-	3.305	-	-	-	-	-	-	-	-	-	-
AH6: *Disruptive Energetics and Propulsion Technologies*	-	7.934	8.124	8.413	-	8.413	-	-	-	-	-	-
AH7: *Lethal and Scalable Effects Technologies*	-	1.792	1.018	1.911	-	1.911	-	-	-	-	-	-
AH8: *Lethality Materials and Processes Technology*	-	3.791	4.007	4.019	-	4.019	-	-	-	-	-	-
AH9: *Advanced Warheads Technology*	-	9.030	22.933	25.032	-	25.032	-	-	-	-	-	-
AI1: *Advanced Terrain Shaping Technology*	-	-	4.902	-	-	-	-	-	-	-	-	-
BS6: *Lethality Technology (CA)*	-	43.000	76.500	-	-	-	-	-	-	-	-	-
CF7: *Solid-state Laser Concepts and Architectures*	-	-	-	7.547	-	7.547	-	-	-	-	-	-
CF8: *Terminal Effects Against Critical Targets Tech*	-	-	-	4.040	-	4.040	-	-	-	-	-	-
CG4: *Advanced Radar Concepts and Technologies*	-	-	-	4.687	-	4.687	-	-	-	-	-	-
CJ1: *Lethality Enabling University Applied Research*	-	-	-	5.794	-	5.794	-	-	-	-	-	-
CJ6: *Advanced Energetics for Missile Technologies*	-	-	-	1.185	-	1.185	-	-	-	-	-	-
CJ7: *Future Air Defense Missile Enabling Tech*	-	-	-	1.498	-	1.498	-	-	-	-	-	-

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 1 of 33

R-1 Line #8

Volume 1b - 8

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	

A. Mission Description and Budget Item Justification

Work done in this PE researches technologies, methodologies, and models required to enable next generation lethality. The effort focuses on: lethal mechanism technologies for projectiles and warheads that provide revolutionary capability to defeat Tier 1 adversary vehicle and body armors; selection of propulsion and energetic materials and technology to validate novel energetic materials concepts to exploit controllable energy release for future gun/missile systems; scalable effects for mixed target defeat while simultaneously decreasing warhead mass; development of materials solutions for improvement of weight and volume efficiency, lethal effects and sustainability for the warfighter in the Army of today and beyond; and multiple pathways to enhance lethal effects by investigating synergistic effects of novel micro warheads using advanced materials. Funding in this PE is a continuation of work done in PEs 0602105A (Materials Technology), 0602618A (Ballistics Technology), and 0602624A (Weapons and Munitions Technology).

Work in this PE complements PEs 0602147A (Long Range Precision Fires Technology), 0602150A (Air and Missile Defense Technology), 0602143A (Soldier Lethality Technology), 0602144A (Ground Technology), 0602145A (Next Generation Combat Vehicle Technology), and 0603116A (Lethality Advanced Technology).

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

Work in this Project is performed by the United States (US) 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	69.961	42.425	45.824	-	45.824
Current President's Budget	68.852	117.484	64.126	-	64.126
Total Adjustments	-1.109	75.059	18.302	-	18.302
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	76.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.109	-1.441			
• Adjustments to Budget Years	-	-	18.302	-	18.302

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Project: BS6: *Lethality Technology (CA)*		
Congressional Add: *Medium Range Railgun Weapon System*	20.000	-
Congressional Add: *Additive Manufacturing Research*	5.000	-
Congressional Add: *Mobile Environment Contaminant Sensors*	5.000	-

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 2 of 33

R-1 Line #8

Volume 1b - 9

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Congressional Add: *Hybrid Additive Manufacturing*	8.000	-
Congressional Add: *Next Generation Air-Breathing Propulsion Technology*	5.000	-
Congressional Add: *Program increase - next generation remote sensing*	-	5.000
Congressional Add: *Program increase - Advanced lethality concepts and analysis*	-	7.500
Congressional Add: *Program increase - counter UAS technology in arctic environments*	-	10.000
Congressional Add: *Program Increase- Hybrid additive manufacturing*	-	10.000
Congressional Add: *Program increase - novel and sustainable energetic materials*	-	24.000
Congressional Add: *Program increase - quantum technologies for armament systems*	-	10.000
Congressional Add: *Program increase - solid fuel propulsion technology*	-	10.000
Congressional Add Subtotals for Project: BS6	43.000	76.500
Congressional Add Totals for all Projects	43.000	76.500

Change Summary Explanation

Increases in Program Element funding in Fiscal Year (FY) 2022 support new efforts in Projects CF7 (Solid-state Laser Concepts and Architectures), CG4 (Advanced Radar Concepts and Technologies), CJ1 (Lethality Enabling University Applied Research), CJ6 (Advanced Energetics for Missile Technologies), and CJ7 (Future Air Defense Missile Enabling Tech).

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 3 of 33

R-1 Line #8

Volume 1b - 10

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602141A I *Lethality Technology*				**Project (Number/Name)** AH5 I *Projectile and Multi-Function Warhead Technologies*		

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**
AH5: *Projectile and Multi-Function Warhead Technologies*	-	3.305	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and validates novel lethal mechanism technologies to reduce energy or mass required to defeat emerging armor threats and provide multipurpose options for revolutionary capability to include defeat of advanced Tier 1 adversary vehicle and body armors.

This research is coordinated with PE 0602141A (Lethality Technology) / Project AH7 (Lethal and Scalable Effects Technologies), PE 0602143A (Soldier Lethality Technology / Project AY6 (Soldier Squad Small Arms Armaments Technology), and PE 0603462A (Next Generation Combat Vehicle Advanced Technology) / Project BF5 (Adv Lethality & Accuracy System for Med Cal Adv Tech) and builds upon weapon target interaction research in PE 0601102A Defense Research Sciences / Project AA7 (Mechanics and Ballistics).

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 (US) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Defeat of Adversary Vehicle Armors	2.234	-	-
Description: This effort designs, models and evaluates longer range, higher velocity munitions though reduction of parasitic mass required to launch and deliver lethality via new composite materials and architecture; Develops higher energy, more lethal cannon (1.5X M256) through modification of blast field. This effort provides testing and modeling and simulation of Lightweight 50mm Armor Piercing round for advanced, direct-fire medium caliber weapons.			
Title: Defeat of Adversary Body Armor	1.071	-	-
Description: This effort designs, models and evaluates defeat mechanisms for adversary body armor through time-resolved penetration mechanics and energy efficient munitions. This effort supports the development of small caliber lethal mechanisms for PE 0602143A (Soldier Lethality Technology) / Project AY6 (Soldier Squad Small Arms Armaments Technology).			
Accomplishments/Planned Programs Subtotals	3.305	-	-

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* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** AH5 *I Projectile and Multi-Function Warhead Technologies*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy
 N/A

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

Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** AH6 *I Disruptive Energetics and Propulsion Technologies*

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**
AH6: *Disruptive Energetics and Propulsion Technologies*	-	7.934	8.124	8.413	-	8.413	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates, models, and assesses energetic material and propulsion technologies to validate novel concepts such as maximizing total energy density and power delivered on target. This Project also optimizes propellant grains for increased range, and altering gun configurations to increase energy on target in order to exploit the controllable/scalable energy release required for improving effectiveness and reducing vulnerability of future gun/missile systems. This Project builds upon disruptive energetic materials discovery efforts to synthesize new materials with energy content from 50% to up to two times that of Research Department Explosive (RDX) in PE 0601102A (Defense Research Sciences) / Project AA7 (Mechanics and Ballistics). This Project also leverages the advanced additive manufacture efforts of PE 0602144A (Ground Technology) / Project BL1 (Materials and Manufacturing Research Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Synthesis, Formulation and Diagnostics of Energetic Materials *Description:* This effort pursues novel approaches to synthesize and scale up disruptive and traditional energetic materials with increased performance as well as design new formulation avenues in order to discover new materials and formulations to extend range and increase effect on target. This effort also investigates and develops revolutionary ways to release energy and characterize energetic behavior at early time and small length scales for rapid determination of detonation and propellant performance parameters to enable a ?fail early, fail often? strategy. *FY 2021 Plans:* Continue to develop new materials and formulations with 50% better performance than current state of the art; develop scale-up processes of molecules for transition as melt cast / eutectics formulations (go/no-go depending on passing safety, scale-up, and performance parameters); develop new energetic plasticizers and high-temperature materials; formulate new explosive and propellants using synthesized materials (both energetic and polymer); utilize previous or currently under development micro-scale diagnostic techniques to characterize and assess traditional and disruptive energetic candidates for use as high performing rocket / gun propellants or explosive formulations. *FY 2022 Plans:*	4.862	4.764	5.021

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** AH6 *I Disruptive Energetics and Propulsion Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will synthesize and scale-up novel high energy density materials, polymer precursors, plasticizers, and high temperature energetics for inclusion in formulations (melt-cast, cast-cure, and additively manufactured) targeting 50% increased performance in explosive and propellant applications; develop novel small scale rapid experimental assessment methodologies and apply these methodologies to characterize novel energetic material candidates and formulations to assess enhancements in both range and lethality. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Modeling and Simulation of Energetics and Munitions ***Description:*** This effort develops, codes, and subsequently employs advanced models to predict multiscale response of energetic materials for both propellant and explosive purposes. Develops new simulation methods for understanding and design of advanced concepts and energetic formulations to rapidly iterate and optimize towards increased range and enhanced lethality. ***FY 2021 Plans:*** Continue to investigate improved predictive capability for gun interior ballistics design into energetics and munitions software and equation of state and reactivity from first principles into the warhead design continuum software suite; will design simulation results with and transitioned to formulators and advanced concept designers. ***FY 2022 Plans:*** Will further develop novel grain scale modeling capability for inclusion into engineering continuum scale codes for explosive applications; predict expanded sets of chemical kinetic rates for usage in continuum propulsion software for modeling of novel propellants and propulsion concepts; support synthesis and formulation chemists in the prediction of material properties prior to synthesis through the development of machine learning toolsets. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	1.627	1.787	1.804
Title: Advanced Weapon Concepts ***Description:*** This effort investigates new propellants and grain designs, burn rate/combustion modifier ingredients, as well as new gun and munition designs for extended range. ***FY 2021 Plans:***	1.445	1.573	1.588

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** AH6 *I Disruptive Energetics and Propulsion Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Continues to develop and assess advanced additively manufactured propellant designs and geometries to produce higher muzzle energy, longer range gun launched munitions; develops new gun geometries to maximize muzzle velocity while decreasing system weight. ***FY 2022 Plans:*** Will develop, validate, and transition novel weapon concepts, advanced additively manufactured propellant designs, printing technologies, and solid fuel ramjet concepts to partners to enable extended ranges, higher muzzle velocities, and reduced system mass. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	7.934	8.124	8.413

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

D. Acquisition Strategy
 N/A

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 8 of 33

R-1 Line #8

| Volume 1b - 15 |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*					**Project (Number/Name)** AH7 *I Lethal and Scalable Effects Technologies*		
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**
AH7: *Lethal and Scalable Effects Technologies*	-	1.792	1.018	1.911	-	1.911	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

Work in this Project designs, determines and assesses technology options for scaling warhead lethality and providing extreme efficiency for highly effective, simultaneous mixed/multi target defeat and collateral damage. This Project will also design and assess scalable structure defeat to mitigate collateral damage for disruptive urban Warfighting. This research is coordinated with Project AH5 (Projectile and Multi-Function Warhead Technologies) and Project AH6 (Disruptive Energetics and Propulsion Technologies) within this PE and builds upon disruptive energetic and ballistic sciences research in PE 06011102A Defense Research Sciences / Project AA7 (Mechanics and Ballistics). 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 (US) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Munition Efficiency and Scalability	1.792	1.018	1.911

Description: This effort investigates, designs, determines, and assesses technologies to produce blast-fragment warheads with tailored fragment geometries to optimize target defeat. This effort identifies and develops warhead impact patterns to optimize target defeat with reduced collateral damage. This effort also designs, models, and assesses technologies for the cost effective, preprogrammed delivery of multiple scalable warheads capable of simultaneously engaging multiple targets. This effort leverages guidance technologies from PE 0602147A (Long Range Precision Fires) / Project AH4 (Precision and Coop Weapons in a Denied Env Tech), and metal additive manufacturing from PE 0602144A (Ground Technology) / Project BL1 (Materials and Manufacturing Research Technology).

FY 2021 Plans:
Conduct experiments, simulations, and analytic analyses to determine spatial and temporal requirements to achieve synergistic effects; continue to design high fidelity models to optimize munition for mixed target sets and improved models for weapons effects in urban environments; perform vulnerability and lethality studies to select lethal mechanisms for modular munitions.

FY 2022 Plans:
Will continue conducting experiments and lethality studies, will select promising materials and mechanisms for preliminary component-level terminal ballistic experiments; will design and develop devices incorporating improved metals and energetics and integrate concepts into warheads for assessments in full-scale experiments.

FY 2021 to FY 2022 Increase/Decrease Statement:

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 9 of 33

R-1 Line #8

Volume 1b - 16

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** AH7 *I Lethal and Scalable Effects Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding change in FY22 reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	1.792	1.018	1.911

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

D. Acquisition Strategy
 N/A

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 10 of 33

R-1 Line #8

| **Volume 1b - 17** |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602141A I *Lethality Technology*					**Project (Number/Name)** AH8 I *Lethality Materials and Processes 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**
AH8: *Lethality Materials and Processes Technology*	-	3.791	4.007	4.019	-	4.019	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

Work in this Project designs, determines , and assesses innovative materials solutions aimed at achieving leap ahead increases in lethality and weapons effectiveness through improvements in weight and volume efficiency, lethal effects, and sustainability of military systems. This research is coordinated with Projects AH6 (Disruptive Energetics and Propulsion Technology) and Project AH7 (Lethal and Scalable Effects Technologies) within this PE, and PE 0602147A (Long Range Precision Fires Technology) / AH4 (Precision and Cooperative Weapons in a Denied Environment) and builds upon and ballistic sciences research in PE 0601102A (Defense Research Sciences) / Project AA7 (Mechanics and Ballistics).

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 (US) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Materials for Advanced Lethality	3.791	4.007	4.019
Description: This effort researches innovative materials aimed at achieving leap-ahead increases in lethality and weapons effectiveness through improvements in weight and volume efficiency, lethal effects, and sustainability of military systems that can only be achieved through advances in materials technology. *FY 2021 Plans:* Conduct performance testing on C-C composites to withstand the high temperature regimes of large caliber gun launch and flight while retaining structural integrity; conduct three-dimensional printing at 100 micron resolution optimized with energetic propellants to achieve designed progressive burn rates sufficient to increase projectile speeds and ranges in support of PE 0602147A (Long Range Precision Fires Technology). *FY 2022 Plans:* Will develop algorithms to design novel geometries of propellant grains that give progressive or other novel burn behaviors to increase projectile speeds and ranges; assess the effect of ceramic powder modifications for long wave infrared transmission capability on the material toughness and light transmission in the this regime. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	3.791	4.007	4.019

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** AH8 *I Lethality Materials and Processes Technology*

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 12 of 33

R-1 Line #8

Volume 1b - 19

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

Appropriation/Budget Activity 2040 / 2				R-1 Program Element (Number/Name) PE 0602141A / Lethality Technology					Project (Number/Name) AH9 / Advanced Warheads 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
AH9: *Advanced Warheads Technology*	-	9.030	22.933	25.032	-	25.032	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project explores multiple pathways to enhance lethal efforts for future warheads against emerging peer/near peer target sets. Investigates synergistic effects of novel micro warheads using advance materials. This Project investigates innovative energetic materials and novel processing techniques for the next generation of explosives and propulsion applications to enable an increase in range, lethality, and utility of munitions. It also directly supports Army Modernization Priorities through researching and developing energetic (propellant) technologies and processes for increased performance, expanded operation temperature bounds, and improved safety and environmental compliance of missile systems.

Work in this Project complements PE 0602147A (Long Range Precision Fires Technology) / AG6 (Energetic Materials and Advanced Processing Techno), PE 0603464A (Long Range Precision Fires Advanced Technology / AG7 (Energetic Materials and Adv Processing Adv Tech),PE 0602150A (Air and Missile Defense Technology), PE 0602148A (Future Vertical Lift Technology), and 0602145A (Next Generation Combat Vehicle Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Advanced Warheads	9.030	10.488	10.763
Description: This effort explores multiple pathways to enhance lethal effects for future warheads against emerging peer/near peer target sets; Investigates synergistic effects of novel warheads using advanced concepts of operations, materials, geometries, and manufacturing processes. *FY 2021 Plans:* Investigate reactive materials and advanced fragmentation technology to increase lethality by imparting additional energy and enhanced effects on target; investigate novel structural materials and tunable warhead technologies that will provide additional lethality while enabling survivability in high-g gun environments. *FY 2022 Plans:* Will continue to investigate reactive and novel materials including advanced fragmentation designs for integration in warheads that can survive high-g gun environments during projectile launch. Will investigate advanced manufacturing methods, designs and materials for warhead and lethal mechanism concepts to create advances in lethality at increased range and standoff across a broad spectrum of applications. Will investigate advanced Explosively Formed Penetrators (EFP) concepts for increased			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602141A / Lethality Technology	Project (Number/Name) AH9 / Advanced Warheads Technology

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
performance. Will design and develop advanced Modeling and Simulation capabilities using deep learning methods to optimize Shape Charge, Fragmentation and EFP Designs. Will conduct experiments to validate these materials and designs for integration into future munition projects. Will investigate the utility of novel warhead geometries for increased lethality in distributed scenarios.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding decrease due to realignment to PE 0602141A / Project AH9 Advanced Pyrotechnics for exploration of novel pyrotechnic technologies for application across all Army priorities.			
Title: Advanced Energetics	-	11.246	12.810
Description: This effort develops advanced energetic materials and novel processing techniques for future explosives and propulsion applications that enable an increase in range, lethality, and utility of ammunitions. **FY 2021 Plans:** Develop nano-energetic component technologies for use in melt-cast formulations. Develop polymer kinetics for amorphous energetics; investigate next-generation melt-cast and cast-cure ingredients for higher energy formulations. Investigate reaction kinetics for ingredient synthesis. Investigate energetic materials to enable novel energy release mechanisms; design and develop processing parameters necessary to produce energetic materials for additive manufacturing; develop new techniques to accurately predict energetic materials performance in novel and unique geometries **FY 2022 Plans:** Will investigate novel energetic materials; will conduct experiments of enhanced lethality explosive formulations; will conduct experiments of enhanced novel propellant formulations. Will mature advanced initiation concepts and conduct experiments of high energy formulations in representative munitions. Will validate processing parameters necessary to produce energetic materials for additive manufacturing; will investigate modeling and simulation tools required to accurately predict energetic materials performance in novel and unique geometries. Will investigate analytical and experimental capabilities to characterize advanced energetic materials. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.			
Title: Energetics (Propellants)	-	1.199	-
Description: This effort investigates new and emerging energetic ingredients and processes for propellant formulations to enable enhanced performance and mission flexibility by extending the reach and effects of tactical and strategic missile systems. **FY 2021 Plans:**			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** AH9 *I Advanced Warheads Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Investigate current and future substances that provide higher delivered specific impulse density in rocket propellants; novel binders (both energetic and inert); advanced processing techniques to improve mass fraction; investigate improved combustion properties to improve efficiency. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Advanced Pyrotechnics ***Description:*** This effort investigates compositions, components, and technologies to provide novel pyrotechnic formulations and devices to increase overall system performance and survivability. Coordinates research, strategic assessments and development of novel pyrotechnic technologies that will enable disruptive capabilities for Multidomain Operations. This effort supports the Army Modernization Priorities. ***FY 2022 Plans:*** Will investigate novel pyrotechnic materials, components, and configurations. Will investigate pyrotechnic concepts and evaluate the performance and effectiveness for military utility. Will conduct experiments on pyrotechnic components and formulations supporting Army Modernization and Multi-Domain Operations. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase due to realignment to PE 0602141A / Project AH9 Advanced Warheads for exploration of novel pyrotechnic technologies for application across all Army priorities.	-	-	1.459
Accomplishments/Planned Programs Subtotals	9.030	22.933	25.032

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* 2				**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*					**Project (Number/Name)** AI1 *I Advanced Terrain Shaping 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**
AI1: *Advanced Terrain Shaping Technology*	-	-	4.902	-	-	-	-	-	-	-	-	-

Note

In FY 2022, this Project is realigned to:
PE 0602141A Lethality Technology
*Project CF8 Terminal Effects Against Critical Targets Tech

A. Mission Description and Budget Item Justification

This Project designs and develops engineering tools and high-fidelity modeling and simulation capabilities for materials and structural response to predict high-velocity weapons performance to ensure lethality against structures and critical assets. Through dynamic impact experiments for a broad range of velocities against conventional and advanced structural materials, this project develops engineering tools and technologies to rapidly evaluate and predict weapon performance.

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 (U.S.) Engineer Research and Development Center (ERDC) in coordination with U.S. Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advanced Terminal Weapons Effects Technology	-	4.902	-
Description: This effort develops and validates terminal weapons effects prediction capabilities for Long Range Precision Fires (LRPF) weapons against geomaterials, structures, and other critical assets. *FY 2021 Plans:* Conduct laboratory and field experiments to develop and validate modeling and simulation capabilities for accurate prediction of terminal effects and lethality; design and develop fast running engineering tools to support LRPF weapon design optimization and performance evaluation; and design critical structural targets with advanced protective materials to validate weapon performance. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change in FY22 reflects planned lifecycle of this effort; beginning in FY22, work continues under PE 0602141A Project CF8 (Terminal Effects Against Critical Targets Tech).			
Accomplishments/Planned Programs Subtotals	-	4.902	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** AI1 *I Advanced Terrain Shaping Technology*

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

D. Acquisition Strategy
 N/A

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 17 of 33

R-1 Line #8

Volume 1b - 24

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 / 2					**R-1 Program Element (Number/Name)** PE 0602141A / Lethality Technology				**Project (Number/Name)** BS6 / Lethality Technology (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**
BS6: *Lethality Technology (CA)*	-	43.000	76.500	-	-	-	-	-	-	-	-	-

Note
 Congressional Interest Item funding provided for Lethality Technology.

A. Mission Description and Budget Item Justification
 Congressional Interest Item funding provided for 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**
Congressional Add: Medium Range Railgun Weapon System	20.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Medium Range Railgun Weapon System. Work executed by Army Futures Command.		
Congressional Add: Additive Manufacturing Research	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Additive Manufacturing Research. Work executed by Army Futures Command.		
Congressional Add: Mobile Environment Contaminant Sensors	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Mobile Environment Contaminant Sensors. Work executed by Army Futures Command.		
Congressional Add: Hybrid Additive Manufacturing	8.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Hybrid Additive Manufacturing. Work executed by Army Futures Command.		
Congressional Add: Next Generation Air-Breathing Propulsion Technology	5.000	-

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 18 of 33

R-1 Line #8

Volume 1b - 25

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602141A / *Lethality Technology*	**Project (Number/Name)** BS6 / *Lethality Technology (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
FY 2020 Accomplishments: Program Increase supported applied research on Next Generation Air-Breathing Propulsion Technology. Work executed by Army Futures Command.		
Congressional Add: Program increase - next generation remote sensing	-	5.000
FY 2021 Plans: Conduct applied research in Next Generation Remote Sensing. Work executed by Army Futures Command.		
Congressional Add: Program increase - Advanced lethality concepts and analysis	-	7.500
FY 2021 Plans: Conduct applied research in Advanced Lethality Concepts and Analysis. Work executed by Army Futures Command.		
Congressional Add: Program increase - counter UAS technology in arctic environments	-	10.000
FY 2021 Plans: Conduct applied research in Counter UAS Technology in Artic Environments. Work executed by Army Futures Command.		
Congressional Add: Program Increase- Hybrid additive manufacturing	-	10.000
FY 2021 Plans: Conduct applied research in Hybrid Additive Manufacturing. Work executed by Army Futures Command.		
Congressional Add: Program increase - novel and sustainable energetic materials	-	24.000
FY 2021 Plans: Conduct applied research in Novel and Sustainable Energetic Materials. Work executed by Army Futures Command.		
Congressional Add: Program increase - quantum technologies for armament systems	-	10.000
FY 2021 Plans: Conduct applied research in Quantum Technologies for Armament Systems. Work executed by Army Futures Command.		
Congressional Add: Program increase - solid fuel propulsion technology	-	10.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** BS6 *I Lethality Technology (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
FY 2021 Plans: Conduct applied research in Solid Fuel Propulsion Technology. Work executed by Army Futures Command.		
Congressional Adds Subtotals	43.000	76.500

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* 2					**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*					**Project (Number/Name)** CF7 *I Solid-state Laser Concepts and Architectures*		
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**
CF7: *Solid-state Laser Concepts and Architectures*	-	-	-	7.547	-	7.547	-	-	-	-	-	-

Note
 This effort has been realigned from PE0602150A Project AD2 in FY 2022.

A. Mission Description and Budget Item Justification
 This Project provides the research and development of advanced solid-state laser materials and architectures to support the Army Directed Energy Strategy for laser-based directed energy (DE) weapons. This Project investigates advanced laser technologies based on unconventional solid-state laser concepts and designs, scalable and intelligent power modules, and advanced thermal management systems for the development of less complex, low size, weight, and power (SWaP) Army DE weapons and tactical lasers with much improved capabilities.

 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 (US) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: High Energy Laser (HEL) Enabling Technologies for Tactical Directed Energy Weapons *Description:* Investigate novel solid-state laser concepts, architectures, and components in support of the Army?s HEL weapons strategy.; develop innovative laser gain materials with much improved spectral, thermal, thermo-mechanical, and thermo-optical properties; and develops increased power while reducing size and weight, and complexity of all HEL components *FY 2022 Plans:* Will further explore the potential of fiber laser power scaling based on crystalline core/crystalline cladding (C4) fiber designs, as it pertains to power scaling to a 5 kW power level, continuous wave (CW); design and develop new high power pump couplers with reduced insertion loss and advanced heat management; investigate advanced fiber end-capping techniques, enabling power scaling out of a single fiber aperture well beyond the current state-of-the-art; model and analyze wide band gap semiconductor performance in the power switching system with the goal of providing higher efficiency. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort has been realigned from PE0602150A Project AD2 in FY 2022.	-	-	7.547
Accomplishments/Planned Programs Subtotals	-	-	7.547

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** CF7 *I Solid-state Laser Concepts and Architectures*

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 22 of 33

R-1 Line #8

Volume 1b - 29

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 **/** 2					**R-1 Program Element (Number/Name)** PE 0602141A **/** *Lethality Technology*					**Project (Number/Name)** CF8 **/** *Terminal Effects Against Critical Targets Tech*	

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
CF8: *Terminal Effects Against Critical Targets Tech*	-	-	-	4.040	-	4.040	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this Project is realigned from: PE 0602141A Lethality Technology, *Project AI1 Advanced Terrain Shaping Technology

A. Mission Description and Budget Item Justification

This Project designs and develops engineering tools and high-fidelity modeling and simulation capabilities for materials and structural response to predict and enhance weapons performance to ensure lethality against structures and critical assets. Through dynamic impact experiments for a broad range of velocities against conventional and advanced structural materials, this project develops engineering tools and technologies to rapidly evaluate and predict weapon performance.

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 (U.S.) Engineer Research and Development Center (ERDC) in coordination with U.S. Army Futures Command (AFC).

Work in this Project complements PE 0603116A (Lethality Advanced Technology) / Project CH5 (Terminal Effects Against Critical Targets Adv Tech).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Advanced Terminal Weapons Effects Technology	-	-	4.040
Description: This effort develops and validates terminal weapons effects prediction capabilities for Long Range Precision Fires (LRPF) weapons against geomaterials, structures, and other critical assets. *FY 2022 Plans:* Will conduct lab and scaled field experiments of blast/fragmentation munitions against critical protective materials; will design and begin development of fast running engineering tools to support LRPF weapon design and performance evaluation; and will investigate Battle Damage Assessment (BDA) using Non-Line-of-Sight (NLOS) imagery. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change in FY22 reflects planned lifecycle of this effort; beginning in FY22, this effort continues research conducted previously under PE 0602141A Project AI1 (Advanced Terrain Shaping Technology) for enhanced battle damage assessment and effectiveness using current and new long range Army weapon systems.			
Accomplishments/Planned Programs Subtotals	-	-	4.040

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** CF8 *I Terminal Effects Against Critical Targets Tech*

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 24 of 33

R-1 Line #8

Volume 1b - 31

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*					**Project (Number/Name)** CG4 *I Advanced Radar Concepts and Technologies*		

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
CG4: *Advanced Radar Concepts and Technologies*	-	-	-	4.687	-	4.687	-	-	-	-	-	-

Note
This effort has been realigned from PE0602150A Project AD5 in FY 2022.

A. Mission Description and Budget Item Justification

This Project conducts experiments on single crystal diamond and diamond hetero-structure semiconductor materials, layered structures, and novel devices for Diamond Electronics for Radar, Communications, and improved Size, Weight, and Power (SWaP) Department of Defense systems. Efforts include multiscale modeling, material and structure growth and characterization, and novel device design and fabrication. This research has application to radars, communication systems, electronic warfare, directed energy, electronics for hypersonic systems, radiation hard systems, quantum sensing, and others. This Project directly supports Air and Missile Defense modernization priority capabilities by investigating essential component technologies for insertion into Multi-Mission Army Radar systems. This Project addresses the challenges of integrating new materials into Silicon Complementary Metal Oxide Semiconductor (CMOS) processing flows, and electronics reliability including protection against unintended adversarial use of state-of-the-art semiconductor materials, devices, and systems for Air and Missile Defense in contested environments.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) Project AD6 (Next Generation Fires Radar Advanced Technology).

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Antennas and RF Device Components for Advanced Electronic Systems	-	-	4.687
Description: Conduct experiments into novel diamond material and device structures operable in the Radio Frequency (RF) electromagnetic spectrum with high radiated power density for increased radar range and better target detection, improved efficiency of communications systems, smaller Size, Weight, and Power (SWaP) for electronics/cooling of autonomous systems, high temperature electronics for hypersonics, and radiation hardened electronics.			
FY 2022 Plans: Will investigate the growth and properties of single crystal diamond and diamond/boron nitride heterostructures, including different carbon-boron-nitrogen compositions, n-type and p-type doping of the alloys, and the generation of defects associated with growth techniques and fundamental studies on chip-scale.			
FY 2021 to FY 2022 Increase/Decrease Statement:			

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 25 of 33

R-1 Line #8

| Volume 1b - 32 |

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** CG4 *I Advanced Radar Concepts and Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
This effort has been realigned from PE0602150A Project AD6 in FY 2022.			
Accomplishments/Planned Programs Subtotals	-	-	4.687

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* 2					**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*					**Project (Number/Name)** CJ1 *I Lethality Enabling University Applied 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
CJ1: *Lethality Enabling University Applied Research*	-	-	-	5.794	-	5.794	-	-	-	-	-	-

Note

This is a new start in FY 2022.

This project is a FY22 new start. This project was created to demonstrate increased investment in our university partners.

A. Mission Description and Budget Item Justification

The Project leverages research and technological innovations from academia, of lethal directed energy, laser diagnostics and accelerated design of future hypersonics, deep learning (DL) and novel materials of importance to the Army, by accelerating research and conducting experiments focused on getting technology to the warfighter more quickly. This Project performs discovery research efforts to focus more on mid to far-term Army modernization priorities while also maintaining delivery of near-term technologies critical to the Long Range Precision Fires and Air and Missile Defense. This Project focuses on employment of research technologies originating from extramural applied research in academia pertaining to lethal directed energy, laser diagnostics, future hypersonic glide body design, deep learning (DL), novel materials, and expansion of the Ballistic, Aero-Optics and Materials (B.A.M.) range applied to lethality. This effort conducts applied research and development leading to potential emerging technologies in areas of strategic importance to the Army in directed energy, future hypersonic glide body design, deep learning (DL) and novel materials, etc., by bringing competitively selected Universities with research and development teams into Technical Alliances.

Work in this Project supports the Army Modernization Priority Long Range Precision Fires and Air and Missile Defense.

The cited work is consistent with 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 (US) Army Futures Command.

This work is done in coordination with PE 0602147A (Long Range Precision Fires), PE 0602150A (Air and Missile Defense Technologies)

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Laser Diagnostics for Hypersonics and Directed Energy	-	-	1.978
Description: This effort researched systematic expansion in laser diagnostics technologies to assess hypersonic turbulence and boundary layer transition. Work is conducted in collaboration with university partners to advance the effects of atmospheric turbulence on laser propagation and gain applied knowledge in directed energy systems effectiveness and range. *FY 2022 Plans:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021		
Appropriation/Budget Activity 2040 *I* 2		**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** CJ1 *I Lethality Enabling University Applied Research*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will investigate methods to expand laser diagnostics and the flight envelope of the existing glide body, accelerate design of block upgrades and future hypersonic glide bodies; reduce flight test risks. Will investigate new backward lasing guidestar methods to improve correction for atmospheric distortion. Will conduct experiments to inform the development of the Ballistic, Aero-Optics and Materials (B.A.M.) range for testing and evaluation of hypersonic and directed energy systems. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort is a new start.			
Title: Turbulence and Transition Modeling and Validation for Hypersonic Vehicles ***Description:*** This effort is conducted in collaboration with university partners to develop modeling tools to help inform the flight envelope of existing hypersonic vehicles to accelerate design of future hypersonic glide bodies. ***FY 2022 Plans:*** Will design and develop modeling techniques to expand the flight envelop and control of the existing glide body. Funds applied research to inform the development of the Ballistic, Aero-Optics and Materials (B.A.M.) range for testing and evaluation of aerothermodynamic performance at hypersonic speeds. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort is a new start.	-	-	1.852
Title: Novel Materials for Extreme Environments ***Description:*** This effort produces a test environment for thermal and ablation evaluation of novel materials relevant to hypersonic vehicles. Work is conducted in collaboration with university partners to assess material characteristics and develop computational models of high strain rate materials to mitigate the effects of high kinetic energy impacts. ***FY 2022 Plans:*** Will develop critical high temperature materials and characterize for the design of thermal protection systems to overmatch from high temperatures and high kinetic energy impacts. Will investigate material ablation models and the effect of material layering on ballistics and hypervelocity impact energy absorption, damage mitigation, and penetration resistance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort is a new start.	-	-	1.100
Title: Intelligent Hypersonics and Other Vehicle Systems ***Description:*** This effort develops and designs geometrically relevant testing hardware required to study aerothermodynamic performance. Work is conducted in collaboration with university partners to collect experimental data and insights required to	-	-	0.864

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** CJ1 *I Lethality Enabling University Applied Research*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
train deep learning neural networks used for the development of hypersonic vehicle flight systems with adaptability and increased lethality. ***FY 2022 Plans:*** Will investigate characterization of hardware ablation (or structural deformation) using Mach 5 or above wind tunnel. Will design and develop testing hardware for data collection and training of deep neural network using wind tunnel data and synthetic flight control system of a geometrically relevant vehicle. Will develop intelligent defense vehicle systems using deep learning (DL) algorithms for improved surveillance, detection, and tracking and overcoming line-of-sight constraints. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort is a new start.			
Accomplishments/Planned Programs Subtotals	-	-	5.794

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* 2				**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*					**Project (Number/Name)** CJ6 *I Advanced Energetics for Missile Technologies*		
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**
CJ6: *Advanced Energetics for Missile Technologies*	-	-	-	1.185	-	1.185	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project was realigned from Program Element (PE) 0602141A/AH9 Advanced Warheads Technology.

A. Mission Description and Budget Item Justification

This Project directly supports Army Modernization Priorities through funding research and developing energetic (propellant) technologies and processes for increased performance, expanded operation temperature bounds, and improved safety and environmental compliance of missile systems.

Work in this Project complements PE 0602147A (Long Range Precision Fires Technology), PE 0602150 (Air and Missile Defense Technology); and 0602141A/AH9 Advanced Energetics Technology.

The cited work is consistent with the Assistant 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 (US) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advanced Energetics Technology (Missiles) *Description:* This effort investigates new and emerging energetic ingredients and processes for propellant formulations to enable enhanced performance and mission flexibility by extending the reach and effects of tactical and strategic missile systems. *FY 2022 Plans:* Will investigate current and future substances that provide higher delivered specific impulse density in rocket propellants; novel binders (both energetic and inert); will mature processing techniques to improve mass fraction; and will investigate explore concepts for improved combustion properties to improve efficiency. *FY 2021 to FY 2022 Increase/Decrease Statement:* Fiscal Year (FY) 2022 this Project was realigned from Program Element (PE) 0602141A/AH9 Advanced Warheads Technology	-	-	1.185
Accomplishments/Planned Programs Subtotals	-	-	1.185

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* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** CJ6 *I Advanced Energetics for Missile Technologies*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy
 N/A

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 31 of 33

R-1 Line #8

Volume 1b - 38

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602141A I *Lethality Technology*						Project (Number/Name) CJ7 I *Future Air Defense Missile Enabling Tech*	
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
CJ7: *Future Air Defense Missile Enabling Tech*	-	-	-	1.498	-	1.498	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project was realigned from Program Element (PE) 0602150A/AD3 Manuever Air Defense Technology, Task Future Air Defense Missile Enabling Technology.

A. Mission Description and Budget Item Justification

This project investigates, develops, and evaluates critical missile technologies and components necessary for advanced lethal capability in support of future/mid to far term affordable short range air defense interceptor capability to defeat Cruise Missile (CM), Rotary Wing (RW), Tactical / Lethal Unmanned Aerial System (UAS), and Fixed Wing (FW) threats. This effort designs and develops technologies to provide advanced materials for reduced size weight and power and cost for Maneuver Short Range Air Defense (MSHORAD), Short Range Air Defense (SHORAD), and Lower Tier essential to maintain overmatch against mid-/far-term threats. This project supports Air and Missile Defense Modernization priority efforts.

This research is coordinated with Project PE 602141A Lethality Technology /CJ6 (Advanced Energetics for Missile Technologies); PE 0602147A Long Range Precision Fires Technology /AF3 (Extended Range Propulsion) and AF8 (Affordable Extended Range Precision). The research complements PE 602150A Air and Missile Defense Technology /AD3 (Manuever Air Defense Technology) and PE 0603466A Air and Missile Defense Advanced Technology / AD4 (Maneuver Air Defense Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Future Air Defense Missile Enabling Technology	-	-	1.498

Description: Designs and develops reduced cost advanced Air Defense missile critical components essential to maintain overmatch against mid/far term Maneuver-Short Range Air Defense (M-SHORAD), SHORAD, and Lower Tier threats.

FY 2022 Plans:
Will conduct component level trade studies and will investigate reduced space, weight, power and cost designs for improved future Air Defense missile seeker, guidance and control, aerostructures, and propulsion technologies.

FY 2021 to FY 2022 Increase/Decrease Statement:

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602141A *I Lethality Technology*	**Project (Number/Name)** CJ7 *I Future Air Defense Missile Enabling Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Realigned from Program Element (PE) 0602150A/AD3 Manuever Air Defense Technology, Task Future Air Defense Missile Enabling Technology;			
Accomplishments/Planned Programs Subtotals	-	-	1.498

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

D. Acquisition Strategy
 N/A

PE 0602141A: *Lethality Technology*
Army

UNCLASSIFIED
Page 33 of 33

R-1 Line #8

Volume 1b - 40

| 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 2: Applied Research					PE 0602142A I Army Applied 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	-	30.733	30.757	28.654	-	28.654	-	-	-	-	-	-
BS1: Army Applied Research	-	30.733	30.757	28.654	-	28.654	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

The Army Applied Research budget line includes systematic application of knowledge toward the production of useful materials, devices and systems or methods including the design, development and improvement of science and technology for Army applications.

Efforts in this budget line include studies, investigations and non-system specific technology efforts leading to bread-board hardware or proof of principle analysis.

B. Program Change Summary ($ in Millions)

	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Previous President's Budget	30.819	30.757	29.510	-	29.510
Current President's Budget	30.733	30.757	28.654	-	28.654
Total Adjustments	-0.086	0.000	-0.856	-	-0.856
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.086	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	-0.856	-	-0.856

PE 0602142A: Army Applied Research
Army

UNCLASSIFIED
Page 1 of 1

R-1 Line #9

Volume 1b - 41

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality 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**
Total Program Element	-	141.154	201.750	105.168	-	105.168	-	-	-	-	-	-
AN1: *Narrowband SATCOM Technology*	-	3.836	-	-	-	-	-	-	-	-	-	-
AY6: *Soldier Squad Small Arms Armaments Technology*	-	17.590	13.122	8.825	-	8.825	-	-	-	-	-	-
AY8: *Small Arms Fire Control Technology*	-	-	1.828	4.172	-	4.172	-	-	-	-	-	-
AZ2: *Body Armor & Integrated Headborne Technology*	-	8.081	6.575	6.664	-	6.664	-	-	-	-	-	-
AZ5: *Soldier Protection Technology - Vulnerability*	-	7.770	11.974	9.357	-	9.357	-	-	-	-	-	-
AZ9: *Soldier Protection Advanced Tech - Detectability*	-	4.314	3.278	1.883	-	1.883	-	-	-	-	-	-
BB4: *Dismounted Soldier Survivability Materials*	-	4.742	2.991	2.828	-	2.828	-	-	-	-	-	-
BB5: *Physical Augmentation: Tech for Human Interactions*	-	1.438	1.451	1.332	-	1.332	-	-	-	-	-	-
BB7: *Exoskeleton: Technology for Man-Machine Interface*	-	1.534	1.541	-	-	-	-	-	-	-	-	-
BB9: *Human Performance Tech for Mobility & Lethality*	-	2.397	2.997	2.961	-	2.961	-	-	-	-	-	-
BC2: *Next Gen Mobility & Lethality Tech for Warfighters*	-	5.444	7.245	7.725	-	7.725	-	-	-	-	-	-
BC3: *Soldier Decision Making & Comms Performance Tech*	-	10.316	4.378	-	-	-	-	-	-	-	-	-
BC6: *Human Perf - Tech for Warfighter Enhancement*	-	2.566	2.918	3.350	-	3.350	-	-	-	-	-	-
BC7: *Training Technology (Other than STE)*	-	-	13.651	14.244	-	14.244	-	-	-	-	-	-

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 1 of 61

R-1 Line #10

Volume 1b - 42

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 2: *Applied Research*

R-1 Program Element (Number/Name)
PE 0602143A I *Soldier Lethality Technology*

BD1: *Adv Soldier Sensors/ Displays Tech for Dismounts*	-	4.763	11.100	11.651	-	11.651	-	-	-	-	-	-
BD6: *Soldier Sys Interfaces/ Integration- Sensor Tech*	-	1.077	1.084	0.513	-	0.513	-	-	-	-	-	-
BD8: *Soldier & Sm Unit Tactical Energy Tech*	-	8.769	9.043	4.467	-	4.467	-	-	-	-	-	-
BE1: *Support Technology to Mission Command*	-	0.696	-	-	-	-	-	-	-	-	-	-
BE3: *Joint Service Combat Feeding Technology*	-	3.832	4.109	4.024	-	4.024	-	-	-	-	-	-
BE6: *Reactive/Resp Surfaces & Matls-Soldiers & Sys*	-	2.632	6.215	2.955	-	2.955	-	-	-	-	-	-
BE8: *Synthetic Training Environment (STE) Technology*	-	14.802	13.649	14.741	-	14.741	-	-	-	-	-	-
BP9: *Soldier Lethality Technologies (CA)*	-	30.626	79.000	-	-	-	-	-	-	-	-	-
BR9: *Personnel & Airdrop Safety Technology*	-	3.929	3.601	3.476	-	3.476	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This PE conducts fundamental research on Soldier Lethality technologies to develop an integrated Soldier and Squad architecture of equipment and systems that improve Soldier and Small Combat Unit survivability, sustainability, mobility, combat effectiveness, and individual cognitive and physical readiness. To address the challenges of integrating multiple technologies and sub-systems, research conducted in this PE, significant Science and Technology applied research investments in all areas of Soldier Lethality, focus on how to improve the effectiveness of the technologies a Soldier utilizes and apply systems-level practices to mitigate constraints from size and weight of the equipment. Research areas encompass individual and crew-served weapon designs and technologies as well as applied research in lightweight and transparent armor materials to mitigate effects from blast and ballistic threats, counter explosive hazard detection, counter-sensor capabilities, and signature management of weapons, equipment, personnel and high value targets. This PE investigates, develops and designs materials, technologies, methodologies and system models required to experiment and optimize Soldier lethality and survivability through investments in mobility, human-agent teaming, and improved situational awareness interfaces and display technologies as well as to provide Soldier-borne power and energy materials and components that support multiple Soldier-borne systems. This PE also investigates Warfighter training technologies and develops the underpinning technologies to establish architecture standards and interfaces necessary for creating realistic synthetic environments to create a single, interconnected synthetic training system to enable Army units and leaders to conduct realistic multi-echelon / multi-domain combined arms maneuver and mission command training, increasing proficiency through repetition. Human Factors Engineering projects conduct applied research to design weapon systems standards, guidelines, handbooks, and Soldier training curriculum and tools.

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*

Results of these efforts are transitioned within the Army Futures Command, the Program Executive Offices, Army Training and Doctrine Command (TRADOC), Army Medical Command (MEDCOM), Human Systems Integration (HSI) Directorate (Army G1), and the Army Test and Evaluation Command (ATEC).

Work in this PE complements PE 0603118A (Soldier Lethality Advanced Technology).

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	145.900	125.435	130.599	-	130.599
Current President's Budget	141.154	201.750	105.168	-	105.168
Total Adjustments	-4.746	76.315	-25.431	-	-25.431
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	79.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-4.746	-2.685			
• Adjustments to Budget Years	-	-	-25.431	-	-25.431

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

	FY 2020	FY 2021
Project: BP9: *Soldier Lethality Technologies (CA)*		
Congressional Add: *Medical simulation and training*	3.626	-
Congressional Add: *Active and passive camouflage concealment and deception*	3.000	-
Congressional Add: *Human systems integration*	10.000	-
Congressional Add: *Expeditionary mobile base camp technology*	2.000	-
Congressional Add: *SOCOM communications capability*	2.500	-
Congressional Add: *Soldier Lethality Technologies Program Increase*	5.000	-
Congressional Add: *Harnessing Emerging Soldier Lethality Technology Research*	4.500	-
Congressional Add: *Program increase - pathfinder airborne*	-	8.000
Congressional Add: *Program Increase - Pathfinder Air Assault*	-	10.000
Congressional Add: *Program increase - Rapidly deployable shelters*	-	3.000

PE 0602143A: *Soldier Lethality Technology*
Army
UNCLASSIFIED
Page 3 of 61
R-1 Line #10
Volume 1b - 44

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Congressional Add: *Program increase - UTDD catalyst*	-	5.000
Congressional Add: *Program increase - lightweight body armor mechanisms and materials*	-	10.000
Congressional Add: *Program increase - advanced textile-based products*	-	6.000
Congressional Add: *Program increase - HEROES program*	-	5.000
Congressional Add: *Program increase - soldier ballistic technologies*	-	5.000
Congressional Add: *Program increase - medical simulation and training*	-	4.000
Congressional Add: *Program increase - body armor study*	-	4.000
Congressional Add: *Program increase - academic accelerator pilot program*	-	15.000
Congressional Add: *Program increase - Advanced ballistics technology for personal protective systems*	-	4.000
Congressional Add Subtotals for Project: BP9	30.626	79.000
Congressional Add Totals for all Projects	30.626	79.000

Change Summary Explanation

Program element decrease primarily due to the creation of a new program element, 0602184A - Soldier Applied Research. This PE has a focus on enabling technologies that are fundamental to Warfighter success and advancement.

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 4 of 61

R-1 Line #10

Volume 1b - 45

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

| Appropriation/Budget Activity
2040 / 2 | | | | | R-1 Program Element (Number/Name)
PE 0602143A / Soldier Lethality Technology | | | | Project (Number/Name)
AN1 / Narrowband SATCOM 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
AN1: *Narrowband SATCOM Technology*	-	3.836	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops technologies to enable gateway communications across disparate Narrowband Satellite Communications (SATCOM) networks, enabling resiliency in contested environments. The Narrowband SATCOM network is the largest tactical network operated by the Army to provide situational understanding across all echelons. This Project investigates technologies and protocols to enable risk mitigation solution sets and awareness through adaptive learning capabilities.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) / Project AN2 (Narrowband SATCOM Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Narrowband Satellite Communication Technology	3.836	-	-
Description: This research effort designs and develops technologies to enable gateway communications across disparate Narrowband SATCOM networks, enabling resiliency in contested environments. The Narrowband SATCOM network is the largest tactical network operated by the Army to provide situational understanding across all echelons. This project investigates technologies and protocols to enable risk mitigation solution sets and awareness through adaptive learning capabilities.			
Accomplishments/Planned Programs Subtotals	3.836	-	-

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 5 of 61

R-1 Line #10

Volume 1b - 46

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2						**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*				**Project (Number/Name)** AY6 *I Soldier Squad Small Arms Armaments 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**
AY6: *Soldier Squad Small Arms Armaments Technology*	-	17.590	13.122	8.825	-	8.825	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates individual and crew-served weapon designs and technologies that enhance the fighting capabilities and survivability of the dismounted Warfighter in support of all of the Services. In addition, it conceives and advances weapon concepts based on innovative ballistic and advanced incapacitation technologies that will enhance the defeat of hard and soft infantry targets at extended ranges based upon the Joint Service Small Arms Technology Development Strategy (JSATDS). The Project will continue to support technology needs from the all Services to include the Next Generation Family of Weapons. In addition, this Project will develop the technology/weapons concepts that will upgrade medium and heavy support weapons at echelons. Finally, this Project will perform research directed toward non-kinetic modalities to incapacitate combatants.

Work in this Project supports key Army needs and leverages the technical research of several PEs to include PE 0601102A (Defense Science Research) / Project AA7 (Mechanics and Ballistics), PE 0603118A (Soldier Lethality Advanced Technology), and PE 0602141A (Lethality Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Soldier/Squad Lethality Technology	2.072	4.103	4.027
Description: This effort conceives and investigates advanced weapons concepts based on innovative ballistic technologies that will enhance the defeat of hard and soft infantry targets at extended ranges to ensure overmatch in Soldier and Squad lethality. This effort will also perform research directed toward non-ballistic modalities to incapacitate combatants. *FY 2021 Plans:* Continue to identify novel lethal mechanisms for future weapons concepts and technical approaches for increased lethality at reduced energy for behind armor/barrier threats; utilize state of the art instrumentation to further characterize technology concepts to enable a reduction in dispersion for complex projectiles; determine benefits in capability for novel weapons systems for increased performance of heavy small caliber weapons as well as precision systems; and assess biological effects and incapacitation potential of advanced high powered microwave and acoustic directed energy technologies in small and large animal models. *FY 2022 Plans:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021		
Appropriation/Budget Activity 2040 I 2		R-1 Program Element (Number/Name) PE 0602143A I *Soldier Lethality Technology*	Project (Number/Name) AY6 I *Soldier Squad Small Arms Armaments Technology*		

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will design the basic theory for dispersion to reduce the dispersion complex lethal mechanisms required by next generation individual and precision (sniper) weapons; investigate advanced experimental capabilities to reduce the time and significantly increase the capacity of free flight spark ranges; investigate the potential capability for medium and heavy weapons that offer significant improvements in size, weight (reductions), and lethality (classified) performance; continue pursuing incapacitation potential of advanced high powered microwave and acoustic directed energy technologies in small and large animal models using new experimental facilities for determining underlying theory of these technologies. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.			
Title: Human-Agent Interactions for Intelligent Squad Weapons **Description:** This effort investigates enhanced target acquisition, situational awareness, and shooting performance through Soldier-centered integration of intelligent technologies and distributed information in augmented squad weapons. Enhances operational performance of individuals and teams of Soldiers through novel weapon and human-agent interaction technologies. **FY 2021 Plans:** Develop and document knowledge products, including data analysis documentation and guidelines for Soldier/Advanced Target Recognition (ATR) interaction methods, contributing to a framework for bidirectional ATR display and interaction techniques, aimed at maximizing Soldier-intelligent fire control teamed target acquisition performance and situational awareness within the usable field of view. **FY 2021 to FY 2022 Increase/Decrease Statement:** In FY 2022, effort has been realigned to PE 0602184A Project CN2.	3.408	3.713	-
Title: Next Generation Carbine Technology (NGCT) **Description:** This effort develops next generation squad weapon systems and ammunition by providing tech insertions to augment capabilities and mitigate risks. Mature small arms weapon system components and validate them through experimentation in support of the Joint Warfighter?s capability needs. Mature weapon system technology readiness levels and validate confidence of functionality in advanced operating scenarios.	1.333	-	-
Title: Next Generation Family of Ammo (NGFoA) **Description:** This effort designs and develops a family of ammunition for automatic rifles and carbine weapons with the objective of decreasing weight, increasing lethality and hit performance over current fielded systems; develops capabilities to defeat threat targets at extended ranges.	6.412	1.677	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** AY6 *I Soldier Squad Small Arms Armaments Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2021 Plans: Finalize maturation of component technologies for the next generation of small arms training rounds, training tracer projectiles, and ammunition training aides; conduct experiments with mature tracer component technologies to validate tracer design performance characteristics. *FY 2021 to FY 2022 Increase/Decrease Statement:* NGFoA effort ends in FY 2021			
Title: Small Arms Enabling Technologies *Description:* This effort designs and develops small arms weapon systems, enablers, and ammunition technologies that will maintain decisive lethal overmatch capabilities to the Joint Warfighter. This effort matures small arms weapon system designs through experimentation in support of Joint Warfighter's capability needs. *FY 2021 Plans:* Investigate emerging small arms technologies to develop remote powered armament systems, advanced target recognition and aim augmentation, alternate barrel materials and coatings, signature reduction technologies, etc.; continue investigation of small arms remote armament component technologies for increasing the overall probability of hit. *FY 2022 Plans:* Will Investigate and conduct experiments on remote armaments for precision, volume, and counter defilade fires; augmentation technologies for increased weapon system/man-in-the loop performance; non-line of sight, three-dimensional battlefield target sensing and reconstruction; and technologies that reduce small arms weapon maintenance. Will investigate component technologies for future small arms concepts to enable a more efficient, effective, and lethal Joint Warfighter. *FY 2021 to FY 2022 Increase/Decrease Statement:* The increase provides for investigation and experiments for the Dismounted Soldier advances in denied and austere environments in the areas of NGSW supporting component technologies, passive technologies to reduce weapon system signature, and leverage and integrate emerging AI technology to weapon enablers.	4.365	3.629	4.798
Accomplishments/Planned Programs Subtotals	17.590	13.122	8.825

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

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 8 of 61

R-1 Line #10

Volume 1b - 49

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** AY6 *I Soldier Squad Small Arms Armaments Technology*

D. Acquisition Strategy
  N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 9 of 61

R-1 Line #10

| **Volume 1b - 50** |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602143A I *Soldier Lethality Technology*					**Project (Number/Name)** AY8 I *Small Arms Fire Control 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
AY8: *Small Arms Fire Control Technology*	-	-	1.828	4.172	-	4.172	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops enabling technology for advanced small arms fire control in order to achieve lethality overmatch by supporting target prioritization, enhancing processing of information from multiple sources, and investigating aim assistance tools which remove Soldier aim error. This Project specifically supports the Army Science and Technology Soldier Lethality modernization priority.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Modernization Strategy, and the Soldier Lethality Cross Functional Team (CFT) efforts. All FY21 adjustments align program financial structure to Army Modernization Priorities in support of the National Defense Strategy.

This Project complements work done in PE 0603118A (Soldier Lethality Advanced Technology) / AY7 (Small Arms Fire Control Advanced Technology).

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: Adv. Fire Control Tech **Description:** This Project investigates software and hardware mechanisms to enable enhanced kill chain processes on small arms platforms. This includes investigating artificial intelligence and neural network hardware, conducting experiments on both Commercial and Government Off-The-Shelf (COTS and GOTS) artificial intelligence and machine learning algorithms, and validating Soldier accuracy performance models. It also includes investigation of lightweight optical components and determines viability of weight reduction and balancing approaches. **FY 2021 Plans:** Refine technical requirements based on capability needs; investigate existing artificial intelligence and machine learning algorithms on COTS & GOTS; determine implementation and validation approaches as well as research of human-system integration and pairing; and mature components of polymer lens and housing technologies, and three-dimensional printing solutions. **FY 2022 Plans:**	-	1.828	4.172

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** AY8 *I Small Arms Fire Control Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will investigate and validate mature technology development work for enhanced dismounted combatant/non-combatant automated target recognition algorithms; design improved decision aides for small arms maneuver; validate technical approaches through modeling and simulation; conduct investigations into the ability to recognize threats based on behavior. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The increase builds on the requirements defined in FY21 by way of engineering tasks execution in support of iterative designs and development for Small Arms Fire Control technologies for the Dismounted Soldier.			
Accomplishments/Planned Programs Subtotals	-	1.828	4.172

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 11 of 61

R-1 Line #10

Volume 1b - 52

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602143A I *Soldier Lethality Technology*					Project (Number/Name) AZ2 I *Body Armor & Integrated Headborne 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
AZ2: *Body Armor & Integrated Headborne Technology*	-	8.081	6.575	6.664	-	6.664	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops materials for Soldier-borne protective equipment, such as body armor and combat helmets, to increase protection from ballistic, blast, and blunt impact threats. This Project also investigates and executes systematic studies to mature and develop materials, devices, systems and methods that enable the identification of protective solutions against ballistic, blast and directed energy threats. Included are investigations of emerging technologies, novel materials, and test methods and integration of personnel armor, combat helmets, hearing protection, eyewear, and other personal protective equipment items.

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: Body Armor & Integrated Headborne Technology	8.081	6.575	6.664

Description: This research effort supports the investigation of novel materials, component designs, and material modeling to design and develop technologies that protect Soldiers against ballistic, blast, and directed energy threats. This effort utilizes a cross-disciplinary, human-focused approach to develop technologies which optimize tradeoffs in ballistic and blast protective component design. This effort addresses the Army challenge of easing overburdened Soldiers in small units and aligns to Soldier protection modernization priorities.

FY 2021 Plans:
Mature components of an integrated single lens substrate for use in Soldier vision protection system that includes anti-fog, variable light transmission, and lenses with laser flash and dazzle protection capabilities; conduct analytical and laboratory studies to physically validate the performance of high hardness and anti-fog coatings to protect and extend the operational life of various Soldier-borne display technologies; validate the operating performance capability of the advanced blast simulator and its correlation to free field blast overpressure conditions from artillery and antipersonnel threats as a means to systematically study headborne equipment in a controlled blast environment; validate material composite pre-stress processing methods and investigate its use with multiple material substrates as a means to enhance the ballistic performance of multiple end-items.

FY 2022 Plans:
Will investigate the application of single lens technology with variable light transmission and active and passive anti-fog mitigation approaches from single curve substrates to complex curves shapes for incorporation into future head mounted displays and eye

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 12 of 61

R-1 Line #10

Volume 1b - 53

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** AZ2 *I Body Armor & Integrated Headborne Technology*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
protection; execute concept exploration efforts to study alternative headborne protection concepts from blast overpressure threats utilizing the advanced blast simulator to systematically study headborne equipment in a controlled blast environment; conduct experiments to systematically study emerging high performance materials, associated processing conditions to include layups, consolidation methods, temperature and pressure consolidation conditions with the objective of increasing protection against future small arms threat requirements. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	8.081	6.575	6.664

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 13 of 61

R-1 Line #10

Volume 1b - 54

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602143A I Soldier Lethality Technology						Project (Number/Name) AZ5 I Soldier Protection Technology - Vulnerability	

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
AZ5: *Soldier Protection Technology - Vulnerability*	-	7.770	11.974	9.357	-	9.357	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops materials, methods, and models that enable design and integration of emerging material technologies into lightweight, flexible and modular Soldier equipment to protect against the range of existing and emerging threats for head, torso, and extremity protection. Specific research thrusts include the development of materials and mechanisms to enhance ballistic protection; computational models and associated experiments to provide a fundamental understanding of material properties and failure mechanisms, as well as correlation to ballistic/blast/blunt impact performance of Soldier personal protective equipment (PPE) and improved fibers, composite, and ceramic materials. Specific technologies support experimental helmets that reduce impact and blast loading to the head, Soldier torso protection systems to increase protection from ballistic and blunt impacts, and novel fibers and fabrics that provide additional survivability mechanisms.

Work in this Project supports key Army needs and is fully coordinated with several PEs and Projects to include PE 0602143A (Soldier Lethality Technology) and 0603118A (Soldier Lethality Advanced Technology); and leverages the technical research of several PEs to include PE 0601102A (Defense Research Sciences) / Project AA7 (Mechanics and Ballistics) and 0602144A (Ground Technology) / Project BL1 (Materials and Manufacturing Research Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Soldier Protection Technologies	4.043	3.936	3.640
Description: This effort develops integrated lightweight, flexible, and modular protection equipment that is tailored to support the 'Soldier as a system' approach for defeat of emerging threats. Research areas encompass high fidelity ballistic impact injury models for hard and soft tissues, novel ceramic architectures to include graded and hierarchically structured ceramics, and novel fiber solutions for backing materials to deliver Soldier protection systems to meet emerging ballistic and signature management threats. This effort supports small caliber lethal mechanisms research in PE 0602143A (Soldier Lethality Technology) / Project AY6 (Soldier Squad Small Arms Armaments Technology). *FY 2021 Plans:* Design and develop armor mechanisms to protect dismounted Soldiers from emerging ballistic threats through experimental and computational analysis; increase head protection through determination of advanced mitigation techniques; investigate thoracic			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602143A I *Soldier Lethality Technology*	**Project (Number/Name)** AZ5 I *Soldier Protection Technology -* *Vulnerability*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
soft tissue and hard tissue injury mechanisms; continue to explore new concepts in limb protection from blast events; validate armor model for behind armor blunt trauma metrics. *FY 2022 Plans:* Will validate armor mechanisms to protect dismounted Soldiers from advanced ballistic threats through experimental and computational analysis; conduct simulations and analyze results for active armor concepts across anthropometric spectrum (e.g. body measurements and proportions such as height and weight); explore helmet material designs to improve protection against ballistic impacts and blast exposure while reducing helmet weight *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding reduced as work in the area of hard tissue injury mechanisms was reduced.			
Title: Soldier-Borne Composite Materials *Description:* Utilizing understanding of fibers, fabrics, and composite materials, conduct applied research of emerging lightweight materials and structures to enable affordable designs for head, torso, and extremity protection systems. Provide quantitative scientific basis for modeling and simulation that result in materials that utilize new schemes to enhance Warfighter survivability. This effort supports Soldier Protection Technologies bullet. *FY 2021 Plans:* Explore the processing and layout of novel fibers and films as a composite for potential soft body/torso armor and head protection (helmets); and investigate computational methodology processes and the resulting structure-performance relationships of composites for helmets. *FY 2022 Plans:* Will assess improved material composite backers and helmet shells that utilize computational geometry and layering, improved fibers and films, and novel manufacturing methods such as pressure processing and fiber placement. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding increased to support additional assessments of composite materials utilizing novel manufacturing processes.	2.556	2.311	2.725
Title: Soldier-Borne Advanced Protection Materials *Description:* Utilizing understanding of protection materials such as armor ceramics and associated failure mechanisms, conduct applied research of emerging armor materials to enable affordable design of lightweight ballistic protective systems for the future Soldier. Provide quantitative scientific basis for modeling and simulation that result in materials that utilize new lethal mechanisms/ protection schemes for the individual Warfighter. This effort supports Soldier Protection Technologies bullet and small caliber	1.171	2.730	2.992

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602143A / *Soldier Lethality Technology*	**Project (Number/Name)** AZ5 / *Soldier Protection Technology -* *Vulnerability*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
lethal mechanisms research in PE 0602143A (Soldier Lethality Technology) / Project AY6 (Soldier Squad Small Arms Armaments Technology), *FY 2021 Plans:* Will explore novel ceramics and ceramic structures for ballistic applications; develop processing pathways for multiscale architectures and assess their ballistic performance; research experimental techniques to assess failure mechanisms for multiscale architectures under ballistically-relevant states of stress. *FY 2022 Plans:* Will explore computational methods to capture failure mechanisms in different material architectures, allowing pathways for future rifle projectile defeat materials development; investigate alternative processing methodologies for multi-scale architecture that provide higher resolution, broader geometric flexibility, or tailored interfaces, and explore novel ceramic blends and ceramic structures for improved ballistic performance at reduced weight; design high throughput modeling and experimental methodologies to accelerate correlations between material structure, properties, and processing with ballistic performance. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding increased to support additional work in the area of computational methods to capture failure mechanisms in different material architectures.			
Title: Multifunctional Soldier Materials - Soldier Augmentation *Description:* This effort researches novel multifunctional Soldier protection materials and associated processing science aimed at enabling critical Army applications in survivability via Soldier augmentation technologies. Research efforts include: multifunctional fibers, films, and coatings; adaptive and responsive materials for passive biomechanical assistance; materials for sensing body forces and kinematics; materials for high power and high speed actuation; actuator fibers and textiles; functionally graded materials; and color-changing materials. *FY 2021 Plans:* Explore the development of new materials and structures, both passive and active that can be integrated with the human body to modify human biomechanics, and /or change color on demand; determine metamaterial structures that can be reconfigured rapidly and with spatial complexity to re-direct load paths or enhance energy absorption in real time. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding realigned to support higher priority efforts in PE 0602181 (All Domain Convergence Applied Research), Project CM7 (Collaborative Convergence Applied Research).	-	2.997	-
Accomplishments/Planned Programs Subtotals	7.770	11.974	9.357

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 16 of 61

R-1 Line #10

Volume 1b - 57

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** AZ5 *I Soldier Protection Technology - Vulnerability*

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

Remarks

D. Acquisition Strategy
  N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 17 of 61

R-1 Line #10

Volume 1b - 58

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*					**Project (Number/Name)** AZ9 *I Soldier Protection Advanced Tech - Detectability*		

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
AZ9: *Soldier Protection Advanced Tech - Detectability*	-	4.314	3.278	1.883	-	1.883	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and designs novel materials, technologies, techniques and applications increasing the capabilities of camouflage and concealment against known and emerging sensor threats. The results of this Project enable effective deception capabilities, combinations of physical and electronic signature decoy components, and determination of analytical processes for modeling signature management technologies during multi-domain operations. These technologies will provide subsystems and concepts that shall decrease the probability of detection and targeting by peer and near-peer adversaries, enabling freedom of movement of semi-independent and dispersed formations and increased protection of dismounted soldiers. Components designed under this Project will transition to Advanced Technology Development efforts in Soldier Lethality protection/survivability Projects to provide disruptive Camouflage, Concealment and Deception technologies to the Operational Army to support expeditionary maneuver in the Multi-Domain Battle Environment and retain windows of advantage.

Work in this Project supports key Army needs and leverages/complements the technical research of several PEs to include PE 0601102A (Defense Research Sciences), PE 0602143A (Soldier Lethality Technology) / Project BB4 (Dismounted Soldier Survivability Materials), Project AZ5 (Soldier Protection Technology - Vulnerability), Project BE1 (Support Technology to Mission Command), PE 0603118A (Soldier Lethality Advanced Technology) / Project AZ8, (Soldier - Small Unit Detectability Adv Technology), and PE 0602712A (Countermine Systems) / Project H35 (Camouflage and Counter-Recon Tech).

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: Camouflage, Concealment and Decoys Technologies for Soldier and High-Value Assets	4.314	3.278	1.883
Description: This effort investigates and designs materials, processes, and concepts for innovative camouflage, concealment and deception technologies for Soldier and High-Value assets to defeat advanced current and emerging adversary Intelligence, Surveillance and Reconnaissance (ISR) threats including multispectral, hyperspectral and Light Detection and Ranging (LiDAR) sensors, and to reduce the probability of detection in multi-domain operations. Investigates analytical processes to model material and system performance and predict probability of detection in the multi-domain operational environment, assisting in closing the capability gap between current camouflage, concealment, and deception technologies and defeating enemy sensorial capabilities in future operating environments. *FY 2021 Plans:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** AZ9 *I Soldier Protection Advanced Tech - Detectability*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Leverage performance effectiveness of camouflage materiel technologies to mature components of most promising solutions; determine design metrics that will be relevant for defeating known emerging sensor threats; leverage data showing vulnerability against ground surveillance radar for experimenting with flexible Soldier worn materials to reduce Soldier radar cross section; investigate technologies to alert Soldiers if detected by ground surveillance radar; design and mature components of active color changing materials for future integration into Soldier clothing and individual equipment; research alternative active and passive identification of friend versus foe capabilities for the individual Soldier to provide tailorable mission-dependent capability; validate performance effectiveness of new camouflage technologies against continuously emerging and changing threats based on previous results; evaluate camouflage system solutions in support of new/emerging hyperspectral and LiDAR sensor defeat; interrogate candidate deception solutions; continue to investigate color and optical property changing materials for high value asset concealment, utilizing varying environments. ***FY 2022 Plans:*** Will conduct systematic studies of fiber processing, additives, coatings and complex geometries to assess new techniques that enable heat transfer and emission control of Soldier thermal signatures against near peer and peer sensor threats operating in the electromagnetic spectrum; investigate virtual reality based methods to assess operational impact of camouflage effectiveness against direct line of sight small arms engagement scenarios and developing advanced (lifelike) Soldier camouflage avatars; continue to design and mature components of active color changing materials assessing film based materials incorporating recent advancements in electrowetting, electrodesposition, and plasmonics, for future integration into Soldier clothing and individual equipment. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding in this effort was realigned to PE 0602146A (Network C3I Technology) / AQ9 (Expeditionary Data to Decisions Technology).			
Accomplishments/Planned Programs Subtotals	4.314	3.278	1.883

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 19 of 61

R-1 Line #10

| Volume 1b - 60 |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602143A I Soldier Lethality Technology						Project (Number/Name) BB4 I Dismounted Soldier Survivability Materials		
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
BB4: Dismounted Soldier Survivability Materials	-	4.742	2.991	2.828	-	2.828	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates fibers, textiles, components, and materials focused on enhancing Soldier survivability from combat threats (flame and thermal, blast and ballistic, multispectral sensor, and laser threats) and environmental threats (e.g., cold, heat, wet, vector, antimicrobial, etc.) to increase operational effectiveness while decreasing the Soldier's physical and cognitive burden. The results from this Project will transition knowledge, materials, subcomponents and methods to Advanced Technology Development efforts in support of enhancing Soldier Lethality by providing protective material solutions focused on the aspects of dismounted movement and maneuver operations of the Army. This Project develops and applies validation methods that enable systematic studies of human systems integration principles and practices to protective equipment materials and designs to advance the understanding of trade-offs between protection, lethality, and mobility.

Work in this Project supports key Army needs and leverages/complements the technical research of several PEs to include PE 0601102A (Defense Research Sciences), PE 0602143A (Soldier Lethality Technology) / Project AZ5 (Soldier Protection Technology - Vulnerability), and PE 0603118A Soldier Lethality Advanced Technology / Project BB3 (Dismounted Soldier Survivability Equip/Tech Integ).

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: Dismounted Soldier Survivability Materials	4.742	2.991	2.828
Description: This effort investigates materials, devices and methods that aid in the design and development of multifunctional materials for Soldier protective clothing and individual equipment. This effort conducts research to investigate and identify multi-functional material properties at the micron and sub-micron level to mitigate Soldiers susceptibility and vulnerability to operational threat, i.e., flame, thermal, environmental, and multispectral sensors. Efforts also investigate and develop devices and systems that enable extended dismounted mission duration by reducing the demand for water resupply and enabling Squad organic water filtration systems			
FY 2021 Plans: Conduct experiments on novel multi-component fiber architectures and fabric treatments to incorporate functionalities for improved durability over the life of the garment, providing more effective protection against operational threats for a longer period; design fibers and fabrics that can transmit power supporting integration of wearable electronics for situational awareness			

PE 0602143A: Soldier Lethality Technology
Army

UNCLASSIFIED
Page 20 of 61

R-1 Line #10

Volume 1b - 61

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BB4 *I Dismounted Soldier Survivability Materials*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
and decreased load; continue to investigate and validate materials and processes that enable individual Soldiers to desalinate contaminated water such that proper hydration levels can be maintained from any indigenous water source. *FY 2022 Plans:* Will explore the incorporation of additional dimensions to fabric structures by researching approaches to take fibers and fabrics from traditional two-dimensional substrates to a third dimension, adding functionality within the substrate, to include stimuli-responsive fibers and yarns for real-time situational awareness, physiological monitoring, and environmental protection; investigate non-traditional procedures and techniques using additive approaches to tailor multi-functionality of Soldier personnel protective equipment at very small length scales and incorporate the results of prior year?s multi-functional and e-textile findings; in support of developing personal water filtration capabilities to enable Soldiers to filter and hydrate from contaminated water sources, conduct experiments of leading candidate sophisticated breadboard hardware, capable of separating salt and other contaminants from brackish and salt water sources; investigate the potential of handheld or embedded sensing concepts to provide continuous monitoring of water quality, before and after treatment. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding decrease reflects realignment to support higher priority efforts in PE 0602181 (All Domain Convergence Applied Research) / CM7 (Collaborative Convergence Applied Research) and PE 0603041 (All Domain Convergence Advanced Research) / CM2 (Collaborative Convergence Adv Tech Development).			
Accomplishments/Planned Programs Subtotals	4.742	2.991	2.828

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 21 of 61

R-1 Line #10

Volume 1b - 62

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*					**Project (Number/Name)** BB5 *I Physical Augmentation: Tech for Human Interactions*		

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**
BB5: *Physical Augmentation: Tech for Human Interactions*	-	1.438	1.451	1.332	-	1.332	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project advances the understanding of human augmentation and interaction for enhanced operational performance with a focus on adaptation, training, human variability, metrics/methodologies for assessment, and task quantification. Research encompasses conducting applied research to develop metrics, measures, tools, and techniques to quantify and understand the relationships that enable maximum effectiveness of integrated Soldier-augmentation technologies. The resulting data are the basis for physical augmentation systems and equipment design standards, guidelines, and intelligent agent requirements to improve equipment operation and Soldier-system synergy. Application of this research will yield reduced workload, reduced Soldier training requirements, enhanced Soldier lethality/survivability, user acceptance, and allow Soldiers to achieve maximum performance. Major efforts explore novel techniques for Soldier assessment, characterization of individual variability effects on performance, development of evidence based design guidance for the application of augmentation technologies, exploration of the relationship of exoskeleton and physical assist device adaptation and baseline Soldier parameters such as gait, neuromuscular motor control and proprioception. This Project will also explore novel training paradigms for reduced Soldier-augmentation technology adaptation times to address current and future warrior performance issues. Individual efforts exploit wearable sensor technologies, translate surrogate task performance to operational outcomes, develop approaches to distinguish tasks and individual state and intent of movement, establish database of human movement variability to inform intelligent system design, and identify high impact applications of augmentation.

Work in this Project supports key Army needs and leverages the technical research of several PEs to include PE 0602143A (Soldier Lethality Technology) / Project BC2 (Next Gen Mobility & Lethality Tech for Warfighters), Project BB9 (Human Performance Tech for Mobility & Lethality), Project BC6 (Human Perf - Tech for Warfighter Enhancement), and Project BB7 (Exoskeleton: Technology for Man-Machine Interface); and supports PE 0603118A (Soldier Lethality Advanced Technology) / Project BC1 (Human Performance AdvTech for Mobility & Lethality), Project BB6 (Physical Augmentation: Adv Tech for Field Demo), and Project BB8 (Soldier Centric Advanced Technology). Additionally, work in this Project complements and is fully coordinated with the Medical Research and Development Command under the Military Operational Medicine Research Program within PE 0602787A (Medical Technology) / Project 869 (Warfighter Health Prot & Perf Stnds), and the Veteran Administration's exoskeleton research area. This Project also complements and is fully coordinated with work performed across Army, Navy, and Air Force under the Reliance 21 Human Systems Community of Interest: Protection, Sustainment, and Warfighter Performance and with our international partners through The Technical Cooperation Program / Human Resources and Performance Group / Panel JP1 (TTCP HUM JP1).

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: Training Adaptation and Movement Science	1.438	1.451	1.332

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BB5 *I Physical Augmentation: Tech for Human Interactions*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort investigates the science behind movement for physical augmentation to maximize mobility capacity and training adaptation to decrease learning curve with physical augmentation systems (e.g. physical assist devices, exoskeletons). This work will enable the Army to make informed decisions on the ultimate effectiveness of human augmentation technologies before significant resources are expended. *FY 2021 Plans:* Mature design criteria and develop training interventions to optimize physical augmentation systems for the greatest performance benefit; validate design criteria for smart controls of augmentation systems that are capable of anticipating changes in movement states (e.g. walk to sprint) and adjusting in real time based on previously categorized Soldier movement characteristics; conduct experiments that manipulate control parameters of augmentation systems to determine optimal control settings for various tasks and individuals. *FY 2022 Plans:* Will refine and modify training interventions for more complex, potentially multi-joint devices that may require novel or adjusted training interventions to optimize physical interactions between the Soldier and augmentation systems; improve robustness of smart control systems for characterizing movement and predicting movement intent, and will evaluate in varied environments; expand experiments to include additional Soldier loads, grades, and speeds, that manipulate control parameters of augmentation systems to determine optimal control settings for additional Soldier tasks (e.g., loaded walking, running) and to account for individual variability. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding decrease reflects realignment to support higher priority efforts in PE 0602181 (All Domain Convergence Applied Research) and PE 0603041 (All Domain Convergence Advanced Research).			
Accomplishments/Planned Programs Subtotals	1.438	1.451	1.332

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 23 of 61

R-1 Line #10

Volume 1b - 64

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

Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BB7 *I Exoskeleton: Technology for Man-Machine Interface*

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**
BB7: *Exoskeleton: Technology for Man-Machine Interface*	-	1.534	1.541	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project conducts applied research on metrics, measures, tools, and techniques to understand the relationships which enable maximum effectiveness of integrated Soldier-augmentation technologies. The resulting data are the basis for physical augmentation systems and equipment design standards, guidelines, and intelligent agent requirements to improve equipment operation and Soldier-system synergy. Application of this research will yield reduced workload, reduced Soldier training requirements, enhanced Soldier lethality/survivability, user acceptance, and allows the Soldier and systems to jointly achieve maximum performance. Major efforts explore novel techniques for Soldier assessment, characterization of individual variability effects on performance, and development of evidence based design guidance for the application of augmentation technologies to address current and future warrior performance issues. Individual efforts exploit wearable sensor technologies, translate surrogate task performance to operational outcomes, develop approaches to distinguish tasks and individual state, establish database of human movement variability to inform intelligent system design, and identify high impact applications of augmentation.

Results of these efforts supports key Army needs and leverages the technical research of PEs 0602143A (Soldier Lethality Technology) and 0603118A (Soldier Lethality Advanced Technology). Additionally, this work complements and supports the Medical Research and Development Command under PE 0602787A (Medical Technology), Army Training and Doctrine Command (TRADOC), Human Systems Integration (HSI) Directorate (Army G1), and the Army Test and Evaluation Command (ATEC).

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: Exoskeleton	1.534	1.541	-
Description: This effort will accelerate Soldier lifting and mobility capabilities through applied research on exoskeleton systems with improved safety and reduced training requirements. ***FY 2021 Plans:*** Conduct experiments with integrated operational scenario and performance metrics for assessment of dismounted Soldier performance; expand models of human movement variability and performance outcomes to inform development of adaptive system designs and control approaches. ***FY 2021 to FY 2022 Increase/Decrease Statement:***			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BB7 *I Exoskeleton: Technology for Man-Machine Interface*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding realigned in FY 2022 to higher priority Artificial Intelligence efforts within in this PE 0602143A.			
Accomplishments/Planned Programs Subtotals	1.534	1.541	-

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 25 of 61

R-1 Line #10

Volume 1b - 66

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602143A I *Soldier Lethality Technology*					**Project (Number/Name)** BB9 I *Human Performance Tech for Mobility & Lethality*		

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
BB9: *Human Performance Tech for Mobility & Lethality*	-	2.397	2.997	2.961	-	2.961	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates human performance based information portrayal system design parameters that integrate mobility & lethality considerations (such as cognitive workload, target discrimination and engagement, and fatigue) into training/education tools, mission command platforms, and technologies that help Soldiers more rapidly and efficiently acquire complex skills and make decisions quickly from training through mission planning and execution. This Project supports the Measuring and Advancing Soldier Tactical Readiness and Effectiveness (MASTR-E) Science and Technology program supported by the Office of the Secretary of Defense Close Combat Lethality Task Force.

Work in this Project directly supports integration of design guidance for multiple PE/Projects including PE 0603118A (Soldier Lethality Advanced Technology) / Project BD7 (Soldier Sys Interfaces/ Integration-Sensor Adv Tech), Project AY9 (Body Armor & Integrated Headborne Advanced Tech), and Project BC9 (Adv Soldier Sensors/ Displays AdvTech for Dismounts).

This Project is fully coordinated and complementary with the other PE/Projects in support of MASTR-E to include the following: PE 0602143A (Soldier Lethality Technology) / Projects BC6 (Human Perf-Tech for Warfighter Enhancement), BC2 (Next Gen Mobility & Lethality Tech for Warfighters), and PE 0603118A (Soldier Lethality Advanced Technology)/ Projects BC1 (Human Performance AdvTech for Mobility & Lethality). This Project also leverages PE 0603118A (Soldier Lethality Advanced Technology) / Project BD7 (Soldier Sys Interfaces/ Integration-Sensor Adv Tech), Project AY9 (Body Armor & Integrated Headborne Advanced Tech), and Project BC9 (Adv Soldier Sensors/ Displays AdvTech for Dismounts).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Modernization Strategy and the Soldier Lethality Cross Functional Team (CFT), as well as the Office of the Secretary of Defense's Close Combat Lethality Task Force.

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: Human Interaction for Situational Understanding	2.397	2.997	2.961
Description: This effort investigates, designs, and develops design guidance for information portrayal systems and sub-systems in augmented/virtual reality that enable Soldiers to make better, faster decisions for close combat operations at the small unit level. This effort also conducts experiments to populate performance models that have application across materiel and non-materiel solutions. *FY 2021 Plans:*			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BB9 *I Human Performance Tech for Mobility & Lethality*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Investigate the impact of virtual reality and augmented reality design parameters (e.g. graphical level of detail, uncertainty, degraded network conditions, focal depth) on decision-making, situational awareness, and navigation; continue to investigate Soldiers? response time, cognitive burden, and behavioral measures of performance to inform what and how information should be portrayed to a Soldier in order for it to be meaningful and actionable. *FY 2022 Plans:* Will conduct experiments to determine the best approaches for visually cueing Soldiers for rapid target acquisition via augmented reality displays; continue to investigate the impact of mixed reality design parameters (e.g., graphical level of detail, uncertainty, degraded network conditions, focal depth) in ambulatory settings on decision-making, situational awareness, and navigation (including subterranean environments). This work will transition for further maturation and demonstration to a variety of partners including TRADOC Mobile (for schoolhouse distribution), CCDC Armaments Center, CCDC Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR) Center, the Synthetic Training Environment-CFT, and PM-Integrated Visual Augmentation System (IVAS). *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflective of planned project lifecycle.			
Accomplishments/Planned Programs Subtotals	2.397	2.997	2.961

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 27 of 61

R-1 Line #10

Volume 1b - 68

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

Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602143A I *Soldier Lethality Technology*	Project (Number/Name) BC2 I *Next Gen Mobility & Lethality Tech for Warfighters*

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
BC2: *Next Gen Mobility & Lethality Tech for Warfighters*	-	5.444	7.245	7.725	-	7.725	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates the means to monitor, assess and predict Soldier and squad shoot and move performance to provide design guidance for individual and mission specific equipment (e.g. individual protection, small arms, load carriage, etc.). Research conducted focuses on translating mission tasks to measures of human performance. These measures of human performance will inform predictive algorithms and human based modeling and simulation that enable Soldier performance trade space analysis for acquisition, training, and operations. These data and algorithms will allow us to determine the impact of new capabilities on Soldier and Squad performance and effectiveness. This Project supports the Measuring and Advancing Soldier Tactical Readiness and Effectiveness (MASTR-E) Science and Technology program supported by the Office of the Secretary of Defense Close Combat Lethality Task Force.

This Project is fully coordinated and complementary with the other PE/Projects in support of MASTR-E to include the following: PE 0602143A (Soldier Lethality Technology) / Projects BC6 (Human Perf-Tech for Warfighter Enhancement), BB9 (Human Performance Tech for Mobility & Lethality), and PE 0603118A (Soldier Lethality Advanced Technology)/ Projects BC1 (Human Performance AdvTech for Mobility & Lethality). This Project also leverages PE 0603118A (Soldier Lethality Advanced Technology) / Project AY9 (Body Armor & Integrated Headborne Advanced Tech), Project AY5 (Soldier Squad Small Arms Armaments Advanced Technology), Project BD7 (Soldier Sys Interfaces/Integration-Sensor AdvTech), and Project BB6 (Physical Augmentation: Adv Tech for Field Demo).

Work in this Project complements and is fully coordinated with the Medical Research and Development Command under the Military Operational Medicine Research Program as well as Defense Medical Research and Development Program under Military Operational Medicine (JPC-5) to include Projects in PE 0602787A (Medical Technology). This Project also complements and is fully coordinated with work performed across Army, Navy, and Air Force under the Reliance 21 Human Systems Community of Interest: Protection, Sustainment, and Warfighter Performance.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Modernization Strategy, and the Soldier Lethality Cross Functional Team (CFT), as well as the Office of the Secretary of Defense Close Combat Lethality Task Force.

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: Human Interaction for Mobility & Lethality	5.444	7.245	7.725
Description: This effort investigates and develops human performance based design guidance for protection and weapon systems and sub systems to improve the mobility and lethality of individuals and small units. The applied research translates traditional means for measuring and understanding human performance to the means to conduct assessment for Warfighter and small unit readiness and/or new capabilities.			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BC2 *I Next Gen Mobility & Lethality Tech for Warfighters*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Identify, validate, and mature components of innovative wearable sensors and algorithms for monitoring and assessment of situational awareness, cognitive state, and decision-making during critical Soldier tasks to provide the means for Soldier and Squad assessment for both training and test & evaluation purposes; identify predictive measures for Soldier shoot, move, communicate, navigate, and decide tasks during conditions of physical and cognitive stress in future operating scenarios; determine quantitative data and algorithms to populate commander decision aids, a predictive squad performance model, and the Synthetic Training Environment (STE). *FY 2022 Plans:* Will design processing pipeline to prepare data for analysis and interpretation; validate innovative wearable sensors for maturity of the technology and evaluate dimensionality reduction techniques; validate predictive algorithms for monitoring and assessment of situational awareness, cognitive state and decision-making during critical Soldier tasks to provide the means for Soldier and Squad assessment for both training and test & evaluation purposes; refine predictive measures for Soldier shoot, move, communicate, navigate, and decide tasks during conditions of physical and cognitive stress in future operating scenarios; through machine learning, develop performance algorithms and a predictive squad performance model for validation in a relevant environment; develop additional head supported mass requirements based on Soldier task performance, design guidance for maxillofacial protection, and guidance for the design of headborne displays that enables cognitive/perceptual performance, including decision making and situation awareness *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	5.444	7.245	7.725

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 29 of 61

R-1 Line #10

| Volume 1b - 70 |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602143A I *Soldier Lethality Technology*					**Project (Number/Name)** BC3 I *Soldier Decision Making & Comms Performance Tech*		
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**
BC3: *Soldier Decision Making & Comms Performance Tech*	-	10.316	4.378	-	-	-	-	-	-	-	-	-

Note
 This project was realigned from 0602143A / BC3 to 0602184A / CO2.

A. Mission Description and Budget Item Justification
 This Project conducts applied research to create analytical and empirical capabilities to characterize, model, and forecast human behavior related to cyber electromagnetic events through experimentation and field data collection. The result is increased mission effectiveness that enables strong mission command, intelligence operations, and cyber defenses, which lead to high information sharing, situational awareness, and collaboration. Major efforts focus on applied research to understand the conduct of effective cyber electromagnetic operations in that knowledge is required to create and effectively deploy cyber work systems that optimize human-machine interactions and account for operator and adversary behavior to achieve maximum effects.
 Results of these efforts are provided to Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Program Managers, Human Systems Integration (HSI) Directorate (Army G1), and the Army Test and Evaluation Command (ATEC).

 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: Soldier Performance in Sociotechnical Environments	10.316	2.929	-
Description: This research provides human cyber operations assessment and advanced human decision-support capabilities to deploy cyber work systems that optimize human-machine interactions and account for operator and adversary behavior. Without these capabilities, future cyber work systems will be too complex and burdensome for operator use and training resulting in critical bottlenecks as operators have to ?catch-up? with the speed of cyber activity. This research also supports technologies for Squad-level SA assessment (information visualization) that provide command-level decision support with communication and intervention capabilities. Research focuses on algorithms for the quantification and visualization of collective uncertainty at the squad level for mission command decision making. This effort also supports the monitoring and assessing of Soldier tactical readiness and effectiveness through technologies and approaches for opportunistic human sensing. *FY 2021 Plans:* Develop and document knowledge products capturing best-practices and frameworks for the creation and exploitation of a physiological time-series database to enable Soldier performance prediction; conduct experiments with advanced machine			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BC3 *I Soldier Decision Making & Comms Performance Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
learning algorithms on physiological time-series data to quantify situational awareness and predict performance of the dismounted Soldier/Squad. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort is being realigned to PE 0602184A Project CO2 Soldier-Intelligent Technology Research.			
Title: Algorithms for Sensing Soldier in Mission Context *Description:* This effort investigates enhanced decision making under conditions of uncertain, complex, time sensitive, and dynamically changing information to optimize human-artificial intelligence (AI) shared situational understanding. Enhances operational performance of individuals and teams of Soldiers through novel visualization technologies that represent complex time-sensitive information in uncertain dynamic environments. ***FY 2021 Plans:*** Develops techniques for customized and intuitive visualizations to translate disparate and uncertain sources of complex, dynamic information into actionable knowledge for improved mission critical decision making. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort is being realigned to PE 0602184A Project CO2 Soldier-Intelligent Technology Research.	-	1.449	-
Accomplishments/Planned Programs Subtotals	10.316	4.378	-

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 31 of 61

R-1 Line #10

Volume 1b - 72

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602143A I *Soldier Lethality Technology*						Project (Number/Name) BC6 I *Human Perf - Tech for Warfighter Enhancement*	
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**
BC6: *Human Perf - Tech for Warfighter Enhancement*	-	2.566	2.918	3.350	-	3.350	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops mechanisms for safely and effectively optimizing and enhancing Warfighter ability to shoot, move, communicate, and decide. These mechanisms have the potential to exploit the Soldier and Squad as the capability platform beyond materiel solutions provided to the individual and small unit. This project also conducts experiments to populate human performance models that enable tradespace analysis for portions of doctrine, organization, training, materiel, leadership and education, personnel and facilities (DOTMLPF) analysis. This Project supports the Measuring and Advancing Soldier Tactical Readiness and Effectiveness (MASTR-E) Science and Technology program supported by the Office of the Secretary of Defense Close Combat Lethality Task Force.

This Project is fully coordinated and complementary with the other PE/Projects in support of MASTR-E to include the following: PE 0602143A (Soldier Lethality Technology) / Projects BC2 (Next Gen Mobility & Lethality Tech for Warfighters), BB9 (Human Performance Tech for Mobility & Lethality), and PE 0603118A (Soldier Lethality Advanced Technology)/ Projects BC1 (Human Performance AdvTech for Mobility & Lethality). This Project also leverages PE 0603118A /BD7 (Soldier Sys Interfaces/Integration-Sensor AdvTech)), PE 0602143A /BE3 (Joint Service Combat Feeding Technology) and PE 0603118A /BE2 (Joint Service Combat Feeding Advanced Technology). It also has potential to inform materiel solutions within PE 0603118A (Soldier Lethality Advanced Technology) for the Soldier/Small unit.

Work in this Project complements and is fully coordinated with the Medical Research and Development Command under the Military Operational Medicine Research Program as well as Defense Medical Research and Development Program under Military Operational Medicine (JPC-5) to include Projects in PE 0602787A (Medical Technology). This Project also complements and is fully coordinated with work performed across Army, Navy, and Air Force under the Reliance 21 Human Systems Community of Interest: Protection, Sustainment, and Warfighter Performance. Work in this Project complements and is fully coordinated with research at the US Army Combat Capabilities Development Command Army Research Laboratory (ARL).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Modernization Strategy, and the Soldier Lethality Cross Functional Team (CFT), as well as the Office of the Secretary of Defense Close Combat Lethality Task Force.

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: Human Performance Technology for Warfighter Enhancement	2.566	2.918	3.350
Description: This effort investigates mechanisms for exploiting human physiology to develop safe and effective interventions that create smarter, faster, more lethal Close Combat Warfighters. This work will result in a Soldier's ability to shoot, move,			

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 32 of 61

R-1 Line #10

Volume 1b - 73

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BC6 *I Human Perf - Tech for Warfighter Enhancement*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
communicate, and decide faster than an adversary. Findings from these experiments will leverage existing systems and platforms to get the greatest human performance return in training and operations. *FY 2021 Plans:* Conduct experiments to investigate the trade space for whom, when, and how neurostimulation is effective for improving tactically relevant skill acquisition and performance; compare and validate available neurostimulation systems for administration and efficacy for performance enhancement; validate the individualized Soldier benchtop gut microbiome model to determine inter and intra personnel variations for enabling higher precision recommendations for nutritional interventions that enhance Soldier performance via the gut/brain connection. *FY 2022 Plans:* Will design beta neurostimulation trade space tool and continue experiments to investigate for whom, when, and how neurostimulation is effective for improving tactically relevant skill acquisition and performance; conduct experiments and collect data to quantify the impact of neurostimulation on measures of small arms kill chain performance including threat detection, classification, and marksmanship; investigate biomarkers from the gut microbiome related to Soldier performance outcomes; conduct experiments to characterize candidate probiotic interventions to augment Soldier performance and recovery in stressful operational environments. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase reflects support of increased effort on the neurostimulation trade space tool development and quantifying the impact on small arms kill chain performance measures.			
Accomplishments/Planned Programs Subtotals	2.566	2.918	3.350

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* 2				R-1 Program Element (Number/Name) PE 0602143A *I Soldier Lethality Technology*						Project (Number/Name) BC7 *I Training Technology (Other than STE)*		
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
BC7: *Training Technology (Other than STE)*	-	-	13.651	14.244	-	14.244	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates novel medical training simulations that address all levels of care through improvements in haptic feedback and automated performance assessments in support of Army medical Individual Critical Task Lists (ICTLs). This Project designs and develops early proof-of concept training systems to support non-traditional medical areas, such as dental training simulations. This Project conducts research in immersive virtual, mixed, and augmented reality environments that stimulate human senses (e.g. sight, sound, and touch) and also conducts experiments to understand how users interface with the technology in order to improve the realism of simulation environments and therefore create enhanced immersion and more effective training systems. Research is also conducted to support the modernization of the current Live Training Environment (LTE) to allow fair fight engagements across all training environments and training devices, to include the cyberspace domain.

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) and at the Institute for Creative Technologies (ICT) University Affiliated Research Center (UARC) at the University of Southern California.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Medical Training Technology	-	3.190	3.644
Description: Included in this effort will be the development of new medical training simulations to train medical personnel across all levels of care. Improvements in haptic capabilities will ensure hyper bio-fidelity for all levels of care. Automated measures of student performance will support Army medical Individual Critical Task Lists (ICTLs). Research areas will also include more realistic tissue properties supporting part-task trainers and modular patient simulator systems. Initial exploration of Army ICTLs will result in early proof-of-concept development of proof-of concept training systems to support non-traditional medical areas, such as dental training simulations. *FY 2021 Plans:* Develop haptics capabilities supporting augmented, mixed, and virtual reality by extending sense of hyper bio-fidelity and integrating emerging research into automated objective performance measures supporting Individual Critical Task Lists (ICTLs); develop proof-of-concept training systems to close capability gaps between current simulation technologies and ICTL requirements; validate usability studies and training effectiveness evaluations to gauge value of initial proof-of-concept development efforts; investigate updates to military medical training protocols (e.g., new emphasis on prolonged field care);			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BC7 *I Training Technology (Other than STE)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
develop research plans to include proof-of-concept development, usability studies, technology, and training effectiveness evaluations. ***FY 2022 Plans:*** Will design automated, multi-sensor, computer vision and AI-based medical grading and mentoring capabilities; determine if direct brain measures can be correlated to medical knowledge transfer; investigate additive manufacturing capabilities to create soft and hard tissues based on human anatomic measures; determine smart medical device surrogates for training on dumb patient manikins; investigate the usability of hyper fidelity haptic delivery in mixed and virtual medical training environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Warfighting M/S Concepts and Design (ICT)	-	1.272	3.872
Description: This Project designs and develops photorealistic synthetic environments, multi-sensory interfaces, artificially intelligent agents, and human performance assessment technologies to create virtual, augmented, and mixed reality simulation environments for training. This Project uses advanced modeling, simulation, and leadership development techniques to leverage the emerging immersive technologies of industry and the research and development community to advance the Army's capabilities. ***FY 2021 Plans:*** Conduct research on immersive, virtual, mixed, and augmented reality environments that incorporate senses such as sight, sound, and touch; will develop tools, techniques and technologies to understand how users interface with technology to improve perceptions of immersion in simulated environments to create enhanced realism and more effective training systems. ***FY 2022 Plans:*** Will investigate visual abstraction techniques to portray objects in resource constrained (low bandwidth, reduced computing power) virtual environments without a loss in training effectiveness; design a common framework allowing collaboration across multiple disciplines to design virtual human appearances and behaviors to create interactive artificially intelligent characters for training. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding realigned from another task within this Project (Innovative Synthetic Training) reflecting a shift in research focus from the near term development of the Synthetic Training Environment (STE) capabilities to longer term research supporting training of multi-domain operations through the application of artificial intelligence.			
Title: Cyberspace Electromagnetic Activities (CEMA) Effects Modeling and Simulation	-	1.464	1.472

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 35 of 61

R-1 Line #10

Volume 1b - 76

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army				Date: May 2021	
Appropriation/Budget Activity 2040 I 2		R-1 Program Element (Number/Name) PE 0602143A I *Soldier Lethality Technology*		Project (Number/Name) BC7 I *Training Technology (Other than STE)*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort investigates and develops capabilities to more accurately model and simulate Cyberspace Electromagnetic Activities (CEMA) necessary to support training events for Corps and below. *FY 2021 Plans:* Mature cloud-based network simulation components to support collective Army cyber training events; determine standard data representations to tag information on simulated networks sufficient for training Information Warfare techniques relevant to the conduct of Multi-Domain Operations (MDO); investigate collective training measurement methods for CEMA training assessments. *FY 2022 Plans:* Will investigate the training fidelity of cloud-based network simulation services to support collective Army cyber training events; design and develop software to tag information on simulated networks to enable training Information Warfare techniques relevant to the conduct of Multi-Domain Operations (MDO); investigate techniques to validate collective training measurement methods for CEMA training assessments. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Innovative Synthetic Training Technology *Description:* This effort investigates and designs methods of applying Artificial Intelligence (AI) into the STE to simulate a fully immersive environment in large urban settings with a population of adaptable, noncombatant virtual human agents for increasing the realism and complexity of training scenarios. In addition, it develops tools, techniques and technologies for improving the immersion of human senses within simulation environments with the goal of creating enhanced realism within the simulated environment. *FY 2021 Plans:* Investigate neural networks and reinforcement learning techniques to simulate a ?fabric of Life? or fully immersive environment in a large urban setting with the population of adaptable, noncombatant virtual human agents to increase the realism and complexity of training scenarios; design and develop photorealistic synthetic environments, multi-sensory interfaces, artificially intelligent agents, and human performance assessment technologies to create virtual, augmented, and mixed reality simulation environments for training; investigate and design techniques and methods for integrating different sensory cues into virtual environments that result in enhanced training and leader development; and validate the design of virtual humans that embody natural language, gesture, gaze, and language understanding to simulate conversational speech within virtual humans. *FY 2022 Plans:* Will investigate reinforcement learning techniques using neural networks to create artificially intelligent entities in synthetic, virtual training environments to simulate complex military training behaviors; investigate the use of photogrammetric techniques	-	5.507	2.994

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 2		**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BC7 *I Training Technology (Other than STE)*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
to create photorealistic 3D synthetic terrains for the use in virtual and augmented reality training applications; investigate using advanced virtual humans using sensory feedback, natural language, and cognitive architectures to create simulated social engagements focused on leader development; design a simulation environment to accelerate the design and assessment of emerging simulation technologies using artificial intelligence. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding realigned to another task within this Project (Warfighting M/S Concepts and Designs) reflecting a shift in research focus from the near term development of the Synthetic Training Environment (STE) capabilities to longer term research supporting training of multi-domain operations through the application of artificial intelligence.			
Title: STE Live Training ***Description:*** This effort investigates technology to enhance the fidelity of live training systems and investigates future live training capabilities for conducting force-on-force, combined arms exercises to enhance readiness at Army home stations and Combat Training Centers. ***FY 2021 Plans:*** Investigate eBullet capability to simulate tactical engagements with realism equivalent (or near) to Infantry weapon systems; investigate capability to simulate combat vehicle ballistic fly-out of munitions to a precise point of impact on target and accurately adjudicate weapon effects based on lethality/vulnerability models; investigate capability to simulate friendly and enemy combat vehicle vulnerability/lethality for battle damage assessment. ***FY 2022 Plans:*** Will investigate state-of-the-art sensor technologies to establish a baseline sensor suite with acceptable size, weight, power and performance characteristics; design capability to simulate tactical engagements using high fidelity micro terrain; design and develop algorithms to simulate ballistic fly-out of various infantry munitions to determine validity of geo-pairing solution in a virtual environment. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort	-	2.218	2.262
Accomplishments/Planned Programs Subtotals	-	13.651	14.244

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

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 37 of 61

R-1 Line #10

| Volume 1b - 78 |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BC7 *I Training Technology (Other than STE)*

D. Acquisition Strategy

 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 38 of 61

R-1 Line #10

Volume 1b - 79

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*					**Project (Number/Name)** BD1 *I Adv Soldier Sensors/Displays Tech for Dismounts*		

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
BD1: *Adv Soldier Sensors/ Displays Tech for Dismounts*	-	4.763	11.100	11.651	-	11.651	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops low power, next generation modular sensor and display components for detection and identification of both threats and friendlies in all environments to increase situational awareness, decrease fratricide, and enable Soldiers to respond more quickly for greater lethality. Work in this Project supports the Army Science and Technology Soldier Lethality, Next Generation Combat Vehicle, and Future Vertical Lift Army Modernization Priorities.

This effort supports work done in PE 0603118A (Soldier Lethality Advanced Technology) / BC9 (Adv Soldier Sensors/Displays AdvTech for Dismounts).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Modernization Strategy, and supports the Soldier Lethality Cross Functional Team (CFT).

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: Advanced Soldier Sensors/Displays Technology for Dismounts *Description:* This effort models, simulates, investigates, designs, and develops novel low power, modular electro-optic / infrared (EO/IR), displays, augmented reality approaches and integrates aided/automatic target detection and recognition algorithms to enable improved Soldier maneuver and lethality through greater information fidelity to increase Soldier probability of recognition/ identification and tracking of all threats. This effort is coordinated with PE 0603118A (Soldier Lethality Advanced Technology), PE 0603462A (Next Generation Combat Vehicle Advanced Technology), PE 0603463A (Network C3I Advanced Technology), PE 0603465A (Future Vertical Lift Advanced Technology), and PE 0602145A (Next Generation Combat Vehicle Technology). *FY 2021 Plans:* Validate computer-aided prototyping design models and augmented reality (AR) applications; develop synthetic image generation techniques to enable optimized designs of advanced electro-optic / infrared (EO/IR) sensors and algorithms; mature components of virtual prototyping capabilities to support validation of sensor performance against various threats; model performance of advanced low-light sensors in multiple, simulated battlefield conditions; investigate designs for backside illuminated silicon (BSI) complementary metal-oxide-semiconductor (CMOS) to validate approaches for improved quantum efficiency (QE) in near-IR for advanced low light level imaging; develop low power, high performance application specific integrated chips (ASIC) to reduce the	4.763	11.100	11.651

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BD1 *I Adv Soldier Sensors/Displays Tech for Dismounts*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
size, weight, power, and cost of solid state low light level sensors; develop readout integrated circuits (ROICs) with pixel bins that provide high resolution, high definition imagery in darkest conditions. ***FY 2022 Plans:*** Will conduct experiments with mixed reality (MR) applications to validate sensor system target performance; investigate atmospheric simulation techniques to improve the generation of images in the visible and infrared spectrums; examine tools that support image generation from a synthetic low light level sensor to enable data augmentation and virtual prototyping efforts; design high quantum efficiency (QE) low light level focal plane arrays; determine dark current and system noise reduction techniques to improve the sensitivity for low light level sensor performance under starlight; investigate digital readout integrated circuits (ROICs) with the Application Specific Integrated Chips (ASIC) and processing approaches to enable dynamically binned readouts for high resolution, high definition imagery in light conditions, and improved sensitivity in dark conditions; investigate frame rate throttling of sensors to adapt to environmental and usage conditions including low-light to avoid degradation of situational awareness. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	4.763	11.100	11.651

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 / 2				R-1 Program Element (Number/Name) PE 0602143A / Soldier Lethality Technology					Project (Number/Name) BD6 / Soldier Sys Interfaces/Integration- Sensor Tech		

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
BD6: *Soldier Sys Interfaces/ Integration- Sensor Tech*	-	1.077	1.084	0.513	-	0.513	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates, designs, and validates advanced technologies and algorithms for enhancing dismounted Soldier deployed robotics and autonomous systems used to improve the Small Unit's situational awareness, survivability, and lethality. Technologies to be investigated may include: algorithms for dismounted robotic systems to enable autonomous navigation, automated object recognition, persistent surveillance, launch and recovery from vehicles, networked lethality, manned-unmanned teaming, and collaborative behaviors; and advanced user interfaces to optimize human-robotic interaction during dismounted operations. These advanced technologies will enable Squad and Platoon level autonomous reconnaissance using robotic systems to minimize the operator's dedicated control of the systems and reduce their cognitive burden, thus allowing Soldiers to be more lethal and survivable.

Work in this Project supports key Army needs and leverages the technical research of several PEs to include PE 0603118A (Soldier Lethality Advanced Technology) / Project BD7 (Soldier Sys Interfaces/Integration-Sensor AdvTech) and Project BC9 (Adv Soldier Sensors/Displays AdvTech for Dismounts).

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: Soldier System Interfaces & Integration (Sensor Technology)	1.077	1.084	0.513
Description: This effort will investigate, design, and validate advanced dismounted Soldier robotic and autonomous systems technologies to enable autonomous navigation, manned-unmanned teaming, and networked reconnaissance to improve Soldier lethality, situational awareness, and survivability during tactical operations. *FY 2021 Plans:* Investigate, design, and develop autonomous navigation algorithms, such as obstacle avoidance algorithms for fast flights and operations during night, to enhance the movement and maneuver of dismounted Small Unmanned Aerial Systems (UAS); investigate, design, and develop autonomous search and sensing algorithms to enable resource constrained Small UAS to perceive, detect, identify, and recognize objects in the environment; investigate, design, and develop mission and path planning algorithms and associated user interfaces for autonomous Small UAS; investigate, design, and develop algorithms to enable precision landing, recharging, and launch capabilities for Small UAS to enable extended operations; validate functionality of			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BD6 *I Soldier Sys Interfaces/Integration-Sensor Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
algorithms on open architecture Small UAS platforms in laboratory and simulated environment to reduce risk and improve system design. ***FY 2022 Plans:*** Will investigate, design, and develop autonomous navigation algorithms (e.g. collaborative autonomy, dynamic retasking and task decomposition), to enhance the movement and maneuver of dismounted Small Unmanned Aerial Systems (SUAS); investigate, design, and develop algorithms to enable perch and stare and precision landing capabilities for SUAS to enable extended operations; investigate, design, and develop target pose estimation and advanced motion planning algorithms to enhance autonomous search capability for resource constrained SUAS; investigate, design, and develop multi-agent teaming algorithms and associated user interfaces to enable collaboration between Platoon and Squad level autonomous systems; validate functionality of algorithms on open architecture SUAS platforms in laboratory and simulated environment to reduce risk and improve system design. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding realigned to PE 0602180, Project CL7 (ATR using Multiple Cooperative Sensors Tech)			
Accomplishments/Planned Programs Subtotals	1.077	1.084	0.513

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 2					R-1 Program Element (Number/Name) PE 0602143A I *Soldier Lethality Technology*						Project (Number/Name) BD8 I *Soldier & Sm Unit Tactical Energy Tech*	
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
BD8: *Soldier & Sm Unit Tactical Energy Tech*	-	8.769	9.043	4.467	-	4.467	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project conducts applied research and development on materials and component level power and energy technologies in the areas of energy storage, power generation, alternative energy, and intelligent power distribution and thermal management designs that support Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) and Soldier power needs to include next generation squad weapons and advanced optical devices and sensors. Enables future Soldier lethality and mobility for longer mission durations at lighter weights to provide enhanced lethality and tactical overmatch of adversaries, and to reduce the burden on the Soldier.

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: Tactical Power for Soldier Lethality	3.692	3.695	3.557

Description: This effort investigates, designs, and develops innovative materials and component level power generation and energy storage technologies that support next generation weapons, sensors, radios, and human augmentation devices enabling Soldiers and Small Units to maximize probability of target hits, improve collective situational awareness, ensure multiple communication streams, and assist with tactical tasks in order to decrease Soldier load and power burden, and increase power capabilities by providing more energy to prolong mission run-time.

FY 2021 Plans:
Develop Si-Anode based buttstock batteries (BSBs) for the Next Gen Squad Weapon that minimize weight and maximize energy; conduct component level Technology Readiness Level 5 verification and validation of these high capacity batteries in a laboratory environment; investigate advanced energy storage and power generation materials and components specifically targeted at increasing runtimes of digital Soldier devices; investigate energy storage, weight distribution, power distribution, and safety for the next generation squad weapons power/data rail and native battery; investigate advanced cathode materials and pairings to determine increase on the runtime of Soldier borne devices in small, lightweight, flexible form factors; mature components of small, power generation devices powered by logistically available fuels to enable integrated Soldier borne/operated sensors and radios for critical applications.

FY 2022 Plans:

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BD8 *I Soldier & Sm Unit Tactical Energy Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Research High Voltage Electrolyte (HiVE) and innovative high power density cathode materials; investigate pairing these research materials with Silicon and Li-Metal anode technologies to validate the functionality of the Technology Readiness Level 4 material developments in a laboratory environment, which will enable greater material energy densities from 400-600 WH/Kg for longer runtimes, in distributed operations, with limited resupply; conduct experiments to quantify power trade space and requirements analysis that will enable development of high energy density materials for longer runtime durations for Soldier Tactical Power, Robotics, and Swarming UAS or other priorities identified by the Soldier Lethality Cross Functional Team (CFT); investigate power generation technologies to provide autonomous, on-the-move recharging through power management and distribution for critical Soldier Lethality applications and enable extended duration missions. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.			
Title: Materials & Component Technologies for Energy Independence **Description:** The effort develops technologies to substantially reduce the number of batteries required to accomplish dismounted Soldier/Squad mission objectives by developing more efficient power and thermal management for small systems and harvesting energy and alternative energy technologies thereby significantly reducing Soldier-borne load and logistics requirements for Soldier/Squad power and energy. **FY 2021 Plans:** Investigate optimized coupling between multifuel-fired heat sources and thermophotovoltaic converters for portable multifuel-fired power generators; research and develop multiplexed micro reactors and investigate at different scales for wearable or portable multifuel-fired power generator heat sources; develop flexible and safe aqueous/gel batteries and validate use in diversified application platforms for follow-on robustness studies; investigate the solvation, transport, liquid structure, and interface/interphase of multivalent cation electrolytes; further extend the new halide-graphite intercalation chemistry to multivalent cations; investigate devices based on a series of new materials and chemistries in both aqueous, non-aqueous, and hybrid systems; investigate reversible Martensitic phase transformations in solid-state cooling materials such as nickel-titanium alloys and new architectures, and conduct experiments with advanced characterization techniques to enable future high-performance and silent operation for applications related to directed energy, pulse power, and Soldier wearable cooling; fund research on blue whirl combustion technology for harvesting energy from a broad range of liquid fuels at a much higher efficiency than currently possible; determine new catalytic materials and pyrolysis reactor process in one-step to produce useful chemicals/fuels as energy scavenger for compact energy power sources for robotic autonomous systems. **FY 2022 Plans:** Will design, develop, and validate conceptual device that couples multifuel, excess enthalpy reactors with solid state thermal energy conversion for portable power generation; explore microchannel and porous media surface composition and thermal	5.077	5.348	0.910

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BD8 *I Soldier & Sm Unit Tactical Energy Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
designs to vaporize liquid fuels while minimizing carbon deposits on microchannel walls and pressure drop; investigate fabrication and integration methods that enhance cavity design flexibility including packaging for vacuum or thermally insulating sealed cavities between microreactors, spectral control elements, and photovoltaic cells to enable high view factors, providing lower energy losses across the small gaps in the cavity, and low thermal loss when scaling for compact, thin profiles for wearable power sources			
FY 2021 to FY 2022 Increase/Decrease Statement: A significant portion of the funding in FY 2022 is being realigned to PE 0602184A Project CO1 (Soldier Power And Energy Concepts and Technologies).			
Accomplishments/Planned Programs Subtotals	8.769	9.043	4.467

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 45 of 61

R-1 Line #10

Volume 1b - 86

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2						**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*					**Project (Number/Name)** BE1 *I Support Technology to Mission Command*	

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
BE1: *Support Technology to Mission Command*	-	0.696	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and designs technologies that support Soldier/Small Unit survivability, mobility, and combat effectiveness during mission command operations at operational and tactical levels in lethal and contested environments, enabling decentralized and dispersed operations in the future operating environment. This Project designs innovative mission command node platforms with enhanced mobility and agility, increased protection and survivability against electro-magnetic interference (EMI) and other threats, and rapid movement and emplacement, resulting in increased lethality and coordination of dispersed formations during operations and supporting resilient formations in multi-domain operations. Component technologies designed under this Project will transition to Advanced Technology Development efforts in the Soldier Lethality Modernization priority in support of decentralized and dispersed mission command operations in future operating environments and expeditionary maneuver in the Multi-Domain Operations Environment.

Work in this Project supports key Army needs and leverages/complements the technical research of several PEs to include PE 0601102A (Defense Research Sciences), and the following Projects within PE 0602143A (Soldier Lethality Technology): Project BB4 (Dismounted Soldier Survivability Materials), Project BD8 (Soldier & Sm Unit Tactical Energy Tech), Project AZ9 (Soldier Protection Advanced Tech - Detectability), PE 0603118A Soldier Lethality Advanced Technology / Project AZ8 (Soldier - Small Unit Detectability Adv Technology) and PE 0602712A (Countermine Systems) / Project H35 Camouflage and Counter-Recon Tech).

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: Small Unit Expeditionary Mission Command Research	0.696	-	-
Description: This effort investigates and designs components of agile, modular, non-traditional Command Post platforms designed to enable the mission command network, supporting decentralized and distributed mission command operations in the future operating environment. Investigates material node platforms and other component concepts supporting rapid emplacement and displacement with enhanced survivability, mobility, signature management protection, and secured/non-degraded communication capabilities. Investigates and conducts experiments to validate component performance in a multi-domain battle operations. The large-footprint and logistics-intensive nature of current mission command systems compromise Soldier Lethality and mission effectiveness and do not provide the enhanced mobility and protection necessary to effectively execute mission command operations in the extremely expeditionary, multi-domain environment of the future. This research effort will enable tactical leaders to make timely decisions, integrate more seamlessly into the battlefield through a decrease in size,			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BE1 *I Support Technology to Mission Command*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
signature, and logistics burden, and will increase both maneuverability and survivability by enabling the development of agile Command Posts that support Multi-Domain Operations.			
Accomplishments/Planned Programs Subtotals	0.696	-	-

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 47 of 61

R-1 Line #10

Volume 1b - 88

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					R-1 Program Element (Number/Name) PE 0602143A *I Soldier Lethality Technology*					Project (Number/Name) BE3 *I Joint Service Combat Feeding 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
BE3: *Joint Service Combat Feeding Technology*	-	3.832	4.109	4.024	-	4.024	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops nutrient compositions and stabilization techniques to maximize the Warfighter's physical and cognitive performance on the battlefield, investigates technologies to enhance detection and identification capabilities of chemical and biological threats in foods, and develops innovative ration and field feeding technologies to reduce resupply requirements for the multi-domain battlefield. The Army serves as the Executive Agent for this Department of Defense (DoD) program, with oversight and coordination provided by the DoD Combat Feeding Research and Engineering Board.

Work in this PE is related to and fully coordinated with PE 0602787A (Medical Technology) / Project 869 (Warfighter Health Prot & Perf Stnds) to develop technologies and concepts; Army Additive Manufacturing Community of Practice to enable customization, increase readiness, and improve sustainment due to fabrication of end-use items at point of need; Office of the Assistant Secretary of Defense (OASD) Applied Research for Army Priorities (ARAP) to transition and develop materiel solutions in the synthetic biology and microbiome technical areas; Defense Health Agency (DHA) Joint Program Committee-5, which seeks to develop effective nutritional countermeasures against stressors and to maximize health, performance, and well-being; and Office of Navy Research (ONR) PE 0601153N Defense Research Sciences Biosciences program to evaluate nutritional countermeasures to physiological environmental extremes.

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: Joint Service Combat Feeding Technology *Description:* This effort investigates, designs, and develops nutrient compositions and stabilization techniques to maximize the Warfighter's physical and cognitive performance on the battlefield. The effort investigates technologies to enhance detection and identification capabilities of chemical and biological threats in foods and develops innovative ration and field feeding technologies to reduce resupply requirements. Work in this area results in increased performance, less food-borne illness, and overall increased readiness of the Warfighter. *FY 2021 Plans:* Continue investigation of nutritional factors affecting immune function and muscle recovery, and perform ex-vivo experimentation to identify gut microbiome effects on immune, gastrointestinal, and neurological health for preventing performance decrements in deployed troops; validate lipid oxidation analysis techniques to improve monitoring ability in ration components and ensure optimized nutrition; identify effects of high fat intake on physical performance to ensure optimal nutrient profiles in weight reduced	3.832	4.109	4.024

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 48 of 61

R-1 Line #10

Volume 1b - 89

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BE3 *I Joint Service Combat Feeding Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
rations; investigate microbial response to vacuum microwave drying and antimicrobials effects on Salmonella to maintain food safety; mature component technologies for reagent-less biosensors to decrease logistical burdens in multi-domain operations; continue investigation of food product production with additive manufacturing; and design and develop ration packaging system to improve cost and efficiency. *FY 2022 Plans:* Will validate effects of high fat intake on physical performance to ensure optimal nutrient profiles in weight reduced rations; determine effects of nutritional factors on intestinal function, investigate feasibility of developing a 3D intestinal tissue model to identify effects of nutritional interventions and bioactives on immune function and gastrointestinal health and investigate effect of nutrient compounds on circulating biomarkers and immune function to prevent performance decrements in deployed troops;determine correlations between lipid oxidation analysis techniques and sensory results to improve monitoring ability in ration components and ensure optimized nutrition; investigate individual warfighter hydration methods to decrease logistical burdens in multi-domain operations and investigate augmented reality technologies to enable food safety inspections in austere environments *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	3.832	4.109	4.024

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 49 of 61

R-1 Line #10

Volume 1b - 90

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602143A I Soldier Lethality Technology						Project (Number/Name) BE6 I Reactive/Resp Surfaces & Matls-Soldiers & Sys	

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
BE6: *Reactive/Resp Surfaces & Matls-Soldiers & Sys*	-	2.632	6.215	2.955	-	2.955	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs, fabricates, and assesses a variety of bio-based materials through the application of biotechnology advances to develop material capabilities that respond and adapt to a wide range of external stimuli and biological processes for protection, situational awareness, and sustainment. Innovative materials will be sought that are capable of sensing and responding, as well as adapting response, to a broad spectrum of environmental variables. Research will develop materials that are able to self-monitor, self-heal, and self-sustain. Research will 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. These materials have potential to enable more survivable, situationally aware, lighter weight Soldier systems and electronics. Research conducted focuses on unique and/or novel material properties, developing models, materials characterization techniques, non-destructive testing methods and advanced fabrication/processing methodologies.

Work in this PE complements PE 0601102A (Defense Research Sciences) / Project AA3 (Single Investigator Basic Research), Project AA3 (Single Investigator Basic Research), Project AA7 (Mechanics and Ballistics), and Project AA5 (Biotechnology and Systems Biology) and informs PE 0603118A (Soldier Lethality Advanced Technology) / BB3 (Dismounted Soldier Survivability Equip/Tech Integ).

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: Bio-enabled Materials and Processes	2.632	2.882	2.955
Description: This effort conducts applied research through the application of biotechnology advances to develop materials with capabilities to respond and adapt to a wide range of external stimuli and biological processes. Investment in bio-enabled materials research allows for the design of materials that are capable of sensing and responding, as well as adapting to a broad spectrum of environmental variables with the ability to self-monitor, self-heal, and self-sustain. Investments in this area could lead to future applications in Soldier performance, situational awareness, protection and sustainment. Research from this effort has potential to transition to multiple end items and applications. *FY 2021 Plans:* Investigate chemically and structurally diverse biological building blocks (peptide-based) for advanced sensing applications, protection, and interface/assembly of hierarchical materials; investigate advanced coatings and materials assembly utilizing bio-			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602143A / *Soldier Lethality Technology*	**Project (Number/Name)** BE6 / *Reactive/Resp Surfaces & Matls-Soldiers & Sys*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
derived and bio-composite materials for advanced sensing and protection (e.g. situational awareness, counter-biocorrosion, and biological inhibitors) and electro-magnetic applications such as antennas, lenses, and optically triggered skins/coatings; identify targets and design strategy for accelerated degradation of high value assets (electronic components, protective coatings), logistics reduction (e.g., accelerated repair and reclamation of rare-earth elements), and next generation anti-tamper technologies. *FY 2022 Plans:* Will design strategies to integrate biological building blocks with sensor platforms; mature peptide-based building blocks for strength and selectivity of target interactions, and down select candidate peptide materials; validate models and use computational and experimental tools to investigate properties of novel molecules for improved adhesion and structural stability of composites; build characterization and computation tools for rapid prototyping of biomaterials; down-select targets and use computational and analytical tools to validate models of accelerated degradation of high value targets; explore biological engineering strategy to counter material degradation. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Scalable and On-Demand Production of Novel Molecules **Description:** This effort conducts applied research through the investigation of new methods to produce novel biological molecules. Typical customized molecule production is extremely expensive and difficult to achieve. Investment in synthetic biomanufacturing techniques will further the applicability and widespread use of novel molecules to further Warfighter performance. *FY 2021 Plans:* Investigate computational and experimental tools facilitating the use of molecular biology to produce novel molecules of interest. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort ends in FY 2021.	-	3.333	-
Accomplishments/Planned Programs Subtotals	2.632	6.215	2.955

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 51 of 61

R-1 Line #10

| Volume 1b - 92 |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*					**Project (Number/Name)** BE8 *I Synthetic Training Environment (STE) 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
BE8: *Synthetic Training Environment (STE) Technology*	-	14.802	13.649	14.741	-	14.741	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops technologies supporting the Army's Synthetic Training Environment (STE). The Synthetic Training Environment (STE) is the next generation holistic collective training capability that will train units where they will fight, with whom they will fight with, and in complex operational environments to include dense urban and sub-terrain; within the entire range of combined arms maneuver tasks in support of Multi- Domain Operations. STE Information Systems (STE-IS) delivers the Common Synthetic Environment consisting of Global Terrain/One World Terrain (OWT), Training Simulation Software (TSS), and Training Management Tools (TMT). The STE will be available where training occurs (home station, combat training centers, armories, institutions, shipboard, deployed) and will include Air and Ground Reconfigurable Virtual Collective Trainers (RVCTs), a Soldier/Squad Virtual Training (S/SVT), and a live training capability. The STE will be cloud-enabled, compatible with the Army Enterprise Network, and service-based through the Common Operating Environment, including Live and Constructive. The STE will provide the realistic repetitions necessary to fight 25 bloodless battles before the first battle; a Secretary of Defense priority.

This effort is coordinated with work done in PE 0603118A (Soldier Lethality Advanced Technology) / Project BE9 (Synthetic Training Environment (STE) Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Modernization Strategy and supports the STE Cross Functional Team efforts.

Work in this Project is performed by the United States Army Futures Command (AFC) and at the Institute for Creative Technologies (ICT) University Affiliated Research Center (UARC) at the University of Southern California

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Innovative Synthetic Training Technology	7.910	-	-
Description: This effort investigates and designs methods of applying Artificial Intelligence (AI) into the STE to simulate a fully immersive environment in large urban settings with a population of adaptable, noncombatant virtual human agents for increasing the realism and complexity of training scenarios. In addition, develops tools, techniques and technologies for improving the immersion of human senses within simulation environments with the goal of creating enhanced realism within the simulated environment.			
Title: STE One World Terrain	1.934	5.832	5.554

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BE8 *I Synthetic Training Environment (STE) Technology*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort investigates and designs tools and methods to improve the speed and fidelity of a terrain capability that provides a representation of the globe, fully accessible through the Army network and usable by all simulation trainers; develops complex representations (including megacities and subterranean) of the operational environment and the Multi-Domain battlefield in synthetic training environments. *FY 2021 Plans:* Develop a whole world terrain at low to medium resolution using available data; evaluate alternative data sources to fill gaps; develop tools to rapidly process source data into a single representation that serves all application needs; develop and investigate a processes for generating fully attributed hi-resolution terrain insets such as underground geometry, key civilian infrastructure components, complex road networks, hydrological features, and complex structures. *FY 2022 Plans:* Will investigate tools, algorithms and communities of practice to develop automated complex terrain features for Dense Urban Environments and determine level of attribution required to extend OWT data model support for dynamic and cascading effects (e.g., transportation tunnels, civilian infrastructure); investigate and determine OWT data model compliant metadata (e.g., geometry, attributes) towards enriching OWT 3D terrain mesh generation; design terrain correlated material maps with textures to advance simulation sensor implementations and enable physics-based calculation for terrain modification. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: STE Training Management Tool *Description:* This effort investigates Adaptive Training (AT) methods to facilitate authoring, distribution, management, and evaluation of tailored instruction for both individuals and teams; and evaluates the impact of training and education tools/ methods on comprehension, reasoning, learning, performance, retention, and transfer of knowledge and acquired skills to assess Training Effectiveness (TE) in Synthetic Training Environments. *FY 2021 Plans:* Design and develop natural language artificial intelligence (AI) processing techniques for small team verbal communications during task execution; develop proof of principle for automating team performance assessments and for actionable automated after action review (AAR) feedback to teams, leaders, and instructors; develop a robust intelligent team adaptive training capability to maximize training outcomes at point of need; develop AI methods grounded in learning science to support self-optimizing systems that produce skill retention and transfer into the operational environment; conduct experiments to validate team performance measures; assess the effectiveness of different machine learning approaches to facilitate automated authoring of scenario based training for individuals and teams; develop models for assessing competencies of individuals and teams using	4.958	5.269	4.999

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602143A I *Soldier Lethality Technology*	**Project (Number/Name)** BE8 I *Synthetic Training Environment (STE) Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
a combination of live, virtual, and constructive training events in militarily relevant domains; investigate the use of physiological measures as a means of improving automated adaptation of training and for assessing training outcomes, predicting training transfer, and providing real-time feedback to instructors and students during the execution of individual and collective training. ***FY 2022 Plans:*** Will validate techniques for automating team performance assessments and actionable automated after action review (AAR) feedback to teams, leaders, and instructors; continue design of adaptive, intelligent tutor for teaming to maximize training outcomes at the point of need; investigate team tutor technologies to assess team training measures and effectiveness; determine reinforcement learning-based planning models to deliver run-time feedback to teams during simulation-based training; investigate team intelligent tutoring based on roles and functions within the team to assess the overall team readiness level; design team communication analysis toolkit using natural language processing and deep learning neural networks to analyze and assess team communications during simulated training exercises; investigate team performance assessments for the instructors using artificial intelligence models to determine an evaluation of a team?s performance and recommendations to optimize training toward an acceptable readiness level; investigate the association between squad level performance measures for individuals and teams and determine how to best deliver data to assess their performance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects minor change in planned project scope.			
Title: STE Training Simulation Software *Description:* This effort designs and develops Modeling and Simulation (M&S) technologies to enable the Army?s Synthetic Training Environment (STE) Training Simulation Software (TSS). This includes technologies that enable the representation of the development of synthetic military forces and noncombatants leveraging emerging Artificial Intelligence (AI) methods and techniques. This application of AI to simulation use is focused on enabling more complex modeling of the Operational Environment and the representation of Multi-Domain Operations. This effort also investigates methods and means to enable a pipeline of modeling development and reuse from authoritative sources to simulation environments considering the complexities of simulating various echelons of warfare (e.g. squad to ASCC) and their application in support of multiple collective training use cases and user interfaces to access the Training Simulation Software (TSS). ***FY 2021 Plans:*** Investigate autonomous, artificially intelligent agents that adapt to changing battlefield conditions, friendly forces, non-combatants, and enemy threats in a military relevant virtual training environment; investigate multi-resolution modeling applications such as Live, Virtual, and Constructive (LVC) experimentation utilizing AI enabled attributes; and design and develop cutting-edge M&S methods to enable the reuse and development of new Army and Department of Defense (DoD) STE-ready models for	-	2.548	4.188

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 54 of 61

R-1 Line #10

Volume 1b - 95

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602143A I *Soldier Lethality Technology*	**Project (Number/Name)** BE8 I *Synthetic Training Environment (STE) Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Multi-Domain Operations in support of System of Systems (SoS) analysis, experimentation, technology tradeoffs, capability assessments, concept development, and training. *FY 2022 Plans:* Will investigate application of Artificial Intelligence (AI) techniques to enable autonomous squad-level interactions between friendly forces, non-combatants, and enemy threats in support of squad battle drills; will design methods to connect Operational Environment (OE) models, data and algorithms with emerging AI techniques in order to automate generation of representative OE simulation for collective training; will investigate cross-cutting modeling capabilities required to enable Multi-Domain Operations and their effect on model interactions, such as the introduction of complex weather modeling, that could impact the ability to deliver collective training. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increased to further research into AI techniques in support of developing OE models to support MDO training.			
Accomplishments/Planned Programs Subtotals	14.802	13.649	14.741

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 55 of 61

R-1 Line #10

Volume 1b - 96

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*					**Project (Number/Name)** BP9 *I Soldier Lethality Technologies (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**
BP9: *Soldier Lethality Technologies (CA)*	-	30.626	79.000	-	-	-	-	-	-	-	-	-

Note
 Congressional Interest Item funding provided for Soldier Lethality Technologies.

A. Mission Description and Budget Item Justification
 This project is for congressional increases that support applied research in support of Soldier Lethality, where the Soldier and Squad are treated as an integrated combat platform. The fundamental challenge is to overcome an erosion in close combat overmatch relative to the pacing threats identified in the National Defense Strategy. This program increase leverages science, technology, and human potential to achieve the overmatch necessary to maneuver, isolate, and defeat our adversaries in any environment.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Congressional Add: Medical simulation and training	3.626	-
FY 2020 Accomplishments: Congressional Increase. Applied research in support of Soldier Lethality Medical Simulation and Training Work executed by Army Futures Command.		
Congressional Add: Active and passive camouflage concealment and deception	3.000	-
FY 2020 Accomplishments: Congressional Increase. Applied research in support of Soldier Lethality Active and Passive Camoflage, Concealment and Deception. Work executed by Army Futures Command.		
Congressional Add: Human systems integration	10.000	-
FY 2020 Accomplishments: Congressional Increase. Applied research in support of Soldier Lethality Human Systems Integration Work executed by Army Futures Command.		
Congressional Add: Expeditionary mobile base camp technology	2.000	-
FY 2020 Accomplishments: Congressional Increase. Applied research in support of Soldier Lethality Expeditionary Mobile Base Camp Technology		

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 56 of 61

R-1 Line #10

Volume 1b - 97

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army				**Date:** May 2021
Appropriation/Budget Activity 2040 / 2		**R-1 Program Element (Number/Name)** PE 0602143A / *Soldier Lethality Technology*		**Project (Number/Name)** BP9 / *Soldier Lethality Technologies (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Work executed by Army Futures Command.		
Congressional Add: SOCOM communications capability	2.500	-
FY 2020 Accomplishments: Congressional Increase. Applied research in support of Soldier Lethality Communications Capability Work executed jointly by Army Futures Command. and SOCOM.		
Congressional Add: Soldier Lethality Technologies Program Increase	5.000	-
FY 2020 Accomplishments: Congressional Increase. Applied research in support of Soldier Lethality fundamental challenges to overcome is an erosion in close combat overmatch relative to the pacing threats identified in the NDS. This program increase leverages science, technology, and human potential to achieve the overmatch necessary to maneuver, isolate, and defeat our adversaries in any environment. Work executed by Army Futures Command.		
Congressional Add: Harnessing Emerging Soldier Lethality Technology Research	4.500	-
FY 2020 Accomplishments: Congressional Increase. Applied research in support of Soldier Lethality fundamental challenges to overcome is an erosion in close combat overmatch relative to the pacing threats identified in the NDS. This program increase leverages science, technology, and human potential to achieve the overmatch necessary to maneuver, isolate, and defeat our adversaries in any environment. Work executed by Army Futures Command.		
Congressional Add: Program increase - pathfinder airborne	-	8.000
FY 2021 Plans: Conduct applied research in Pathfinder Airborne. Work executed by Army Futures Command.		
Congressional Add: Program Increase - Pathfinder Air Assault	-	10.000
FY 2021 Plans: Conduct applied research in Pathfinder Air Assault. Work executed by Army Futures Command.		
Congressional Add: Program increase - Rapidly deployable shelters	-	3.000

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 57 of 61

R-1 Line #10

Volume 1b - 98

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602143A / *Soldier Lethality Technology*	**Project (Number/Name)** BP9 / *Soldier Lethality Technologies (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
FY 2021 Plans: Conduct applied research in Rapidly Deployable Shelters. Work executed by Army Futures Command.		
Congressional Add: Program increase - UTDD catalyst	-	5.000
FY 2021 Plans: Conduct applied research in UTDD Catalyst. Work executed by Army Futures Command.		
Congressional Add: Program increase - lightweight body armor mechanisms and materials	-	10.000
FY 2021 Plans: Conduct applied research in Lightweight Body Armor Mechanisms and Materials. Work executed by Army Futures Command.		
Congressional Add: Program increase - advanced textile-based products	-	6.000
FY 2021 Plans: Conduct applied research in Advanced Textile-Based Products. Work executed by Army Futures Command.		
Congressional Add: Program increase - HEROES program	-	5.000
FY 2021 Plans: Conduct applied research in HEROES Program. Work executed by Army Futures Command.		
Congressional Add: Program increase - soldier ballistic technologies	-	5.000
FY 2021 Plans: Conduct applied research in Soldier Ballistic Technologies. Work executed by Army Futures Command.		
Congressional Add: Program increase - medical simulation and training	-	4.000
FY 2021 Plans: Conduct applied research in Medical Simulation and Training. Work executed by Army Futures Command.		
Congressional Add: Program increase - body armor study	-	4.000
FY 2021 Plans: Conduct applied research in Body Armor Study.		

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602143A / *Soldier Lethality Technology*	**Project (Number/Name)** BP9 / *Soldier Lethality Technologies (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed by Army Futures Command.		
Congressional Add: Program increase - academic accelerator pilot program	-	15.000
FY 2021 Plans: Conduct applied research in Academic Accelerator Pilot Program.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - Advanced ballistics technology for personal protective systems	-	4.000
FY 2021 Plans: Conduct applied research in Advanced Ballistics Technology for Personal Protective Systems.		
Work executed by Army Futures Command.		
Congressional Adds Subtotals	30.626	79.000

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 59 of 61

R-1 Line #10

| **Volume 1b - 100** |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602143A / *Soldier Lethality Technology*				**Project (Number/Name)** BR9 / *Personnel & Airdrop Safety 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
BR9: *Personnel & Airdrop Safety Technology*	-	3.929	3.601	3.476	-	3.476	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project funds the research and investigation of component technologies to enhance cargo and personnel airdrop capabilities for global precision delivery, rapid deployment, and insertion for force projection into hostile regions. Areas of emphasis include parachute technologies, parachutist injury reduction, precision offset aerial delivery, soft landing technologies, and airdrop simulation. Technologies support the Soldier Lethality Army Modernization Priority. New operational concepts call for increased precision of personnel and cargo in austere environments in which small units are dispersed and logistical supply is limited. The Army requires enhanced payload extraction and other increased capabilities to support the airdrop requirement for current and future vehicles exceeding aircraft payload weight capacity. TheU.S. Army Airborne Board (Chaired by the XVIII Airborne Corps Commanding General) identified increased payload capabilities as a critical requirement to support the mission readiness profile for the Global Response Force (GRF), and will support Joint Forcible Entry requirements while maximizing the capacity of a C-17 aircraft.

Work in this Project supports key Army needs and complements the technical research of several PEs to include PE 0601102A (Defense Research Sciences), PE 0602143A (Soldier Lethality Technology) / Project BD6 (Soldier Sys Interfaces/ Integration- Sensor Tech), and PE 0603118A (Soldier Lethality Advanced Technology) / Project BE5 (Personnel & Airdrop Safety Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Personnel & Airdrop Safety Technology	3.929	3.601	3.476
Description: This effort investigates technologies that enhance payload extraction, which will allow current vehicles to be dropped with more armor and support equipment, and reduce the design constraint on future vehicles that have airdrop as an operational requirement, increase parachute gliding capabilities, and mature delivery accuracy of cargo aerial delivery systems that support varying payload weights. Research in the area of novel parachute materials will provide increased capabilities for cargo and personnel aerial delivery systems. This effort will support an investigation of new Modeling and Simulation (M&S) tools in order to develop validation methods for airdrop concepts. This effort also investigates technologies that advance airborne personnel insertion safety requirements to modernize the Airborne Soldier and provide the ability to effectively execute the airborne mission through reducing safety risk and increasing capabilities. *FY 2021 Plans:*			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602143A *I Soldier Lethality Technology*	**Project (Number/Name)** BR9 *I Personnel & Airdrop Safety Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Conduct research into sensing technologies that augment personnel or autonomous cargo airdrop systems, enabling accurate, reliable insertion and resupply missions across a broad scope of operational conditions and non-traditional airdrop environments; examine new parachute designs and avionics necessary to facilitate maximum mission effectiveness conducted across an array of technologies and modalities using analytical, numerical, and experimental methods. *FY 2022 Plans:* Will mature high altitude personnel and cargo insertion technologies that facilitate extended offset insertions in GPS denied conditions; carry out research on high offset air insertion and resupply mission capability enhancements; perform research into sensor integration and fusion techniques to produce robust navigational datasets suitable for guidance, navigation and control of autonomous systems in contested and challenging mission environments; determine feasibility of materiel and non-materiel solutions focused on reduction of airdrop platform signature. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	3.929	3.601	3.476

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

D. Acquisition Strategy
 N/A

PE 0602143A: *Soldier Lethality Technology*
Army

UNCLASSIFIED
Page 61 of 61

R-1 Line #10

| **Volume 1b - 102** |

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602144A *I Ground 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**
Total Program Element	-	143.172	158.158	56.400	-	56.400	-	-	-	-	-	-
BK7: *Robotics for Engineer Operations Technology*	-	9.889	6.037	1.228	-	1.228	-	-	-	-	-	-
BL1: *Materials and Manufacturing Research Technology*	-	7.792	10.030	9.374	-	9.374	-	-	-	-	-	-
BL2: *Explosives Forensics Technology*	-	1.478	1.514	1.582	-	1.582	-	-	-	-	-	-
BL4: *Countermine Technology*	-	4.070	-	-	-	-	-	-	-	-	-	-
BL5: *Expedient Passive Protection Technology*	-	4.106	1.413	1.906	-	1.906	-	-	-	-	-	-
BL7: *Power Projection in A2AD Environments Technology*	-	2.757	1.843	3.151	-	3.151	-	-	-	-	-	-
BL9: *Protection from Advanced Weapon Effects Technology*	-	4.380	3.812	4.344	-	4.344	-	-	-	-	-	-
BN8: *Ground Technology Materials(CA)*	-	108.700	131.000	-	-	-	-	-	-	-	-	-
CA9: *Predictive Maintenance*	-	-	2.509	-	-	-	-	-	-	-	-	-
CG5: *Ground Vehicle Sensor Concepts and Technologies*	-	-	-	4.146	-	4.146	-	-	-	-	-	-
CG6: *Ground Vehicle Power and Energy Concepts and Tech*	-	-	-	2.681	-	2.681	-	-	-	-	-	-
CG7: *Ground Protection Concepts and Technologies*	-	-	-	14.565	-	14.565	-	-	-	-	-	-
CG8: *Human Autonomy Teaming*	-	-	-	8.599	-	8.599	-	-	-	-	-	-
CI2: *Ground Enabling University Applied Research*	-	-	-	4.824	-	4.824	-	-	-	-	-	-

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	

A. Mission Description and Budget Item Justification

This PE researches efforts that support and enable the Army's modernization priority for the Next Generation of Combat Vehicles including systems for the deployment and sustainment of ground movement and maneuver. This PE designs and validates technologies that are necessary and foundational for legacy and future ground movement, maneuver and protection of Soldiers and systems.

All 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.

Work in the Project supports the Army Science and Technology Ground portfolio.

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

Work in this PE complements PE 0602145A (Next Generation Combat Vehicle Technology), PE 0603119A (Ground Advanced Technology), PE 0603462A (Next Generation Combat Vehicle Advanced Technology), PE 0602143A (Soldier Lethality Technology) and PE 0603118A (Soldier Lethality Advanced Technology).

B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	143.899	28.047	31.666	-	31.666
Current President's Budget	143.172	158.158	56.400	-	56.400
Total Adjustments	-0.727	130.111	24.734	-	24.734
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	131.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.727	-0.889			
• Adjustments to Budget Years	-	-	24.734	-	24.734

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Project: BN8: *Ground Technology Materials(CA)*		
Congressional Add: *Environmental Quality Enhanced Coatings*	5.000	-
Congressional Add: *Environmental Friendly Coatings Technology*	3.000	-
Congressional Add: *Additive Manufacturing for Artificial Intelligence and Machine Learning*	5.000	-

PE 0602144A: *Ground Technology*
Army
UNCLASSIFIED
Page 2 of 41
R-1 Line #11
Volume 1b - 104

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	

<u>Congressional Add Details ($ in Millions, and Includes General Reductions)</u>	**FY 2020**	**FY 2021**
Congressional Add: *Earthen Structures Soil Enhancement*	4.000	-
Congressional Add: *M1 Abrams Tank Track System*	2.200	-
Congressional Add: *High Performance Polymers*	5.000	-
Congressional Add: *Materials Manufacturing Processes*	6.000	-
Congressional Add: *Highly Durable Advanced Polymers for Lightweight Armor*	8.000	-
Congressional Add: *Cellulose Nanocomposite Research*	5.000	-
Congressional Add: *Countermine Program*	5.000	-
Congressional Add: *Materials Research*	17.500	-
Congressional Add: *Additive Manufacturing and Materials Processing*	15.000	-
Congressional Add: *Cold Weather Military Research*	3.000	-
Congressional Add: *Cold Spray Technologies*	15.000	-
Congressional Add: *Center for Research in Extreme Batteries*	10.000	-
Congressional Add: *Program increase: Ice engineering research facility modernization*	-	5.000
Congressional Add: *Program increase: Center for research in extreme batteries*	-	10.000
Congressional Add: *Program increase: Cellulose nanocomposites research*	-	5.000
Congressional Add: *Program increase: Advanced polymers for force protection*	-	8.000
Congressional Add: *Program increase - advanced concrete*	-	4.000
Congressional Add: *Program increase - robotic RTCH*	-	5.000
Congressional Add: *Program increase - military waste stream conversion*	-	5.000
Congressional Add: *Program increase - high performance polymers*	-	5.000
Congressional Add: *Program increase - integrity of transparent armor*	-	5.000
Congressional Add: *Program increase - environmental quality enhanced coatings*	-	5.000
Congressional Add: *Program increase - autonomous digital design and manufacturing*	-	5.000
Congressional Add: *Program increase - materials recovery technologies for defense supply resiliency*	-	10.000
Congressional Add: *Program increase - materials manufacturing processes*	-	10.000
Congressional Add: *Program increase - additive manufacturing machine learning initiative*	-	10.000

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 3 of 41

R-1 Line #11

Volume 1b - 105

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Congressional Add: *Program increase - rapid advanced deposition*	-	10.000
Congressional Add: *Program increase - defense resiliency against extreme cold weather*	-	10.000
Congressional Add: *Program increase - counter UAS technology research*	-	5.000
Congressional Add: *Program increase - cell-free expression for biomanufacturing*	-	10.000
Congressional Add: *Program increase: Earthen structures soil enhancement*	-	4.000
Congressional Add Subtotals for Project: BN8	108.700	131.000
Congressional Add Totals for all Projects	108.700	131.000

Change Summary Explanation

FY22 increase related to the realignment of 5 Projects from 0602145A Next Generation Combat Vehicle Technology to focus on mid to far term deliverables for the ground portfolio

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 4 of 41

R-1 Line #11

Volume 1b - 106

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602144A I *Ground Technology*					Project (Number/Name) BK7 I *Robotics for Engineer Operations 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
BK7: *Robotics for Engineer Operations Technology*	-	9.889	6.037	1.228	-	1.228	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This research investigates and develops standoff robotic capabilities for Combat Engineers to reduce Soldier/Engineer risks and fatalities while conducting activities essential to shaping the environment. It will close the gaps between commercial construction equipment and the requirements of the future Engineer Force to support maneuver, movement, and sustainment. This research will develop the capability to generate a near real-time site model with appropriate engineering details to allow unmanned shaping of the environment through physical interaction (e.g. push, pull, lift, or dig). This effort will also develop the requisite mission planner and task execution controller that accepts input from the user and provides suggestions and feedback based on updates to the site model, reporting from hardware agents, and resource allocation logic. The end state goal is the development of beyond visual line of sight teleoperation and semiautonomous capabilities allowing Engineer robotic support to match pace in near term and future combat environments. This effort will support the development, testing, and evaluation of prototypical robotic Combat Engineer equipment. This Project develops modeling and simulation tools that represent realistic states for Engineer robotic operations and develops and assesses semi-autonomous and autonomous construction equipment technologies needed for remote control Engineer operations.

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 supports the Army Science and Technology Ground Portfolio.

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

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

Work in this Project is related to, and fully coordinated with, PE 0603119A (Ground Advanced Technology) / Project BK8 (Robotics for Engineer Operations Adv Tech).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Dynamic Site Characterization	2.150	-	-
Description: This effort develops the capability to dynamically characterize the environment in which robotic Engineer equipment will operate through implementation of multi-modal sensing, sensor data fusion, and object detection and classification.			
Title: Mission Planning and Task Execution Control	3.100	-	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BK7 *I Robotics for Engineer Operations Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort develops a mission planning and task execution control capability to enable unmanned robotic Engineer equipment operations. This capability will provide a near real time operational view of the area of interest and will convert mission planning directives into commands for the robotic equipment.			
Title: Integration Prototype Model Development	4.639	-	-
Description: This effort develops remote control protocols and processes for testing of construction equipment to assess suitability for use during engineer operations; assesses commercially available autonomy solutions from transportation and construction industries to develop enhanced semi-autonomous and autonomous equipment technology; and develops simulation tools for coordinated, multi-equipment operations.			
Title: Beyond-Visual-Line-of-Sight Teleoperated Engr Ops	-	6.037	1.228
Description: This effort develops site characterization technologies, equipment localization technologies, equipment tools, and controls protocols to support remote control and semi-autonomous engineering operations and develops modeling and simulation tools to support remote operations. *FY 2021 Plans:* Develop Combat Engineer specific library for object classification and identification to allow for greater fidelity in semi-autonomous site characterization; develop site localization technologies for Engineer equipment operating in Global Positioning System denied environments; develop machine learning and artificial intelligence protocols unique to construction equipment tool manipulation and execution; develop equipment controls and control interfaces to allow multiple pieces of equipment to be operated/overseen by one operator. *FY 2022 Plans:* Will investigate operator assist capabilities and operator interface aids for remote tool control; and refine components to the Engineer specific library for object classification, site localization technologies, and site change and manipulation monitoring. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding decrease reflects the planned lifecycle progression to advanced technology development PE 0603119A Project BK8.			
Accomplishments/Planned Programs Subtotals	9.889	6.037	1.228

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

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 6 of 41

R-1 Line #11

| **Volume 1b - 108** |

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BK7 *I Robotics for Engineer Operations Technology*

D. Acquisition Strategy

  N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 7 of 41

R-1 Line #11

Volume 1b - 109

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*					**Project (Number/Name)** BL1 *I Materials and Manufacturing Research 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**
BL1: *Materials and Manufacturing Research Technology*	-	7.792	10.030	9.374	-	9.374	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project links materials research, manufacturing processes, and design to enable higher quality additive manufacturing products for Army applications through the development of high performance feedstock materials (polymers, metals, and ceramics), physics-based process models, and in-situ process monitoring. Integration of these tools with process models enables real-time control and manipulation of materials structure and properties to produce three-dimensional hybrid electronics packaging, power and energy sources and converters and new materials/structures for protection. The goal of this work is to develop robust physics-based models to optimize material properties, structures, and manufacturing processes for Army applications in protection, maneuver, power, sensing, and signature management necessary to rapidly respond to emerging and unknown threats in a battlefield environment.

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

Work in this Project supports the Army Science and Technology Ground and Next Generation Combat Vehicle.

Work in this effort is performed by the United States (US) Army Futures Command.

This work is done in coordination with PE 0602145A (Next Generation Combat Vehicle Technology), 0602143A (Soldier Lethality Technology) and 0603118A (Soldier Lethality Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Agile Expedient Manufacturing	2.227	-	-
Description: This effort researches developing manufacturing processes to accelerate the rate of innovative material adaptations (protection, power, sensing, and signature management) necessary to rapidly respond to emerging and unknown threats in a battlefield environment. Efforts include the development of innovative materials technologies through combinations of additive and subtractive manufacturing, direct write processes, coupled electro-magnetic fields, and other hybrid processes, as well as the development of robust predictive modeling and simulation tools linking manufacturing processes with materials structure, properties, and performance to enable the design and production of optimal materials at the point of need using available materials, energy sources, etc.			
Title: Power and Energy	1.609	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BL1 *I Materials and Manufacturing Research Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort focuses on the design and characterization of chemistries, materials, and components for advanced batteries, fuel reformers, and fuel cells. Potential Army applications include hybrid power sources, smart munitions, hybrid electric vehicles, and soldier power applications. This effort also investigates the applicability of photosynthesis to provide fuel and electricity for soldier power applications, and investigate silicon carbide power module components that could enable compact, high-efficiency, high-temperature, and high-power density converters for motor drive and pulse power applications.			
Title: Additive Manufacturing Research	3.956	8.240	8.471
Description: This effort researches new additive manufacturing (AM) capabilities that enable production of lightweight materials for protection, lethality, and maneuverability that cannot be produced through traditional manufacturing methods. Efforts include the development of new feedstock materials engineered specifically for low-volume additive processes to produce net-shape materials with desired properties and functionalities; integrated process models and real-time monitoring for closed-loop control and production of lightweight materials with optimal architectures, property gradients, and interfaces; and design optimization capabilities that connect materials and manufacturing to access the full design space enabled by additive manufacturing. *FY 2021 Plans:* Build upon prior metallic suspension chemistries to demonstrate electrical interconnect deposition capability for ambient reactive extrusion processes; demonstrate high conductivity, high resolution metallic inks to enable chip to chip interconnect and board level integration; demonstrate modified interfaces into three-dimensional hybrid electronics; develop improved performance for the integrated microprocessors, amplifiers, three-dimensional antennas, and sensors for Army applications; investigate use of electromagnetic fields in metal additive manufacturing processes to control specific microstructures in Magnesium alloys for structural and protection uses. *FY 2022 Plans:* Will mature a closed-loop AM process control experimental capability across a broad array of AM technologies by applying a set of in-situ process (or "within" process) monitoring techniques; design and develop an AM machine learning (ML) architecture for advancing real-time AM process controls by applying the following two deep ML frameworks: (1) convolutional neural networks (CNN) supervised deep learning framework for automatically detecting in-process defects and rapidly computing predictive models such as a structure-processing-property relations model; (2) generative adversarial networks (GANs) unsupervised deep learning framework for training the in-situ data sets and generating referenced data sets in real-time to compare them against in-situ process data for detecting AM process anomalies and for predicting the geometry-dependent optimized AM process parameters. *FY 2021 to FY 2022 Increase/Decrease Statement:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BL1 *I Materials and Manufacturing Research Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Funding change reflects planned lifecycle of this effort.			
Title: Energy Sources and Storage	-	1.790	0.903
Description: This effort focuses on the design and characterization of chemistries, materials, and components for advanced batteries, fuel reformers, and fuel cells. Potential Army applications include hybrid power sources, smart munitions, hybrid electric vehicles, and soldier power applications. This effort also investigates the applicability of photosynthesis to provide fuel and electricity for soldier power applications, and investigate silicon carbide power module components that could enable compact, high-efficiency, high-temperature, and high-power density converters for motor drive and pulse power applications. *FY 2021 Plans:* Develop electrolytes for high-voltage cathodes with high capacity silicon anode that will enable the transition of next generation high energy dense, safe batteries for Soldier use; synthesize and develop highly active low-cost catalysts for fuel production and to use in fuel cell and power conversion applications; investigate modeling of spin activated liquid reserve batteries to explore the design space as it relates to requirements for energy, activation times, and environmental conditions for future munition systems. *FY 2022 Plans:* Will investigate advanced electrolytes to improve safety in ultrahigh energy silicon nanostructured anodes for Soldier-carried batteries including the 3/5 form factor (standard military specification for battery size, with a length over width ratio of 3 to 5) Conformal Wearable Battery (CWB); investigate materials and additives to improving safety in high energy (400 Wh/kg Li-ion); investigate high energy halide intercalation cathodes for transition of metal-free rechargeable batteries (halide intercalation is the reversible inclusion or insertion of a metal hydride molecule or ion into materials with layered structures such as graphite). *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY22, funding was realigned to PE 0602141 (Lethality Technology) / CF7 Solid-state Laser Concepts and Architectures			
Accomplishments/Planned Programs Subtotals	7.792	10.030	9.374

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

D. Acquisition Strategy
 N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 10 of 41

R-1 Line #11

Volume 1b - 112

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*					**Project (Number/Name)** BL2 *I Explosives Forensics 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**
BL2: *Explosives Forensics Technology*	-	1.478	1.514	1.582	-	1.582	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops analytical methods for military explosives, homemade explosives (HME), HME precursors, and residue analysis for forensics attribution purposes. This project pursues research in signatures and algorithms required to provide improved residue analysis of explosives and precursor materials to enable integration into chemical and explosive hazard detection equipment for the warfighter.

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 supports the Army Science and Technology Ground Portfolio.

Work in this effort is performed by the United States (US) Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Forensic Analysis of Explosives Signatures Applied Research	1.478	1.514	1.582
Description: This effort investigates forensics analytical methods for military explosives, HME, HME precursors, and residue analysis for attribution.			
FY 2021 Plans: Develop analytical methods for forensic analysis of explosives and other chemical hazards with the objective of assigning attribution to include collection, preparation, instrumental analysis and advanced statistical techniques; provide solutions for analytical problems encountered by expeditionary laboratories based on the research performed in this task.			
FY 2022 Plans: Will continue to investigate new technologies (hyperspectral imaging, compressed sensing, augmentation of current technology) for development of advanced concepts and operations of forensic analytical techniques to facilitate chemical and explosive detection and reconnaissance.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	1.478	1.514	1.582

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* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BL2 *I Explosives Forensics Technology*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

 N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*					**Project (Number/Name)** BL4 *I Countermine 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**
BL4: *Countermine Technology*	-	4.070	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops selectable explosive hazard (EH) (i.e., mine, minefield, improvised explosive device) neutralization technologies combined with detection confirmation sensor capabilities to provide a future integrated detection and neutralization capability in support of both manned and unmanned mounted route clearance and conventional mine breaching operations.

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 supports Army Science and Technology Ground Portfolio and Soldier Lethality modernization priorities.

Work in this effort is performed by the United States (US) Army Futures Command.

This Project is coordinated with PE 0602145A (Next Generation Combat Vehicle Technology), 0602143A (Soldier Lethality Technology), 0603462A (Next Generation Combat Vehicle Technology Advanced Technology) and 0603118A (Soldier Lethality Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Countermine Technology	4.070	-	-
Description: Designs and develops selectable explosive hazard neutralization technologies combined with detection confirmation sensor capabilities to provide a future integrated detection and neutralization capability in support of both manned and unmanned mounted route clearance and conventional mine breaching operations. Products of this effort include sensor components for high reliability confirmation, cueing algorithms that produce repeatable and accurate registration coordinates for neutralization, and trade off analysis of candidate neutralization techniques to achieve a desired neutralization order of magnitude (low or high order detonation).			
Accomplishments/Planned Programs Subtotals	4.070	-	-

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

D. Acquisition Strategy
 N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 13 of 41

R-1 Line #11

Volume 1b - 115

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*					**Project (Number/Name)** BL5 *I Expedient Passive Protection 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
BL5: *Expedient Passive Protection Technology*	-	4.106	1.413	1.906	-	1.906	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops rapidly deployable passive protective solutions; algorithms for decision support applications and software; and tactics, techniques, and procedures to increase the survivability of personnel, critical assets, and facilities. Through experimental and computational investigation and design, this project develops force protection technologies for complex and urban environments. This Project also develops expedient solutions and decision support applications for protection against advanced energetic threats and large caliber rockets, missiles, and other emerging weapons.

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 supports the Army Science and Technology Ground Portfolio.

Work in this Project is conducted by the United States (US) Army Engineer Research and Development Center and coordinated with US Army Futures Command.

Work in this Project complements PE 0603119A (Ground Advanced Technology) / Project BL6 (Expedient Passive Protection Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Integrate Novel Materials for Tone Down Applications	0.333	-	-
Description: This effort utilizes native vegetation as an unconventional countermeasure for Army concealment. Work includes identification of spectral properties for infrared disruption, and inclusion of additive materials for tone-down applications.			
Title: Force Protection in the Urban Environment	3.773	-	-
Description: This effort develops force protection solutions for urban environments and computational test bed capabilities to develop advanced materials and expedient protective solutions; develops rapidly deployable protection systems; decision support applications and software; and tactics, techniques, and procedures to provide protection with consideration for a complex three-dimensional threat.			
Title: Protection Against High Trajectory Large Caliber Rocket and Missile Threats	-	1.413	1.906
Description: This effort investigates high trajectory large caliber rocket and missile weapon effects on critical assets and facilities and develops expedient force protection solutions for these new weapon threats. These solutions include the application of novel			

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 14 of 41

R-1 Line #11

Volume 1b - 116

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BL5 *I Expedient Passive Protection Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
protective materials and designs. This effort develops and validates deployable protection systems against these threats and develops decision support tools to aid the warfighter in selecting protective positions. *FY 2021 Plans:* Investigate effects of high trajectory large caliber rockets and missiles on legacy protective systems and new conceptual passive protection designs. *FY 2022 Plans:* Will develop new materials and algorithms to protect critical assets in multi-domain operations from emerging threats such as large caliber rockets and missiles, and will develop new design concepts for passive protection against these threats. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase in FY22 will support development of new protective designs against emerging threats (large caliber rockets and missiles).			
Accomplishments/Planned Programs Subtotals	4.106	1.413	1.906

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

D. Acquisition Strategy
 N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 15 of 41

R-1 Line #11

Volume 1b - 117

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*				**Project (Number/Name)** BL7 *I Power Projection in A2AD Environments 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
BL7: *Power Projection in A2AD Environments Technology*	-	2.757	1.843	3.151	-	3.151	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops remote assessment technologies to determine entry and maneuver corridors, develops site selection tools and decision support technologies for all climates in all season conditions including aviation site selection tools, enhanced automated route reconnaissance technologies, mobility models for extreme climates, and road capacity assessment technologies. These technologies reduce reliance on manned on-site reconnaissance for projection platform assessments and provide all season capacity predictions to ensure air and ground battlespace entry and maneuver. This Project also designs and develops material solutions to repair, rebuild and construct infrastructure required for movement and maneuver in highly contested, complex operational environments such as Anti-Access/Area Denial (A2/AD).

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 supports the Army Science and Technology Ground Portfolio.

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

Work in this PE complements PE 0603119A (Ground Advanced Technology) / Project BL8 (Power Projection in A2AD Environments Adv Tech).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Entry and Sustainment in Complex Contested Environments **Description:** This effort develops strategic and tactical level planning tools for assessing engineering behavior of ground surfaces as it relates to battlefield maneuver to include factors affecting on-and-off-road vehicle mobility as well as aviation assembly areas; applies new technologies for data acquisition to engineering design factors to rapidly assess vehicle and terrain interaction. **FY 2021 Plans:** Validate remote sensing data analysis algorithms for predicting off-road mobility in arctic regions; design and develop methodology for rapid road and trail classification; and conduct computational experiments for analyzing ground vehicle impact on bound and unbound granular materials. **FY 2022 Plans:**	2.757	0.880	1.375

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BL7 *I Power Projection in A2AD Environments Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will further develop portions of prediction tools for arctic mobility across snow-covered terrain and in organic soils unique to arctic regions; and will validate methodologies for rapid road and trail classification and determine analytical procedures for estimating capacity of low-volume roads for military vehicles. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase in FY22 will support development of analytical procedures for estimating capacity for low-volume roads.			
Title: Engineering for Battlespace Maneuver *Description:* This effort develops the capability to rapidly repair and upgrade damaged infrastructure along mobility corridors and restaging areas to maintain and enhance freedom of maneuver achieving overmatch and tactical advantage in contested complex environments. ***FY 2021 Plans:*** Design and develop techniques for rapid soil stabilization to support military ground vehicle maneuver; conduct experiments to provide stand-off assessments of existing route characteristics; and develop algorithms to support engineer planning for route maintenance to prioritize maneuver corridors based on available engineer assets. ***FY 2022 Plans:*** Will mature materials and refine techniques for rapid ground stabilization and expedient soil hardening to support military vehicles; will enhance techniques for expedient infrastructure upgrades; and will develop planning aids for engineer support to route remediation. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase in FY22 will support development of enhanced expedient infrastructure upgrade techniques and engineer route remediation planning tools.	-	0.963	1.776
Accomplishments/Planned Programs Subtotals	2.757	1.843	3.151

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* 2				R-1 Program Element (Number/Name) PE 0602144A *I Ground Technology*						Project (Number/Name) BL9 *I Protection from Advanced Weapon Effects 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
BL9: *Protection from Advanced Weapon Effects Technology*	-	4.380	3.812	4.344	-	4.344	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops structural hardening, high-performance computing capabilities, and force protection technologies to enhance survivability of personnel and critical assets. This project investigates and develops advanced materials for protection against blast, fragmentation, and penetration through physical experiments and modeling and simulation. Additionally, this project investigates, designs, and develops passive protection technologies and protective design criteria to mitigate attack from emerging advanced threats.

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 supports the Army Science and Technology Ground Portfolio.

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

Work in this PE complements PE 0603119A (Ground Advanced Technology) / Project BM1 (Protection from Advanced Weapon Effects Adv Tech).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Materials and Modeling for Force Protection	1.410	1.375	-
Description: This effort develops advanced composite and other protective materials and multi-scale modeling techniques to reduce material weight and increase resistance against blast and penetration threats; develops innovative virtual material design procedures; and optimizes manufacturing processes supported by computational modeling and simulation. *FY 2021 Plans:* Develop multi-scale modeling approaches for materials of geological origin and composite material systems. Conduct physical and computational experiments to investigate multiple force protection materials and components against relevant advanced weapon threats. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding decrease in FY22 reflects the planned lifecycle for this effort, ending in FY21.			
Title: Defeat of Complex Attack	2.970	2.437	2.864

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BL9 *I Protection from Advanced Weapon Effects Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort develops passive protection structural hardening designs and solutions against emerging large-caliber advanced weapons; investigates and validates computational models for predicting residual protective capacity for multi-hit threat scenarios; and develops micro-mechanics-based models and material solutions matured by conducting high-rate experiments. *FY 2021 Plans:* Refine algorithms and design methods for structural hardening material solutions by conducting advanced high-rate and high-pressure dynamic experiments to improve computational models at the micro-mechanical and macro-continuum scales. *FY 2022 Plans:* Will develop a full-scale protection/structural solution with predictive algorithm to mitigate precision strike weapon effects; will design multi-hit composite protection subsystems to validate algorithms and material subsystems through testing; and will develop a model to inform engineers on protective design guidance. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase in FY22 supports the development of the predictive algorithm needed to design full-scale protection/structural solutions.			
Title: Advanced Materials and Modeling for Force Protection	-	-	1.480
Description: This effort develops capabilities in the use of poorly-understood and indigenous materials. This effort develops multi-scale material modeling frameworks incorporating physics of deformation and damage mechanisms; a 3D multi-physics material modeling capability to allow for weapons effects models to be informed by remote sensing; and advanced material technologies for force protection. *FY 2022 Plans:* Will develop and refine algorithms for a multi-scale, materials-by-design methodology to model and enhance concrete protective material solutions for weapons effects; and will design and develop metallic, composite, and hybrid material solutions for force protection concepts. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase in FY22 reflects the planned lifecycle for this effort, beginning in FY22, for algorithm development for materials-by-design methodology, and development of material solutions for force protection concepts.			
Accomplishments/Planned Programs Subtotals	4.380	3.812	4.344

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* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BL9 *I Protection from Advanced Weapon Effects Technology*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

  N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 20 of 41

R-1 Line #11

Volume 1b - 122

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*				**Project (Number/Name)** BN8 *I Ground Technology Materials(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**
BN8: *Ground Technology Materials(CA)*	-	108.700	131.000	-	-	-	-	-	-	-	-	-

Note
 Congressional Interest Item funding provided for Ground Technology Materials.

A. Mission Description and Budget Item Justification
 Congressional Interest Item funding provided for Ground Technology Materials.

 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: Environmental Quality Enhanced Coatings	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Environmental Quality Enhanced Coatings. Work executed by Army Futures Command.		
Congressional Add: Environmental Friendly Coatings Technology	3.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Environmental Friendly Coatings Technology. Work executed by Army Futures Command.		
Congressional Add: Additive Manufacturing for Artificial Intelligence and Machine Learning	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Additive Manufacturing for Artificial Intelligence and Machine Learning. Work executed by Army Futures Command.		
Congressional Add: Earthen Structures Soil Enhancement	4.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Earthen Structures Soil Enhancement.		

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 21 of 41

R-1 Line #11

Volume 1b - 123

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BN8 *I Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed by Army Futures Command.		
Congressional Add: M1 Abrams Tank Track System	2.200	-
FY 2020 Accomplishments: Program Increase supported applied research on M1 Abrams Tank Track System. Work executed by Army Futures Command.		
Congressional Add: High Performance Polymers	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on High Performance Polymers. Work executed by Army Futures Command.		
Congressional Add: Materials Manufacturing Processes	6.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Materials Manufacturing Processes. Work executed by Army Futures Command.		
Congressional Add: Highly Durable Advanced Polymers for Lightweight Armor	8.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Highly Durable Advanced Polymers for Lightweight Armor. Work executed by Army Futures Command.		
Congressional Add: Cellulose Nanocomposite Research	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Cellulose Nanocomposite Research. Work executed by Army Futures Command.		
Congressional Add: Countermine Program	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Countermine Program. Work executed by Army Futures Command.		
Congressional Add: Materials Research	17.500	-
FY 2020 Accomplishments: Program Increase supported applied research on Materials Research.		

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 22 of 41

R-1 Line #11

| Volume 1b - 124 |

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BN8 *I Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed by Army Futures Command.		
Congressional Add: Additive Manufacturing and Materials Processing	15.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Additive Manufacturing and Materials Processing. Work executed by Army Futures Command.		
Congressional Add: Cold Weather Military Research	3.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Cold Weather Military Research. Work executed by Army Futures Command.		
Congressional Add: Cold Spray Technologies	15.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Cold Spray Technologies. Work executed by Army Futures Command.		
Congressional Add: Center for Research in Extreme Batteries	10.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Center for Research in Extreme Batteries. Work executed by Army Futures Command.		
Congressional Add: Program increase: Ice engineering research facility modernization	-	5.000
FY 2021 Plans: Conduct applied research in Ice Engineering Research Facility Modernization. Work executed by Army Futures Command.		
Congressional Add: Program increase: Center for research in extreme batteries	-	10.000
FY 2021 Plans: Conduct applied research in Center for Research in Extreme Batteries. Work executed by Army Futures Command.		
Congressional Add: Program increase: Cellulose nanocomposites research	-	5.000
FY 2021 Plans: Conduct applied research in Cellulose Nanocomposites.		

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 23 of 41

R-1 Line #11

Volume 1b - 125

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BN8 *I Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed by Army Futures Command.		
Congressional Add: Program increase: Advanced polymers for force protection	-	8.000
FY 2021 Plans: Conduct applied research in Advanced Polymers for Force Protection.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - advanced concrete	-	4.000
FY 2021 Plans: Conduct applied research in Advanced Concrete.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - robotic RTCH	-	5.000
FY 2021 Plans: Conduct applied research in Robotic RTCH.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - military waste stream conversion	-	5.000
FY 2021 Plans: Conduct applied research in Military Waste Stream Conversion.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - high performance polymers	-	5.000
FY 2021 Plans: Conduct applied research in High Performance Polymers.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - integrity of transparent armor	-	5.000
FY 2021 Plans: Conduct applied research in Integrity of Transparent Armor.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - environmental quality enhanced coatings	-	5.000
FY 2021 Plans: Conduct applied research in Environmental Quality Enhanced Coatings.		

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BN8 *I Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed by Army Futures Command.		
Congressional Add: Program increase - autonomous digital design and manufacturing	-	5.000
FY 2021 Plans: Conduct applied research in Autonomous Digital Design and Manufacturing.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - materials recovery technologies for defense supply resiliency	-	10.000
FY 2021 Plans: Conduct applied research in Materials Recovery Technologies for Defense Supply Resiliency.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - materials manufacturing processes	-	10.000
FY 2021 Plans: Conduct applied research in Materials Manufacturing Processes.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - additive manufacturing machine learning initiative	-	10.000
FY 2021 Plans: Conduct applied research in Additive Manufacturing Machine Learning Initiative.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - rapid advanced deposition	-	10.000
FY 2021 Plans: Conduct applied research in Rapid Advanced Deposition.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - defense resiliency against extreme cold weather	-	10.000
FY 2021 Plans: Conduct applied research in Defense Resiliency Against Extreme Cold Weather.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - counter UAS technology research	-	5.000
FY 2021 Plans: Conduct applied research in Counter UAS Technology.		

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** BN8 *I Ground Technology Materials(CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed by Army Futures Command.		
Congressional Add: Program increase - cell-free expression for biomanufacturing	-	10.000
FY 2021 Plans: Conduct applied research in Cell-Free Expression for Biomanufacturing. Work executed by Army Futures Command.		
Congressional Add: Program increase: Earthen structures soil enhancement	-	4.000
FY 2021 Plans: Conduct applied research in Earthen Structures Soil Enhancement. Work executed by Army Futures Command.		
Congressional Adds Subtotals	108.700	131.000

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 26 of 41

R-1 Line #11

Volume 1b - 128

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2				**R-1 Program Element (Number/Name)** PE 0602144A / Ground Technology					**Project (Number/Name)** CA9 / Predictive Maintenance			
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**
CA9: Predictive Maintenance	-	-	2.509	-	-	-	-	-	-	-	-	-

Note

In Fiscal Year 2022 (FY22) this Project was realigned to:
PE 0602180A AI Technologies / Project CN7 Predictive Maintenance Applied Research

A. Mission Description and Budget Item Justification

This Project develops and characterizes artificial intelligence (AI) and machine learning (ML) tools and capabilities to intelligently predict and analyze maintenance status for emerging and legacy ground platforms; extracts maintenance data from existing databases, sensor data and inference of missing data via virtual simulations investigating maintenance concepts that employ AI data capture and integrate AI tools into enterprise resource planning for military ground vehicles. Research enables use of predictive maintenance to increase fleet operational readiness through reduced downtime by preventing critical failure during missions, maximizing availability to combatant commands.

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

Work in this Project supports the Army Science and Technology Ground Portfolio and the Joint Artificial Intelligence Center (JAIC)

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Predictive Maintenance	-	2.509	-
Description: This effort performs research on AI, deep learning, and predictive analytics to forecast major issues on platforms and enables services to respond to upcoming failures. Focus will be to identify component failure relationships to principal end items for prediction of critical failure prior to corrective maintenance and reactive supply chain requisitions. Research will increase efficiency, decrease fleet operating and sustainment costs for equipment platforms, and reduce the time and costs associated with repair part requisition, management and transportation.			
FY 2021 Plans: Investigates and develops new capabilities of a standardized end-to-end pipeline for gathering data from maintenance sensors in ground platforms (both manned and unmanned); improves performance failure prediction models for critical components; develops engine health model to predict maintenance events; develops data analytics to categorize failures both off-line (in depot tear-downs) and to aid field maintainers.			
FY 2021 to FY 2022 Increase/Decrease Statement:			

PE 0602144A: Ground Technology
Army

UNCLASSIFIED
Page 27 of 41

R-1 Line #11

Volume 1b - 129

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** CA9 *I Predictive Maintenance*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
In FY22, this Project is administratively restructured to PE 0602180A AI Technologies / Project CN7 Predictive Maintenance Applied Research			
Accomplishments/Planned Programs Subtotals	-	2.509	-

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

D. Acquisition Strategy
 N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 28 of 41

R-1 Line #11

Volume 1b - 130

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2						**R-1 Program Element (Number/Name)** PE 0602144A I *Ground Technology*					**Project (Number/Name)** CG5 I *Ground Vehicle Sensor Concepts and Technologies*	
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**
CG5: *Ground Vehicle Sensor Concepts and Technologies*	-	-	-	4.146	-	4.146	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this Project was administratively realigned from:
Program Element (PE) 0602145A, Project BI2 Sensor Protection Technology.

A. Mission Description and Budget Item Justification

This Project investigates, designs, fabricates, assesses, and characterizes advanced sensor protection technologies, components, and concepts that will enable the future Soldier to see and operate through a laser directed energy weapon attack. Both active and passive protection technologies will be investigated to protect Army sensors that operate in the visible, short-wave infrared, mid-wave infrared, and long-wave infrared spectra from battlefield laser threats. Areas of research include passive optical limiters such as nonlinear organic dyes, semiconductors, and meta-materials, as well as fast active switches and tunable filters. As new laser technologies are developed, effects of those threats will be studied and assessed to determine vulnerability of Army sensor systems and sensor system materials.

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 supports the Army Science and Technology Ground and Next Generation Combat Vehicle portfolios.

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

Work in this Project is coordinated with PE 0602145A (Next Generation Combat Vehicle Technology) and PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Laser Protection Technologies	-	-	4.146
Description: This effort develops new materials and devices for the protection of Army sensors and eyes behind day-view optical sights from a variety of laser threats. This research utilizes a combination of technologies based on the nature of the different threats, as well as the fundamental differences in sensors operating over different frequency ranges. Passive optical limiting materials that block specific frequency bands of light will be investigated and developed for the visible and short-wave infrared (SWIR) spectrum, and active meta- material-based solutions will be investigated for uncooled sensors in the long-wave infrared. Vulnerability of sensors and optical sensor systems will be studied against high-power and ultra-short pulsed laser threats to determine protection requirements.			

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 29 of 41

R-1 Line #11

Volume 1b - 131

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** CG5 *I Ground Vehicle Sensor Concepts and Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2022 Plans: Will explore concepts to reduce dazzle from high-power handheld lasers; improve optical system protection concepts from high energy lasers (HEL); reduce the threat of jamming from white light continuum generated by ultra-short pulsed lasers (USPLs): use results from first principles modeling to validate and improve chemical mixtures designed for specific laser light absorption. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort administratively realigned from PE 0602145A Project BI2 Sensor Protection Technology in FY 2022.			
Accomplishments/Planned Programs Subtotals	-	-	4.146

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

D. Acquisition Strategy
 N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 30 of 41

R-1 Line #11

Volume 1b - 132

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*					**Project (Number/Name)** CG6 *I Ground Vehicle Power and Energy Concepts and Tech*		
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**
CG6: *Ground Vehicle Power and Energy Concepts and Tech*	-	-	-	2.681	-	2.681	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project was administratively realigned from:
Program Element (PE) 0602145A, Project BH5 Platform Electrification and Mobility Tech.

A. Mission Description and Budget Item Justification

This Project researches and develops advanced power and energy technologies for combat ground vehicles that are necessary for parallel hybrid, series hybrid, and all- electric vehicle systems. This effort investigates and develops electric conversion technologies to reduce size and weight of military vehicles while increasing performance and capabilities to support current and future mission loads and provide improved military vehicle mobility.

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 supports the Army Science and Technology Ground and Next Generation Combat Vehicle portfolios.

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

Work in this Project is coordinated with PE 0602145A (Next Generation Combat Vehicle Technology) and PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advanced Distributed Power for Autonomous Systems	-	-	1.423
Description: This effort develops technologies for electrification of both manned and unmanned Next Generation Combat Vehicle platforms. Electrification of these platforms will enable advanced lethality and protection systems, reduced battlefield fuel consumption, and provide new capabilities such as burst acceleration, extended silent mobility, and silent watch. The effort investigates and develops electric conversion technologies to reduce size and weight while increasing performance and capabilities to support current and future mission loads and provide improved military vehicle mobility. Research focuses on high power/ temperature power electronics, magnetic gears, electric drive motors, and adaptive device and component level control that optimized operation in real time. Investigation of advanced control methods at the module and conversion component levels provides an understanding of the impact real time optimization and energy tracking can have on power conversion optimization and mission effectiveness. The research enables the integration of component state and behavior into system level management algorithms that support non-autonomous and autonomous operations while providing modular and scalable electrification			

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 31 of 41

R-1 Line #11

Volume 1b - 133

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** CG6 *I Ground Vehicle Power and Energy Concepts and Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
architectures. Efforts will also investigate non-contact magnetic gear technologies coupled with electrical motors and generators to reduce size and weight with an increase in reliability and performance through increased torque and speed operational range. Results of the research inform 0602145A BH5 Platform Electrification and Mobility Tech. *FY 2022 Plans:* Will research control algorithms and topologies for power conversion systems with a focus on stability and improved real time maximum power optimization of component operation; explore coupling of decision making methods to increased awareness of tactical energy effectiveness for increased operational-tempo and to support platform operations and battlespace planning and real time energy tracking through standard energy analysis techniques; model high torque magnetic gear components for platform applications and identify additional optimization strategies and use cases. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort administratively realigned from PE 0602145A Project BH5 Platform Electrification and Mobility Tech in FY 2022.			
Title: Power Electronic Components and Materials	-	-	1.258
Description: This effort investigates and develops electric conversion technologies to reduce size and weight while increasing performance and capabilities to support current and future mission loads and provide improved military vehicle mobility. Research focuses on semiconductor power switches, power switch modules/packaging, and power switch module thermal management. Investigation of high voltage/high frequency power semiconductor materials and devices is concentrated on efficient power switching under militarily relevant temperatures. Development of multi-disciplinary parametric design optimization software tools and multi-functional package structures provides advances in device packaging technology to fully realize device performance improvements. Results of the research inform 0602145A BH5 Platform Electrification and Mobility Tech. *FY 2022 Plans:* Will design and model new high performance power module using holistic co-design methods; investigate control and fabrication methods that can enable real time optimization of packaging performance; develop models for power device architectures appropriate for ultra-wide-band gap semiconductors; fabricate and assess initial test structures and devices. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort administratively realigned from PE 0602145A Project BH5 Platform Electrification and Mobility Tech in FY 2022.			
Accomplishments/Planned Programs Subtotals	-	-	2.681

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* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** CG6 *I Ground Vehicle Power and Energy Concepts and Tech*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

  N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 33 of 41

R-1 Line #11

Volume 1b - 135

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

Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602144A I *Ground Technology*	Project (Number/Name) CG7 I *Ground Protection Concepts and Technologies*

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
CG7: *Ground Protection Concepts and Technologies*	-	-	-	14.565	-	14.565	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project was administratively realigned from:
Program Element (PE) 0602145A, Project BG6 Advanced Concepts for Active Defense Technology.

A. Mission Description and Budget Item Justification

This Project researches advanced materials and mechanisms to defeat the most common and most dangerous threats that are expected to be encountered by our ground forces in near-, mid-, and far-term. This Project also develops experimental and computational tools and techniques (high resolution instrumentation to observe impact events, theories, and algorithms to explain these phenomena and numerical implementation of these algorithms) for the development of mass-efficient armor mechanisms. This project develops armor mechanisms that will be integrated to create multi-threat armor technologies and form the building blocks for Adaptive and Cooperative Protection Technologies in the Advanced Concepts for Active Defense Project (PE 0602145A Next Generation Combat Vehicle Technology). Additionally, research will focus on subcomponent/component models to predict performance of early concepts and the means to assess effectiveness on ground platforms. The Project will balance developments of active threat defeat measures with the necessary advanced passive and reactive components that will ultimately provide for full system solutions which meet the requirements of current and next generation ground tactical and combat vehicles.

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

Work in this Project supports the Army Science and Technology Ground and Next Generation Combat Vehicle.

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

This Project is coordinated with and transition to Projects in PE 0603462A (Next Generation Combat Vehicle Advanced Technology), PE 0602145A (Next Generation Combat Vehicle Technology), and builds upon weapon target interaction research in PE 0601102A (Defense Research Sciences) / Project AA7 (Mechanics and Ballistics).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Advanced Armor and Protection Technologies	-	-	8.166
Description: This effort enables development of the next generation of lightweight protective concepts and technologies for defeat of current and future threats by utilizing real-time information, combined with threat knowledge, to provide increased protection. This effort researches the fundamental physics of new terminal effects concepts and provides an understanding of interaction			

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 34 of 41

R-1 Line #11

Volume 1b - 136

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** CG7 *I Ground Protection Concepts and Technologies*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
between the platform's defeat mechanism and the threat . The effort also investigates the ability to analytically simulate complex threat interactions. Experiments will be conducted to validate the efficacy of the designs. *FY 2022 Plans:* Will conduct experiments to validate several computationally designed pulsed power mechanisms to defeat a wide range of shaped charge warheads; conduct research into the understanding of energetic material response to ballistic events; validate an optimized notional hull concept that includes adaptive and active protection concepts for a combined threat suite through computational and experimental methods. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort being administratively realigned from PE0602145A Project BG6 Advanced Concepts for Active Defense Technology in FY 2022.			
Title: Computational and Experimental Capability *Description:* This effort will develop computational design tools along with diagnostic and experimental capabilities that support the development of advanced protection systems. Such systems include passive, active, and hybrid solutions for defeating (multiple) anti-armor threats and exploit solid-dynamic, explosive-driven, and magneto-hydrodynamic target interactions. This work allows for predicting armor performance and understanding mechanisms, regardless of vehicle platform, with improved and quantified confidence. This effort leverages the Department of Defense and Department of Energy (DOE) Technical Coordination Group Memorandum of Agreement and directly leverages DOE investments in computational platforms for problems in solid dynamics and impact mechanics. *FY 2022 Plans:* Will increase computational and material modeling capability to predict performance of hybrid armor protection mechanisms during threat impact; validate improved cineradiography and tomography diagnostic systems in multiple experimental facilities to capture threat interaction with armor mechanisms including multi-energy flash; designs and develops computational capability to couple the blast/fluid/solid/target interactions during threat engagements and reactive models for predicting mass (fragment), momentum (blast), and energy (heat) target effects for non-ideal explosives (a non-ideal explosive's observed detonation velocity is lower than the calculated ideal value from thermo-hydrodynamic theory); explores machine learning methodology for terminal ballistics design applications. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort being administratively realigned from PE0602145A Project BG6 Advanced Concepts for Active Defense Technology in FY 2022.	-	-	6.399
Accomplishments/Planned Programs Subtotals	-	-	14.565

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 35 of 41

R-1 Line #11

Volume 1b - 137

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** CG7 *I Ground Protection Concepts and Technologies*

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 36 of 41

R-1 Line #11

Volume 1b - 138

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

Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602144A I *Ground Technology*						Project (Number/Name) CG8 I *Human Autonomy Teaming*	

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
CG8: *Human Autonomy Teaming*	-	-	-	8.599	-	8.599	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project was administratively realigned from:
Program Element (PE) 0602145A, Project BF6 Crew Augmentation and Optimization Tech.

A. Mission Description and Budget Item Justification

This Project performs applied research for capabilities that support teams of Soldier and Artificial Intelligence (AI)-enabled systems to execute missions in complex, dynamic, multi-domain operations environments. Centered on ground vehicle mission planning and operations, this Project is focused on core technologies to enable Soldiers and AI-enabled systems to function as a team, to perform at high levels, and to adapt to adversarial actions and new mission requirements. This Project will enable future Soldiers with AI-enabled systems to perform complex missions with increasingly sophisticated technologies, and in increasingly complex, dynamic, socio-technical environments. The applied research will provide the fundamental technologies to enable scalable Soldier-AI teams and team-centered dynamic tasking to effectively utilize the full capabilities of team and technologies. The research will include considerations to reduce data requirements for AI adaptation, increasing appropriate Soldier trust and use of technology, and ensuring ethical behaviors by teams of Soldier and AI-enabled systems. The capabilities created by this research will lead to increased overall Soldier-AI team mission performance, improved Soldier-centric situation awareness technologies, and units that can effectively integrate within a multi-domain battlefield.

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 supports the Army Science and Technology Ground and Next Generation Combat Vehicle portfolios.

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

Work in this Project is coordinated with PE 0602145A (Next Generation Combat Vehicle Technology), PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and PE 0602143A (Soldier Lethality Technology) .

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Soldier?AI Team Mission Planning for Dynamic Complex Environments	-	-	1.264
Description: Planning in multi-domain operations environments is complex and has increased temporal and spatial sensitivities for Soldiers to integrate with AI-enabled systems to plan and execute missions. This effort provides the fundamental concepts and technologies to enable Soldier and AI to team together to plan for multidomain operations from a ground vehicle perspective. This effort focuses on planning enablers to maximize manned-unmanned team performance across squads and platoons and includes mid- to far-term crew station-based emerging technologies in the areas of human- interaction with AI technologies and human-			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** CG8 *I Human Autonomy Teaming*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
guided machine intelligence. Approaches focus on modeling both Soldier and AI capabilities and their limitations as a function of the mission environment and mission requirements, and applying those models to form mission plans. *FY 2022 Plans:* Will investigate initial approaches to leverage Soldier feedback to enable mission-to-mission adaptation of intelligent system behaviors to complement crew performance and meet evolving mission needs. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort administratively realigned from PE 0602145A Project BF6 Crew Augmentation and Optimization Tech in FY 2022.			
Title: Dynamic Soldier-AI Team Resource Allocation *Description:* This effort focuses on creating the concepts and technologies necessary to dynamically allocate Soldiers and unmanned systems during missions in to adapt mission plans to adversarial actions and other events at a squad and platoon level, including responding to degradation or loss of team capabilities, changes in mission goals or priorities, and responding to adversarial actions. The effort includes the allocation of Soldiers, platforms, and platform sub-system capabilities with the focus to ensure that future AI and automation capabilities are focused on the circumstances and conditions where they are most likely to be successful, and to ensure that the Soldier's cognition is focused appropriately to ensure mission success. *FY 2022 Plans:* Will investigate initial algorithms to generate task allocations across a distributed heterogeneous team to enable rapid team reconfiguration and improve team performance in dynamic environments; conduct experiments to examine approaches for Commanders to coordinate actions of a distributed team through a library of preset formations and crew configurations within the Commander?s interface. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort administratively realigned from PE 0602145A Project BF6 Crew Augmentation and Optimization Tech in FY 2022.	-	-	2.458
Title: Soldier Cognition-Centric Interface Technologies *Description:* This effort creates cognitive-centric displays that ensure Soldiers are focused on aspects of situational awareness, mobility, target engagements, and communications that are critical to mission performance as future crew stations and displays provide vast amounts of multi-domain information that has the potential to distract, overwhelm, and mislead Soldiers. This effort ensures that our systems do not capture and misdirect Soldier attention and/or cognition, maximizing the utility of AI-enabled systems to the Soldier. This effort also enables Soldiers to better understand the actions, goals, intents, and general reasoning of the AI systems to ensure they are effectively used, but not inappropriately relied upon. *FY 2022 Plans:*	-	-	1.614

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602144A / Ground Technology	**Project (Number/Name)** CG8 / Human Autonomy Teaming

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will mature approaches to characterize team cohesion in a distributed Soldier-AI team; continue experiments to investigate approaches to assess and calibrate the crew?s trust in AI-enabled autonomous systems. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort administratively realigned from PE 0602145A Project BF6 Crew Augmentation and Optimization Tech in FY 2022.			
Title: Enabling Soldier-AI Technology Adaptation *Description:* This effort develops technologies to rapidly adapt and upgrade AI-enabled system capabilities in response to advancements in AI in the commercial and adversary environments. Focus areas include enabling rapid technology adaption during Soldier experimentation and enabling data to be collected during these events for rapid development of technology updates and modifications. This effort has four goals: 1) increasing the ability of Soldier-AI teams to rapidly adapt to adversarial actions, new technologies, environmental changes, and mission requirements; 2) decreasing the data requirements to train and adapt AI-enabled systems; 3) increasing appropriate Soldier trust and use of technology; and 4) ensuring ethical decisions by using Soldiers to guide the actions and in-field adaptations of Soldier-AI team behaviors. *FY 2022 Plans:* Will develop algorithms that learn from natural interactions to allow Soldiers to communicate their intent to adapt and train autonomous systems; investigate novel approaches using interactive machine learning to enhance the robustness of algorithms for assessing effectiveness of Soldier-AI teams; mature novel machine learning approaches to enable Soldiers to rapidly train AI systems in novel situations and environments. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort administratively realigned from PE 0602145A Project BF6 Crew Augmentation and Optimization Tech in FY 2022.	-	-	3.263
Accomplishments/Planned Programs Subtotals	-	-	8.599

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

D. Acquisition Strategy
 N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 39 of 41

R-1 Line #11

| **Volume 1b - 141** |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*					**Project (Number/Name)** CI2 *I Ground Enabling University Applied 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
CI2: *Ground Enabling University Applied Research*	-	-	-	4.824	-	4.824	-	-	-	-	-	-

Note
In Fiscal Year 2022 (FY22), funding for this Project was realigned from:
Program Element (PE) 0603119A Ground Advanced Technology / BK8 Robotics for Engineer Operations Adv Tech,
PE 0602143A Soldier Lethality Technology / BE8 Synthetic Training Environment (STE) Technology, and
PE 0602145A Ground Technology / BF8 Artificial Intelligence and Machine Learning Tech

A. Mission Description and Budget Item Justification
The Project leverages applied research from academia, in the focus areas of ground autonomy, Artificial Intelligence/Machine Learning (AI/ML) and robotics, occupant/ vehicle survivability and other ground platform technologies of importance to the Army. This Project performs discovery research efforts to focus more on mid to far-term Army modernization priorities while also maintaining delivery of near-term technologies critical to the next generation combat vehicles. This Project focuses on employment of research technologies originating from extramural applied research in academia pertaining to navigation/routing, autonomous robotic vehicles with the use of artificial intelligence and machine learning as applied to ground mobility and maneuver, and other innovative ground enabling applied research technologies. This effort conducts applied research and development leading to potential emerging technologies in areas of strategic importance to the Army in autonomy, robotics and AI/ML, protection of both platform and occupant, and other ground platform technologies in propulsion, survivability, powertrain, etc., by bringing competitively selected Universities with research and development teams into Technical Alliances.

Work in this Project supports the Army Modernization Priority Next Generation Combat Vehicle.

The cited work is consistent with 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 (US) Army Futures Command.

This work is done in coordination with PE 0603119A (Ground Advanced Technology), PE 0602145A (Next Generation Combat Vehicle Technology) and PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Robust autonomous capabilities for ground vehicles	-	-	3.220
Description: This effort researches Artificial Intelligence/Machine Learning (AI/ML) and autonomous mobility-enabled ground vehicles to conduct off-road maneuvers to transition from tele-operated to either fully-autonomous, or semi-autonomous			

PE 0602144A: *Ground Technology*
Army
UNCLASSIFIED
Page 40 of 41
R-1 Line #11
Volume 1b - 142

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602144A *I Ground Technology*	**Project (Number/Name)** CI2 *I Ground Enabling University Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
scenarios. Work is conducted in collaboration with university partners to advance autonomous mobility and protection of both occupant and platform in optionally manned and autonomous ground vehicles. *FY 2022 Plans:* Will develop AI/ML methods to enable robust, autonomous, tactical behaviors for multi-agent air and ground vehicle teams beyond existing behaviors such as leader-follower (e.g., flanking, occupying); as well as increase the speed of autonomous behavior acquisition through effective navigation and route planning using techniques to extract terrain features from imagery and transfer of simulator-learned behaviors to developmental ground platforms. Develop methods of shared control (between human operators and AI/ML systems) that increase overall autonomous system performance with human input. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY22, funding was realigned from PE 0602145 BF8 Artificial Intelligence and Machine Learning Tech			
Title: Human-robot/AI interactions *Description:* This effort develops systems involving physical and cognitive levels of interactions between humans and robots, with the use of reinforcement learning (an area of Machine Learning (ML) research) from human feedback, learning from demonstration, and safe human-aware controllers. Work is conducted in collaboration with university partners to advance autonomous mobility as well as other areas of ground platform technologies in propulsion, survivability, powertrain, etc. *FY 2022 Plans:* Will investigate and develop AI/ML methods to improve autonomous systems by capturing and learning from human teleoperation commands, human interventions, and other forms of human interaction (e.g., spoken language). Will develop tactics and algorithms on common software platforms which enable robots to deal with complex environments on the fly while working fully autonomously around humans for extended periods of time. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY22, funding was realigned from PE 0602145 BF8 Artificial Intelligence and Machine Learning Tech	-	-	1.604
Accomplishments/Planned Programs Subtotals	-	-	4.824

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

D. Acquisition Strategy
 N/A

PE 0602144A: *Ground Technology*
Army

UNCLASSIFIED
Page 41 of 41

R-1 Line #11

| **Volume 1b - 143** |

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle 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**
Total Program Element	-	255.041	258.351	172.166	-	172.166	-	-	-	-	-	-
BF1: *Autonomous Ground Resupply Tech*	-	10.836	10.615	-	-	-	-	-	-	-	-	-
BF3: *Combat Vehicle Robotics Tech*	-	11.178	9.163	16.810	-	16.810	-	-	-	-	-	-
BF6: *Crew Augmentation and Optimization Tech*	-	22.079	19.022	8.906	-	8.906	-	-	-	-	-	-
BF8: *Artificial Intelligence & Machine Learning Tech*	-	21.134	21.425	13.912	-	13.912	-	-	-	-	-	-
BF9: *Sensors for Autonomous Operations and Surv Tech*	-	17.072	36.836	35.489	-	35.489	-	-	-	-	-	-
BG2: *Modeling and Simulation for MUMT Technology*	-	3.953	3.273	6.718	-	6.718	-	-	-	-	-	-
BG6: *Advanced Concepts for Active Defense Technology*	-	51.275	45.754	30.541	-	30.541	-	-	-	-	-	-
BG8: *Obscuration Technology*	-	3.903	2.620	2.576	-	2.576	-	-	-	-	-	-
BH2: *C4ISR Modular Autonomy Technology*	-	4.674	-	-	-	-	-	-	-	-	-	-
BH5: *Platform Electrification and Mobility Tech*	-	9.612	20.563	13.781	-	13.781	-	-	-	-	-	-
BH7: *Enhanced VETRONICS Technology*	-	3.455	-	-	-	-	-	-	-	-	-	-
BH9: *Protection for Autonomous Systems Tech*	-	2.443	1.444	-	-	-	-	-	-	-	-	-
BI2: *Sensor Protection Technology*	-	10.149	10.340	5.878	-	5.878	-	-	-	-	-	-
BI4: *Materials Application and Integration Tech*	-	7.971	7.689	7.648	-	7.648	-	-	-	-	-	-

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 2: *Applied Research*						**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*						
BI9: *Vehicle System Security Technology*	-	2.829	2.676	2.359	-	2.359	-	-	-	-	-	-
BJ2: *Tactical and Navigation Lasers Sensors Technology*	-	4.785	5.372	5.364	-	5.364	-	-	-	-	-	-
BJ3: *Hydrogen Based Combat System Technology*	-	1.515	-	-	-	-	-	-	-	-	-	-
BJ7: *Detection of Explosive Hazards Technology*	-	11.393	-	-	-	-	-	-	-	-	-	-
BJ9: *Autonomous Mobility Tech*	-	2.934	2.407	3.848	-	3.848	-	-	-	-	-	-
BK2: *Virtual Prototyping Technology*	-	5.203	8.295	8.169	-	8.169	-	-	-	-	-	-
BK3: *Next Gen Intelligent Fire Control (NG-IFC) Tech*	-	1.007	4.043	0.987	-	0.987	-	-	-	-	-	-
BK5: *Adv Direct In-Direct Armament Sys (ADIDAS) Tech*	-	1.141	3.814	9.180	-	9.180	-	-	-	-	-	-
BP5: *Ground Vehicle Technology (CA)*	-	44.500	43.000	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

The Fiscal Year (FY) 2022 Direct War/Enduring Operations dollars in the amount of $0.987 million in Project BF8 Artificial Intelligence & Machine Learning Tech will continue to support the research for the Army's modernization priority for the Next Generation of Combat Vehicles. This PE researches, designs, and evaluates combat vehicle technologies that enable the Army to have a smarter, faster, more lethal, more precise, more protected, and more adaptable force. The focus is on building upon the foundational vehicle architectures to support the Next Generation of Combat Vehicles, to include autonomy architecture, power architecture, vehicle electronic architecture, physical architecture, lethality architecture and vehicle protection architecture. The research conducted will provide technologies to enable leap ahead capabilities for manned, optionally manned and unmanned vehicles that deliver decisive lethality.

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

Work in this PE complements PE 0602141A (Lethality Technology), PE 0602144A (Ground Technology), PE 0602146A (Network C3I Technology), PE 0602782A (Command, Control, Communications Technology), PE 0603116A (Lethality Advanced Technology), PE 0603119A (Ground Advanced Technology), PE 0603462A (Next Generation Combat Vehicle Advanced Technology), and PE 0603463A (Network C3I Advanced Technology).

Work in this PE will transition to PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 2 of 70

R-1 Line #12

Volume 1b - 145

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 2: Applied Research*	**R-1 Program Element (Number/Name)** PE 0602145A I *Next Generation Combat Vehicle Technology*

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

Work is performed by the United States Army Futures Command and United States Army Engineer Research and Development Center.

B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	263.547	219.565	237.850	-	237.850
Current President's Budget	255.041	258.351	172.166	-	172.166
Total Adjustments	-8.506	38.786	-65.684	-	-65.684
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-1.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	43.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.350	-			
• SBIR/STTR Transfer	-8.856	-3.214			
• Adjustments to Budget Years	-	-	-65.684	-	-65.684

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Project: BP5: *Ground Vehicle Technology (CA)*		
Congressional Add: *Prototyping Energy Smart Autonomous Ground Systems*	10.000	-
Congressional Add: *Highly Electrified Vehicles*	5.000	-
Congressional Add: *Additive Metals Manufacturing*	3.000	-
Congressional Add: *RPG and IED Protection*	3.000	-
Congressional Add: *Modeling and Simulation*	3.000	-
Congressional Add: *Structural Thermoplastics*	3.000	-
Congressional Add: *Advanced Materials Development for Survivability*	10.000	-
Congressional Add: *Autonomous Vehicle Mobility*	7.500	-
Congressional Add: *Program increase - modeling and simulation*	-	10.000
Congressional Add: *Program increase - silicon carbide electronics*	-	6.000
Congressional Add: *Program increase - highly electrified vehicles*	-	5.000
Congressional Add: *Program increase - additive metals manufacturing*	-	10.000

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 3 of 70

R-1 Line #12

Volume 1b - 146

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Congressional Add: *Program increase - prototyping energy smart autonomous ground systems*	-	12.000
Congressional Add Subtotals for Project: BP5	44.500	43.000
Congressional Add Totals for all Projects	44.500	43.000

Change Summary Explanation

FY2022 funding change due to partial administrative realignments of research in 4 Projects BI2, BH5, BG6 and BF6 to PE 0602144A Ground Technology for better alignment to the mid- to far term priorities of the Ground portfolio; administrative realignment from Project BF8 to university-based research projects in the Ground, Air, Network, Soldier and Lethality BA2 portfolios; realignment from Project BG6 to PE 0603041A All Domain Convergence Advanced Technology for Collaborative convergence advanced technology development.

BF3 - Funding in this effort was increased to emphasis the development of the Human Robotic Interactions, with a major Engineering
Evaluation Test (EET) being conducted to technically understand the maturation level of each technology and how an operator will
interact with the robotic asset.
BF6 - Funding change reflects planned lifecycle of this effort.   Funding in this effort was increased to emphasis the development of the Human Robotic
Interactions, with a major Engineering
Evaluation Test (EET) being conducted to technically understand the maturation level of each technology and how an operator will
interact with the robotic asset.
BF8 - Funding increase reflects planned lifecycle of this effort to focus on architectures and models for tactical teaming. / Funding is realigned in FY 2022 to
PE 0602180A (Artificial Intelligence Technologies) / CN7 Predictive Maintenance Applied / In FY2022, funding from this effort was administratively realigned to
university-based research projects in the Ground, Air,
Network, Soldier and Lethality BA2 portfolios
BF9 - Immaterial Change
BG2 - Funding increase in FY22 will expand analytical tool development to include varied meteorological conditions and terrain types
and will support development of obstacle detection algorithms.
Research Project in to support the application of AI/ML technology for predictive maintenance.
BG6 - In FY 2022, this effort has been realigned to PE 0602144A Project CG7 Ground Protection Concepts and Technologies. / In FY2022, funding is realigned
from PE 602145A Project BG6 to Advancing Concepts and Technology Forecasting
(611102CH9); Collaborative Convergence Adv Tech (633041CM2) ; Ground Protection Concepts and Technologies
(622144CG7).
BI2 - In FY 2022, this effort has been administratively realigned to PE 0602144A Project CG5 Ground Vehicle Sensor Concepts and
Technologies.

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 4 of 70

R-1 Line #12

Volume 1b - 147

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*				**Project (Number/Name)** BF1 *I Autonomous Ground Resupply Tech*		

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
BF1: *Autonomous Ground Resupply Tech*	-	10.836	10.615	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

Autonomous Ground Resupply (AGR) will design and develop modeling and simulation tools and advanced software behaviors to inform future ground supply distribution system requirements across multiple levels of strategic and tactical sustainment operations. The modeling and simulation software tools will be incorporated into a suite of products designed to support every phase of AGR and used to develop and refine AGR concepts, test vehicle designs, evaluate design changes, determine technology performance, and predict outcomes in a wide variety of terrain, weather, and environmental conditions. The effort will utilize the modeling and simulation software tools to design, develop and mature software; and conduct experiments to increase future autonomy capabilities. Increased capabilities will transition to PE 0603462 (Next Generation Combat Vehicle Advanced Technology) to be integrated into a Soldier evaluation to obtain user feedback and inform and transition to the Leader/Follower Program of Record. The architecture and safety work under this Project also lays the groundwork for Army Modernization Priority Next Generation Combat Vehicle (NGCV).

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 supports the Army Modernization Priority NGCV.

Work in this Project is conducted by the United States (US) Army Engineer Research and Development Center and coordinated with US Army Futures Command.

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and the Leader/Follower Program of Record.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Software for Autonomous Systems ***Description:*** Develop and implement advanced system behaviors to address leader follower capabilities, including algorithms for dynamic route planning, world modeling that feature system cues and collaboration to minimize the cognitive load placed on soldiers managing groups of unmanned systems. ***FY 2021 Plans:*** Continue to develop advanced software behaviors and algorithms for integration into the fail-safe autonomous ground vehicle architecture and conduct field testing to validate increased robotic capabilities, which include: the integration of trailers (forward and reverse), convoy reverse capabilities, convoy formations, dynamic route planning and world terrain modeling to minimize the cognitive load placed on Soldiers managing groups of unmanned systems. ***FY 2021 to FY 2022 Increase/Decrease Statement:***	9.593	9.700	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF1 *I Autonomous Ground Resupply Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
This project ends in FY 21.			
Title: Autonomous System Modeling and Simulations	1.243	-	-
Description: This effort matures a real-time, hardware-in-the-loop simulation environment for rapid autonomous system design and development and for robust autonomy algorithm development; investigates novel analyses methods for Modeling and Simulation enhanced demonstrations of autonomous ground vehicles to include adverse environmental conditions.			
Title: Simulation Tools for AGR	-	0.915	-
Description: This effort designs and develops real-time and high-fidelity, hardware and software-in-the-loop simulators capable of rapid design and assessment of ground vehicle autonomous behaviors through integration with autonomy solutions. *FY 2021 Plans:* Investigate simulation design, development, and performance as well as develop tools to explore autonomous system performance; develop simulation-enabled analysis methods for Autonomous Ground Resupply capstone events; and investigate integration of additional sensors and algorithms into simulation tools. *FY 2021 to FY 2022 Increase/Decrease Statement:* This project ends in FY 21.			
Accomplishments/Planned Programs Subtotals	10.836	10.615	-

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 6 of 70

R-1 Line #12

Volume 1b - 149

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2				**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*					**Project (Number/Name)** BF3 / *Combat Vehicle Robotics Tech*		

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
BF3: *Combat Vehicle Robotics Tech*	-	11.178	9.163	16.810	-	16.810	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs, develops, and evaluates a variety of innovative technologies that enable scalable integration of multi-domain robotic and autonomous system capabilities teamed within Army formations supporting all combat warfighting functions (close combat, reconnaissance, targeting and acquisition, etc.). This Project focus areas include autonomous architecture, autonomous behaviors and perception, and soldier machine Interface.

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 supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

Work in this effort is performed by the United States (US) Army Futures Command.

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and transitions to PE 0604017A (Robotics Development).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Autonomous Behaviors and Perception *Description:* This effort contributes to the NGCV Robotic Autonomous Strategy (RAS) to advance the mobility performance of autonomous systems within complex environments/ operations to allow for the completion of mission goals in separate and teaming configurations at varying levels of autonomy. *FY 2021 Plans:* Develop the dynamic obstacle detection and avoidance capability and integrate with advanced off-road autonomous navigation and conduct experiments for defined missions with tactical formations at operationally relevant speeds. *FY 2022 Plans:* Will develop and validate object recognition and environment understanding for autonomous vehicles. Develop and validate a basic framework for applying this knowledge to operationally relevant missions (per U.S military doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF)), enabling customized behaviors to specific combat missions, and prioritization of autonomous mobility tasks and maneuvers when multiple tasks are assigned to a vehicle or team of vehicles. Will develop models to integrate Army operational architectures and military autonomous behavior architectures in Autonomous Ground Vehicle Reference Architecture (AGVRA). Develop robotic-specific cyber architectural views across the autonomous architecture focused on getting autonomous systems certified under the Department of Defense Risk Management	5.104	3.555	9.413

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602145A I *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF3 I *Combat Vehicle Robotics Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Framework. Develop system behavior and structure in assurance testing via model-based systems engineering and formal methods to be containerized and integrated with DoD cloud services. Develop security enhancements in autonomous system component registries to improve Robot Operating System-Military (ROS-M). ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding realigned from the Autonomous Architecture effort in this Project is to focus on the development of the autonomous technologies, integration of Army operational and autonomous behavior architectures in AGVRA at the Engineering Evaluation Test (EET) in FY22.			
Title: Autonomous Architecture ***Description:*** This effort contributes to the NGCV RAS to implement an open autonomous architecture for an inclusive military library of behaviors that are non-proprietary and in a modular format to allow for design and development of payloads across the enterprise. This effort builds upon architecture activities under the autonomous ground resupply activity, further expanding the Autonomous Ground Vehicle Robotics Architecture for increased complexity of military maneuvers as well as the Robotic Operating Systems ? Military (ROS-M) framework. ***FY 2021 Plans:*** Continue to develop and establish ROS-M framework of reusable and adaptable software developed in collaboration with other Government Agencies and industry to align the robotics community to a common architecture. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects realignment of funding for this effort to the Autonomous Behaviors and Perception effort in this Project.	1.973	1.661	-
Title: Human Robotic Interaction ***Description:*** This effort contributes to the NGCV RAS to implement a focused approach to deliver optimized unmanned system and manned-unmanned system team performance through reduced cognitive burden for the Soldier while maintaining real-time unmanned system status/activity, overall mission effectiveness, and predictive capability of the system's intended activity. ***FY 2021 Plans:*** Mature the operator-directed voice recognition for command and control of the robotic ground system maneuver. Assess the performance of how naturally the robotic system interacts with human operators through experiments or experimentation to improve manned-unmanned system teaming. ***FY 2022 Plans:*** Will design and develop the enhanced robotic warfighter-machine?s interface technologies for a combat scenario to demonstrate the ability to operate the robotic vehicle with decreased time to complete a task, thereby enabling the Warfighter to focus on	4.101	3.947	7.397

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF3 *I Combat Vehicle Robotics Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
the overall mission. Will investigate the enhanced robotic warfighter-machine?s interface technologies to enhance the robotic operator?s control of mobility, their reaction time of alerts and their overall success of the mission. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding is increased for planned progression of this effort to research being performed and evaluated at the EET in FY22. The research focus is on development of the Human Robotic Interactions and how an operator will interact with the robotic asset.			
Accomplishments/Planned Programs Subtotals	11.178	9.163	16.810

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 9 of 70

R-1 Line #12

Volume 1b - 152

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				R-1 Program Element (Number/Name) PE 0602145A *I Next Generation Combat Vehicle Technology*						Project (Number/Name) BF6 *I Crew Augmentation and Optimization Tech*	
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
BF6: *Crew Augmentation and Optimization Tech*	-	22.079	19.022	8.906	-	8.906	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding was partially realigned from this Project administratively to Program Element (PE) 0602144A Ground Technology / Project CG8 Human Autonomy Teaming.

A. Mission Description and Budget Item Justification

This Project designs capabilities for reduced vehicle crew sizes to successfully operate a larger number of closed-hatch manned and remote unmanned vehicles in a complex multi-domain operations environment. This Project will enable future crews to perform complex missions with increasingly sophisticated technologies, and in increasingly complex, dynamic socio-technical environments. The applied research will provide the fundamental technologies to enable integrated performance-improving Learning - Warfighter Machine Interfaces (WMIs) that are scalable to multiple crew hardware and functional configurations; reconfigurable frameworks and simulation for concept experimentation and exploration; and team-centered dynamic tasking by machine intelligence to effectively utilize full capabilities of crew and technologies. The research will generate soldier-informed data, reports, and analysis to support operational use in future vehicles through soldier experimentation and assessment of technical concepts in simulation and in-field WMIs. The capabilities created by this research will lead to increased overall crew and team performance; improved soldier safety due to fewer soldier per vehicle, closed-hatch operations, and improved standoff from effective control; and vehicles that can effectively perform across multiple domains of battle.

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 supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

Work in this effort is performed by the United States (US) Army Futures Command.

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and PE 0602143 (Soldier Lethality Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Crew Station / Closed Hatch Operations	3.856	-	-
Description: This effort focuses on crew size reduction and crew stations tailored to mission and soldier needs through the utilization of emerging human-interaction technologies, automations, machine intelligence and the provision of cohesive domain personalization to permit soldiers to achieve leap-ahead performance beyond today's constrained ground vehicle environment.			
Title: Crew Understanding Agents	7.945	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 *I Crew Augmentation and Optimization Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort focuses on increasing the crew's comprehension of physical and virtual intelligent agent actions, intentions, goals, and general reasoning in order to increase the effectiveness of human-agent teaming. The effort will increase soldiers situational awareness and team resilience as well as inform effective use of intelligent assets.			
Title: Agents Understanding Crew *Description:* This effort focuses on increasing intelligent agent ability to understand crew actions, intentions, goals, and general reasoning in order to increase the effectiveness of human-intelligent agent teaming. The effort will enable effective adaptation by intelligent agents, increase appropriateness of intelligent agent actions, increase manned/unmanned team resilience, and is critical for intelligent approaches to dynamic team tasking.	5.924	-	-
Title: Joint Human-Agent Teamwork *Description:* Will design and develop Commander?s interface to enable dynamic task reassignment across crew members and unmanned platforms to provide capability of crew members to manually share critical tasks as capabilities and mission needs change; Will investigate novel algorithms and communication protocols for developing, maintaining and sharing situational awareness across a distributed heterogeneous team to enable improved decision making and rapid team reconfiguration; Will develop novel machine learning approaches to enable Soldiers to rapidly train artificial intelligence systems on simulated and physical platforms	4.354	-	-
Title: Crew & Robotic Mission with Agent Technology *Description:* This effort focuses on the design, development and validation of hardware and software for establishing crew to robotic mission operator interactions to address full vehicle performance. Included are simulation tools and hardware for Soldier-in-the-loop testing including the Learning Warfighter Machine Interface (L-WMI), a seven-Soldier vehicle crew configuration command vehicle simulator; personalization of crew and robotic operator configurations to permit reconfiguration for role, mission requirements and Soldier monitoring; optimization of vehicle crew interactions to permit sharing, reallocation and management of tasks, as well as situational awareness and data management. *FY 2021 Plans:* Validate enhancements to the crew?s ability to plan missions and optimization of crew?s comprehension of crew interactions with unmanned systems by integrating the L-WMI onto a motion-based simulation platform. Validate behavioral and communications-based Soldier state assessment approaches in an operationally-relevant, motion-based simulation environment. *FY 2022 Plans:*	-	1.498	0.487

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602145A I *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 I *Crew Augmentation and Optimization Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will validate optimized sensing approaches to process, share and improve situational awareness (SA) across the crew and improve decision making and mission success within a NGCV formation. Will validate personalization of Warfighter Machine Interface (WMI) configuration to permit role/mission requirement reconfiguration and Soldier monitoring. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort to focus on SA/decision making across the crew for mission success, and personalization of WMI configuration .			
Title: Crew Capability Enhancement ***Description:*** This effort focuses on the dynamic interaction of Soldiers, responsible for both manned and unmanned ground vehicles, working together within a platoon formation. Research focuses on the simultaneous use of multiple technologies by Soldiers including transparent multi-modal user interfaces, commander?s tools for maintaining and enhancing situation awareness, decision aids for enabling dynamic resource allocation and orchestration, and tools to interact with and adapt vehicle based autonomy. Products will include artificial intelligence algorithms, information display technologies, and team-centric design principles. ***FY 2021 Plans:*** Develop a concept for a Commander?s interface to demonstrate dynamic task reassignment across crew to enable crewmembers to manually share critical tasks as capabilities and mission needs change; investigate novel algorithms and communication protocols for developing, maintaining, and sharing situational awareness across a distributed Soldier-Artificial Intelligence team to enable improved decision making and rapid team reconfiguration. ***FY 2022 Plans:*** Will design and develop algorithms that provide an enhanced understanding of crew status, actions, intentions, and goals during simulated mission execution; design and develop initial data-driven approaches to cue Vehicle Commander of possible task sharing opportunities. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	-	2.877	3.233
Title: Characterize Soldier-Adaptive AI Interactions ***Description:*** This effort develops approaches for characterizing Soldier interactions and overall human-system performance of mixed Soldier and intelligent-agent teams to enable robust human system performance for manned and unmanned teams. This effort will focus on flexible, tailorable methodologies for laboratory-grade, high-resolution characterization of joint Soldier and Artificial Intelligence (AI) enabled intelligent-agent adaption in complex environments.	-	2.443	1.133

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 12 of 70

R-1 Line #12

Volume 1b - 155

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602145A I *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 I *Crew Augmentation and Optimization Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Create algorithms for characterizing crew behavior and adaptations; create algorithms for characterizing AI behavior and adaptations; develop initial advanced techniques for integrating subject matter expertise with machine learning approaches for characterizing intelligent-agent behaviors and adaptations.			
FY 2022 Plans: Will design and develop initial capability to characterize the interactions between the Soldier and AI-enabled system behaviors, and the ability to adapt to each other during unscripted simulated mission exercises.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding realigned to support higher priority artificial intelligence effort.			
Title: Human Augmentation for Collective Training **Description:** This effort investigates assessment techniques of crew performance to inform the development of individual and collective training for military vehicles. Assessment techniques will be applicable across a wide-variety of vehicle platforms, training tasks and vehicle crew roles. This effort will support training and increased force readiness of vehicle crews in complex environments by developing accurate and efficient performance assessment techniques evaluated in complex Operational Environments (OE) enabled by the latest advances in simulation and training technology. **FY 2021 Plans:** Design and conduct laboratory experiments to investigate training and visual display concepts that improve coordination and communication in manned-unmanned teaming operations in experimental crew station environments. Investigate and validate training methods using reconfigurable unmanned system command vehicle representative training system testbeds to support improved individual and crew adaptation to dynamic task-changing events and inform training system design for embedded and non-embedded training capabilities. **FY 2022 Plans:** Will investigate embedding of synthetic training environments in ground vehicle embedded computing devices to assess crew performance. Will investigate and design simulation capability for researching embedded training concepts using game engine based simulators. Will conduct experiments to determine data outputs required for live training and develop protocols to deliver data to the processing system for engagement modeling, real-time casualty assessment, and precision targeting. Will research mechanisms for high speed filtering and attribution of terrain features for ground platform training or operational use. Will design and conduct laboratory experiments pertaining to training Soldiers to accommodate task reassignments in order to improve	-	2.254	1.883

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 *I Crew Augmentation and Optimization Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
coordinated platoon-level maneuver in manned-unmanned team operations, utilizing experimental crew stations. Will conduct experiments to investigate and validate intelligent data routing techniques for improved live-synthetic training data transmission. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort for reduced experimentation.			
Title: Platoon Teaming Capability	-	1.339	2.170
Description: This effort focuses on the design, development and validation of intelligent, real-time, within-vehicle task management; data-driven allocation of situational awareness (SA) across platforms within the platoon; coordinated platoon-level manned-unmanned teaming (MUM-T) semi-autonomous maneuver with complex formations; and on-the-fly, platoon-level task optimization. This effort includes WMI modification to evaluate these capabilities in application of intelligent task management and data-driven prediction of crew to support changing mission goals. *FY 2021 Plans:* Validate interface for manual, pre-planned, cross-vehicle task reassignments by the team leader in order to enhance team performance based on crew status and mission objectives. Conduct experiment utilizing limited semi-autonomous maneuver for unstructured off-road operations in a motion-based simulation environment. *FY 2022 Plans:* Will validate approaches for sharing of critical tasks between crewmembers and intelligent technologies based on crewmember workload in order to enhance team performance. Will conduct experiment utilizing limited semi-autonomous maneuver for unstructured off-road operations in a live field exercise. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort for increased focus on experimentation in live field exercises.			
Title: Soldier?AI Team Mission Planning for Dynamic Complex Environments	-	1.251	-
Description: Planning in multi-domain operations environments is complex and has increased temporal and spatial sensitivities for Soldiers to integrate with AI systems to plan missions. This effort provides the fundamental concepts and technologies to enable Soldiers and AI systems to team together to plan for multi-domain operations from a ground vehicle perspective. This effort focuses on planning enablers to maximize manned-unmanned team performance across squads and platoons and includes crew station-based emerging technologies in the areas of human- interaction with AI technologies and human-guided machine intelligence. Approaches focus on modeling both Soldier and AI capabilities and their limitations as a function of the mission environment and mission requirements, and applying those models to forming mission plans. *FY 2021 Plans:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 / *Crew Augmentation and Optimization Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Conduct experiments to augment Learning Warfighter-Machine Interface capabilities to include enhanced mission planning capabilities that account for the relationship between terrain and environmental features as well as crew performance across multiple manned and unmanned ground vehicles. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort is administratively realigned to a new Project titled Human Autonomy Teaming in PE 0602144A_CG8.			
Title: Dynamic Soldier-AI Team Resource Allocation	-	2.434	-
Description: This effort focuses on creating the concepts and technologies necessary to dynamically allocate Soldiers and unmanned systems during missions in to adapt mission plans to adversarial actions and other events at a squad and platoon level, including responding to degradation or loss of team capabilities, changes in mission goals or priorities, and responding to adversarial actions. The effort includes the allocation of Soldiers, platforms, and platform sub-system capabilities with the focus to ensure that future AI and automation capabilities are focused on the circumstances and conditions where they are most likely to be successful, and to ensure that the resources of the Soldier-AI team are focused appropriately to ensure mission success. ***FY 2021 Plans:*** Design and develop Commander?s interface to enable dynamic task reassignment across crew to provide capability of crew members to manually share critical tasks as team capabilities and mission needs change; investigate novel algorithms and communication protocols for developing, maintaining, and sharing situational awareness across a distributed heterogeneous team to enable improved decision making and rapid team reconfiguration. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort is administratively realigned to a new Project titled Human Autonomy Teaming in PE 0602144A_CG8.			
Title: Soldier Cognition-Centric Interface Technologies	-	1.598	-
Description: This effort creates cognitive-centric displays that ensure Soldiers are focused on aspects of situational awareness, mobility, target engagements, and communications that are critical to mission performance as future crew stations and displays provide vast amounts of multi-domain information that has the potential to distract, overwhelm, and mislead Soldiers. This effort ensures that our systems do not capture and misdirect Soldier attention and/or cognition, maximizing the utility of AI systems to the Soldier. This effort enables Soldiers to better understand the actions, goals, intents, and general reasoning of the AI systems to ensure they are effectively used, but not inappropriately relied upon. ***FY 2021 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF6 *I Crew Augmentation and Optimization Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Investigate novel approaches to characterize overall team cohesion in a distributed Soldier-AI team; and conduct experiments to examine approaches for quantifying a crew?s trust in AI-enabled autonomous systems. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, this effort is administratively realigned to a new Project titled Human Autonomy Teaming in PE 0602144A_CG8			
Title: Enabling Soldier-AI Technology Adaptation *Description:* This effort develops technologies to rapidly adapt and upgrade AI-enabled system capabilities in response to advancements in AI in the commercial and adversary environments. Two focus areas include enabling technology adaption during Soldier experimentation and enabling data to be collected during these events for rapid development of technology updates and modifications. This effort has four goals: 1) increasing the ability of Soldier-AI teams to rapidly adapt to adversarial actions, new technologies, environmental changes, and mission requirements; 2) decreasing the data requirements to train and adapt AI-enabled systems; 3) increasing Soldier trust and use of technology; and 4) ensuring ethical decisions by using Soldiers to guide the actions and in-field adaptations of Soldier-AI team behaviors. *FY 2021 Plans:* Leverage data from multiple sensor systems and sensing approaches to improve robustness of real-time algorithms for understanding crew status, actions, intentions, and goals; investigate the ability for using information regarding crew behavior, physiology and interaction with intelligent agents to inform the development of novel approaches for assessing effectiveness of Soldier-AI teams; develop novel machine learning approaches to enable Soldiers to rapidly train AI systems on simulated and physical platforms. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, this effort is administratively realigned to a new Project titled Human Autonomy Teaming in PE 0602144A_CG8.	-	3.328	-
Accomplishments/Planned Programs Subtotals	22.079	19.022	8.906

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* 2					**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*					**Project (Number/Name)** BF8 *I Artificial Intelligence & Machine Learning Tech*		
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**
BF8: *Artificial Intelligence & Machine Learning Tech*	-	21.134	21.425	13.912	-	13.912	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding from this Project was realigned to:
Program Element (PE) 0602144A (Ground Technology) / CI2 Ground Enabling University Applied Research
PE 0603119A (Ground Advanced Technology) / CJ9 Ground Enabling University Advanced Development
PE 0602141A (Lethality Technology) / CJ1 Lethality Enabling University Applied Research
PE 0602182A (C3I Applied Research) / CN4 Network Enabling University Applied Research
PE 0602183A (Air Platform Applied Research) / CL5 Air Platform Enabling University Applied Research
PE 0602184A (Soldier Applied Research) / CN9 Soldier Enabling University Applied Research
PE 0602180A (Artificial Intelligence Technologies) / CL7 ATR using Multiple Cooperative Sensors Tech
PE 0602180A (Artificial Intelligence Technologies) / CN7 Predictive Maintenance Applied Research

A. Mission Description and Budget Item Justification

This Project develops and characterizes artificial intelligence and machine learning software and algorithms to team with soldiers in support of fully autonomous maneuver of the Next Generation Combat Vehicle (NGCV)and other autonomous systems, both physical and non-embodied. Efforts develop capabilities for NGCV and other autonomous agents that increase autonomy, unburdening the soldier operator, with a high degree of survivability and lethality in a highly contested environment. This work also investigates power distribution and conversion technologies to provide compact, efficient, and high power capabilities for electrical and electro-mechanical loads supporting both mobile and stationary unmanned platforms. Research enables combat vehicles to rapidly learn, adapt, and reason faster than the adversary; accomplish missions in contested, austere and congested environments, characterized by lack of structure, adversarial actions, and minimal a priori knowledge; and provide force reduction through self-learning vehicles that can operate in complex militarily relevant environments. This Project also matures emerging research leading to potential technology development in areas of strategic importance to the Army by bringing competitively selected Universities with research teams into Technical Alliances.

The cited work is consistent with 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 (US) Army Futures Command.

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

JUON CC-0558 $0.991M.

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 17 of 70

R-1 Line #12

| Volume 1b - 160 |

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF8 *I Artificial Intelligence & Machine Learning Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Advanced Distributed Power for Autonomous Platforms	1.395	-	-
Description: The effort investigates power distribution and conversion technologies to provide compact, efficient, and high power capabilities for electrical and electro-mechanical loads supporting both mobile and stationary platforms. High voltage and intelligent control methods will be coupled with the ongoing research in autonomy technologies to provide advanced performance enhancements in mobility and capabilities for these platforms. Research on innovative electric machines covering both electrical generation and motor technologies will focus on providing efficient, power dense, fault tolerant generation and mobility capabilities. Research addresses current and future Army-unique power delivery challenges in compact autonomous air and ground platforms and provides increased mission effectiveness with reduced cognitive burden.			
Title: Scalable, Adaptive, and Resilient Autonomous Systems	7.194	4.062	2.903
Description: This effort develops and matures emerging research in Autonomous Vehicle intelligence and decision making, human agent teaming, scalable and collaborative behaviors, embodied and embedded intelligence, and autonomous operations for next generation Army platforms in dynamic Army relevant environments, architectures, and missions. Specific focus will be on the application of Artificial Intelligence/Machine Learning (AI/ML) to autonomous systems and human-intelligent agent teaming; scalable and collaborative behaviors in support of heterogeneous air and ground manned-unmanned teaming (MUM-T) operations; methods for embodied and embedded intelligence for increased understanding, manipulation, and reflexive maneuver through and interaction with dynamic environments; techniques for improved perception, decision making, and adaptive behaviors in contested environments for MUM-T; and new methods for testing and evaluating emerging technologies for intelligent and autonomous systems under Army relevant constraints and environments and in Army relevant architectures. **FY 2021 Plans:** Investigate and develop methods for metric- and semantic-based world models as well as small unmanned aerial system and unmanned ground system coordinated maneuver; validate AI/ML methods to enable tactically-informed behaviors and maneuver of autonomous systems under Army-relevant constraints and environments. **FY 2022 Plans:** Will investigate methods and conduct experiments to increase operational speed and environmental complexity for air and ground based autonomous vehicle perception, learning, reasoning, navigation, and physical capabilities to augment and increase the freedom of maneuver in complex and contested environments. **FY 2021 to FY 2022 Increase/Decrease Statement:**			

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 18 of 70

R-1 Line #12

Volume 1b - 161

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF8 *I Artificial Intelligence & Machine Learning Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
In FY 2022, funding was partially realigned to PE 0602180A (Artificial Intelligence Technologies) Project CL7 (ATR using Multiple Cooperative Sensors Tech) to support artificial intelligence advancements.			
Title: Context-Based Information Dynamics	2.248	2.235	2.459
Description: This effort investigates techniques that integrate on-board and external information sources, and it applies Machine Learning (ML) analytic approaches to support automated intelligence analysis and decision making. The goal is to enable tactical agents to cooperatively share relevant and timely tactical information within a distributed environment. *FY 2021 Plans:* Investigate methods for using machine learning approaches to provide information mediation and transformation to identify approaches that address tactical dynamics and challenges of distributed intelligent command and control system interoperation. *FY 2022 Plans:* Will accelerate the intelligence and design phases of decision making by investigating methods and software that are semantically-aware and can identify, characterize, and exploit data from sensors and other information assets; design and develop capabilities that build on theories and fundamental models for accelerating the intelligence and design phases of machine and human decision making, through the use of aforementioned models. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase reflects planned lifecycle of this effort to develop software for the intelligence and design phases of decision making			
Title: Heterogeneous Computing and Computational Sciences	1.620	1.794	1.810
Description: This effort researches and develops algorithms and architectures to allow adaptable, energy efficient information processing across different computing hardware platforms. The goal of this research is to provide high performance computing and processing capabilities to the Soldier on the battlefield. *FY 2021 Plans:* Continue to develop adaptive computation algorithms for AI/ML processing at resource-constrained tactical edge for NGCV platforms, and to build local decision making framework to enable intelligent computational off-loading and distributed computing under resource constrained and contested environments. *FY 2022 Plans:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF8 *I Artificial Intelligence & Machine Learning Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will design dynamic, scalable architectures to enable energy efficient computation on the tactical edge battlefield; develop algorithms and protocols for resilient teaming and coordination of decentralized and distributed computing device; explore intelligent algorithms for adaptive computing and information processing scheduling and distribution under mission constraints. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort to develop algorithms and protocols for resilient teaming.			
Title: Machine Learning with Constrained Resources *Description:* This effort will research new Machine Learning (ML) and reinforcement learning methods to address issues of statistically mismatched and incomplete information which must be annotated, collected, classified, and used for rapid decisions by joint intelligent agent- Human teams. In addition, multi-modal human interaction approaches will be investigated to ensure effective Soldier interactions and understanding of intent. The goal of this research is to enable joint human-intelligent agent decision making, optimizing the strengths of each in the decision process and creating an adaptive, agile team. This work applies research conducted in PE 0611102A (Defense Research Sciences) / AA6 (Robotics and Mobile Energy) and AA9 (Information and Networking). *FY 2021 Plans:* Investigate novel machine learning approaches that allow trained models to be transferred between autonomous ground vehicles operating in similar domains; investigate algorithms that allow learned models to be developed from synthetic or offline training data; develop algorithms that allow autonomous ground vehicles to use semantic representations of the environment to navigate in complex environments; extend surrogate models for use of physical self-awareness for autonomous flight of unmanned aerial systems (UASs) to incorporate differing, static weather conditions, including pressure, wind-speed, and direction incorporating uncertainty in weather conditions; investigate the use of cyber agility and deception algorithms and methodologies as well as additional evasion defensive algorithms against Adversarial Machine Learning (AML) techniques in order to make tactical and enterprise systems resistant to attacks on their cyber defenses that rely on ML. *FY 2022 Plans:* Will explore cost-effective secure communication and data processing protocols that can be implemented in a resource-constrained tactical network; develop spatial-temporal graphs, graph neural networks, and deep learning algorithms to assist inferring temporal causality relationships of communication and services among assets; research noisy or corrupted military radar intelligence to develop unsupervised machine ML algorithms to generate multiple synthetic reconstructions from a heavily down-sampled image; research signal modulation schemes for low-signature communications and develop unsupervised ML algorithms to encode and decode text messages; develop algorithms for prototype platforms that allow trained models to be transferred between autonomous ground vehicles operating in similar domains; investigate machine learning approaches that allow relevant portions of trained models to be transferred across environments; conduct scientific experimentation to measure	3.993	4.010	4.200

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021	
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / Next Generation Combat Vehicle Technology		Project (Number/Name) BF8 / Artificial Intelligence & Machine Learning Tech	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
the ability of autonomous ground vehicles to navigate complex environments using semantic representations of the environment and reason over semantic observations in the environment; develop, explore, and define assessment metrics and machine learning approaches for training, augmenting, and assessing interaction between and across multi-agent systems and between soldiers and intelligent agents during joint collaborative tasks; design and conduct empirical analysis of modeling and simulation environments augmented with context-aware intelligent agents to enhance mission rehearsal, planning, and decision-making in the command and control operations. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Ground Robotic Vehicle Mobility & Propulsion Technology *Description:* Applied research in ground robotic vehicle mobility and propulsion technologies to enhance intelligent vehicle performance (speed, acceleration, mobility, maneuverability, adaptability, etc.) and enable Army robotic platform maneuverability in complex terrain and environments.	1.354	-	-
Title: Intelligence for High Operational Tempo Maneuver *Description:* Applied research on intelligence for cognitive learning and control architectures to enable efficient and full use of embodied physical capabilities and create the machine intelligence required of autonomous systems to understand physical limitations. Investigates the means through which robotic physical performance attributes (e.g. speed, agility) will be coupled with artificial intelligence to enable resilient maneuver in high operational tempo missions in complex environments. *FY 2021 Plans:* Investigate efficient algorithms that respond quicker to increase maneuver speed, agility, and adaptability of autonomous systems over complex terrain. Establish cognitive and control architectures that enable closed-loop self-aware and resilient tactical teaming behaviors at high operational tempos. *FY 2022 Plans:* Will conduct fundamental research, drawing on existing state-of-the-art work and biological inspiration, on novel models and algorithms that are capable of maneuver over or through complex terrain at high operational tempos, with efficiency in terms of physical movement (i.e. energy) and computation; conduct research on architectures and models that provide predictable performance appropriate for tactical teaming. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase reflects planned lifecycle of this effort to focus on architectures and models for tactical teaming.	-	1.324	1.540
Title: Autonomous Mobility NGCV Challenge	-	3.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF8 *I Artificial Intelligence & Machine Learning Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Develop novel behaviors and algorithms for autonomous off-road mobility in tactical environments to meet capability needs of the Next Generation Combat Vehicle (NGCV). *FY 2021 Plans:* Investigate novel algorithms for autonomous off-road navigation behaviors in complex environments at more operationally relevant speeds. Approaches will include learning from Soldier experimentation events to enable more tactically relevant behaviors with improved resiliency over current approaches. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, funding was realigned to PE 0602180A (Artificial Intelligence Technologies) Project CL7 (ATR using Multiple Cooperative Sensors Tech) to support artificial intelligence advancements.			
Title: Operational Assessment of Artificial Intelligence Developmental Systems *Description:* This effort supports the Combatant Commander's needs by performing operational assessments of AI-intense developmental weapon systems. *FY 2021 Plans:* Continues to work on an operational assessment of Artificial Intelligence developmental systems in support of the Combatant Commander identified need in FY20. *FY 2022 Plans:* Will continue to work on an operational assessment of Artificial Intelligence developmental systems in support of the Combatant Commander identified need in FY21. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort is realigned from support to the Combatant Commanders.	-	2.000	1.000
Title: Army Universities and Technical Alliances Collaboration *Description:* This effort conducts research leading to potential emerging technology development in areas of strategic importance to the Army in AI/ML and Robotics by bringing competitively selected Universities with research teams into Technical Alliances. The Technical Alliance collaborations consist of large collaborative hubs focused on developing and transitioning research in Army critical areas. Technical Alliances will be used to exploit opportunities to advance new capabilities through a sustained long- term multidisciplinary research effort. The primary focus of the Technical Alliances is expanding the frontiers of knowledge in research areas where the Army has enduring needs, and integrates state-of-the-art research programs at academic institutions to increase the supply of scientists and engineers to advance and optimize research within Army laboratories.	-	3.000	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF8 *I Artificial Intelligence & Machine Learning Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2021 Plans: Investigate and research technologies for ground vehicles focusing on autonomy, AI/ML and robotics. Will research geospatially-enabled, autonomy-related machine learning technologies, advanced teaming, and navigation/routing necessary for the Ground Portfolio, NGCV and the Army Modernization Priorities.			
FY 2021 to FY 2022 Increase/Decrease Statement: In FY2022, funding from this effort was administratively realigned to university-based research projects in the Ground (PE 0602144A), Air (PE 0602183A), Network (PE 0602182A), Soldier (PE 0602184A) and Lethality (PE 0602141A) Enabling Projects.			
Title: Small Sample Learning ***Description:*** This effort develops and explores novel algorithms that seek to reduce the time, manpower, and funding necessary to train artificial intelligence/machine learning (AI/ML) systems in image detection.	0.350	-	-
Title: Automated Target Recognition Applied Research ***Description:*** This effort investigates and develops intelligent algorithms to rapidly detect, identify, and cue kinetic options for identified adversary targets.	2.980	-	-
Accomplishments/Planned Programs Subtotals	21.134	21.425	13.912

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 23 of 70

R-1 Line #12

Volume 1b - 166

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*						**Project (Number/Name)** BF9 *I Sensors for Autonomous Operations and Surv Tech*	
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**
BF9: *Sensors for Autonomous Operations and Surv Tech*	-	17.072	36.836	35.489	-	35.489	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops modular and adaptive sensor components, novel embedded processing approaches, innovative threat cueing solutions and novel multi-function sensor payloads integrated with algorithms and machine learning/artificial intelligence tools to provide improved manned and unmanned ground vehicle situational understanding that enables aided target recognition (AiTR) and autonomous navigation in all environments.

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 supports the Army Next Generation Combat Vehicle (NGCV), Soldier Lethality (SL), and Future Vertical Lift (FVL) Modernization priorities.

Work in this effort is performed by the United States (US) Army Futures Command.

This effort is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology), 0603118A (Soldier Lethality Advanced Technology), 0602143A (Soldier Lethality Technology), 0602148A (Future Vertical Lift Technology) and 0603465A (Future Vertical Lift Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Sensors for Autonomous Operations and Survivability	14.589	-	-
Description: This effort will deliver sensor component technologies which greatly improve current and future uncooled thermal sensor performance through novel materials, new pixel designs and enhanced image processing, compression, and analysis capabilities. Research into novel multi-function digital read-out integrated circuits and other sensor components will provide embedded on-chip, non- uniformity correction, dynamic motion compensation, on-chip stabilization of infrared imagery and data compression with a significant reduction in data transmission requirements, greatly increased sensitivity of low size, weight, power and cost thermal sensors, and imaging capabilities through natural and manmade obscurants. This effort will research and develop threat cueing algorithms for unmanned aerial sensor borne electro-optic/infrared and ground penetrating radar sensors, and for ground vehicle based 360 degree sensors. This effort will investigate, develop and validate target detection and recognition algorithms with low false alarms rates and high probability of detection while on-the-move. These components will enable sensor systems to provide vehicle borne and dismounted soldier situational understanding in all environments and improve lethality by reducing decision making timelines.			
Title: Advanced Sensors with Embedded Processing	-	25.177	26.309

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF9 *I Sensors for Autonomous Operations and Surv Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Designs and develops advanced, automated multi-spectral and multi-function sensor components, and image processing techniques with improved performance in all environments and against all threats to include low-contrast targets in camouflage or in degraded conditions to enable combined arms maneuvers in complex environments for NGCV via manned, optionally manned, and robotic platform applications.			
FY 2021 Plans: Validate Digital Readout Integrated Circuit (DROICs) with high dynamic range and on-chip compression to enable high resolution imaging within bandwidth constricted environments. Mature on-chip non-uniformity correction for electro-optical / infrared (EO/IR) sensor components. Mature and demonstrate dynamic on-chip compression of thermal imagery to allow for up to 10x reduction in data rate. Begin development of pixel designs using advanced Micro-Electro Mechanical System (MEMS) to increase sensitivity. Mature compact high resolution uncooled thermal imaging sensors with integrated three-dimensional imaging algorithms to enable compact navigation and threat detection capabilities. Investigate exploitable scene features and target signatures throughout visible to long wave infrared portions of the spectrum to aid in robust threat detection through experiments during various times-of-day/night, sky irradiance, targets and backgrounds. Investigate the environmental parameters and target properties governing target detectability by EO/IR sensors operating at differing wavelengths to identify optimal sensor configurations.			
FY 2022 Plans: Will optimize on-chip non-uniformity correction for electro-optical / infrared (EO/IR) sensor components. Will complete development of pixel designs using advanced MEMSs to increase sensitivity. Will optimize new electronics readout circuitry for high sensitivity uncooled sensors and conduct experiments to ascertain the limits of sensitivity possible with the new readouts. Will investigate components necessary to enable uncooled longwave infrared (LWIR) sensors using smaller pixel pitch and larger pixel count. Will determine the performance of improved uncooled LWIR sensor components for threat warning. Will validate cooled digital ROICs to ensure they provide maximum attainable bit depth and information content available for high dynamic range imaging in order to see all threats no matter the level of clutter or degraded imaging environment. Will integrate low power processing threat warning approaches into the digital ROICs. Will determine new exploitable scene features and target signatures in the polarized visible through LWIR portions of the spectrum. Will determine optimal sensor configurations governing correlation between environmental parameters, target properties, low to moderately cluttered background suppression, and target detectability with polarized EO/IR sensors operating at differing wavelengths.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Multi-Mission Payload	-	5.988	3.289

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BF9 *I Sensors for Autonomous Operations and Surv Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Investigates, designs and develops sensor payloads for ground vehicle based unmanned aerial system to detect line of sight, and beyond line of sight threats and complex obstacles such as personnel and vehicles in all environments. *FY 2021 Plans:* Investigate and design unmanned aerial system (UAS) mountable polarized EO/IR sensors. Conduct experiments co-registering EO/IR, and other modalities to determine design impact to detection performance. Investigate various polarized sensor designs for vehicular, dismounted Soldier, and UAS mountable configurations enabling wider field of regard terrain coverage. *FY 2022 Plans:* Will mature higher resolution polarized optical sensor components for vehicular, dismounted Soldier, and UAS mountable configurations enabling wider field of view terrain coverage, smaller threat object detectability, and extended range leading to more advantageous UAS flight paths. Will determine new exploitable scene features and target signatures with concealment penetrating radar portions of the spectrum. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle glide path of this effort.			
Title: Automated Threat Cueing *Description:* Investigates, matures and validates novel image processing and threat recognition and detection methods to enable automated search and detection of open and concealed threats for cueing and target hand-off to maintain overmatch via speed in cluttered environments. *FY 2021 Plans:* Develop threat cueing algorithms utilizing EO/IR, novel compact ground penetrating radar, and position sensors for on-the-move target detection and tracking. Research novel two-dimensional and three-dimensional based algorithms utilizing exploitable features and signatures of threats in close combat open terrain scenarios. *FY 2022 Plans:* Will conduct experiments to validate processing approaches utilizing EO/IR and position sensors for on-the-move target detection and tracking. Will investigate novel imaging techniques utilizing exploitable optical polarization-based features and signatures of threats in close combat open terrain scenarios to validate threat cueing and recognition. Will conduct experiments with compact ground and concealment penetrating radar antenna designs to determine optimal small UAS and ground vehicle mountable configurations and assess detection capability in low clutter. Will investigate stacking registered radar and EO/IR imagery to	-	5.671	5.891

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021		
Appropriation/Budget Activity 2040 / 2		**R-1 Program Element (Number/Name)** PE 0602145A / Next Generation Combat Vehicle Technology	**Project (Number/Name)** BF9 / Sensors for Autonomous Operations and Surv Tech		

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
improve clutter suppression. Will develop thermal spectral imaging techniques for dimensionality reduction for significantly improved target detection. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Sensors for Automated Target Recognition Applied Research *Description:* This effort researches and investigates the pairing of ground borne, airborne, and soldier worn sensors with artificial agents to rapidly detect and identify adversary targets.	2.483	-	-
Accomplishments/Planned Programs Subtotals	17.072	36.836	35.489

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 27 of 70

R-1 Line #12

Volume 1b - 170

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*				**Project (Number/Name)** BG2 *I Modeling and Simulation for MUMT 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**
BG2: *Modeling and Simulation for MUMT Technology*	-	3.953	3.273	6.718	-	6.718	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding was partially realigned from this Project to Program Element (PE) 0603462A NGCV Advanced Technology / Project BG3 Modeling and Simulation for MUMT Advanced Tech

A. Mission Description and Budget Item Justification

This Project develops Modeling and Simulation (M&S) tools and technologies to assess and improve freedom of movement for ground forces and supports vehicle developers by addressing challenges for robotic and ground vehicles. Through investigation and design, this project develops obstacle detection and classification algorithms for dynamic mobility hazards in urban and complex environments. This project develops tools to evaluate system performance reducing the need for physical testing including: real-time mobility decision support tools, vehicle-terrain interactive models for autonomous convoy operations, simulation tools for vehicle mobility in highly altered terrain, and M&S tools for predicting the performance of autonomous vehicles in a wide variety of weather and terrain conditions. These M&S technologies can be integrated across Army vehicle platforms as required.

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 supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

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

This effort is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology) / Project BG3 (Modeling and Simulation for MUMT Advanced Tech).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Mobility in Complex Urban Environments	3.953	-	-
Description: This effort develops real-time mobility warning technology for manned and unmanned ground vehicles to include a real-time hardware-in-the-loop simulation environment to investigate autonomous vehicle maneuver, matures mobility obstacle detection algorithms, and refines near real-time mobility prediction software in the urban environment.			
Title: Simulation Tools for CoVeR	-	3.273	6.718

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 28 of 70

R-1 Line #12

| Volume 1b - 171 |

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG2 *I Modeling and Simulation for MUMT Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort develops M&S capabilities to evaluate hardware and software technologies enabling battlefield autonomy in complex environments and adaptive learning algorithms for predicting mobility performance in challenging environments. *FY 2021 Plans:* Develop M&S tools for autonomous vehicle design at the component level for successful maneuver in unstructured environments; develop analytical tools for predicting autonomous maneuver performance in unstructured environments. *FY 2022 Plans:* Will develop M&S enabled analytical tools and adaptive learning models for predicting autonomous vehicle performance across varying meteorological conditions and terrain; and will develop advanced algorithms to detect obstacles that affect maneuver corridors in unstructured environments. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase in FY22 will expand analytical tool development to include varied meteorological conditions/terrain types and will support development of obstacle detection algorithms.			
Accomplishments/Planned Programs Subtotals	3.953	3.273	6.718

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* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*					**Project (Number/Name)** BG6 *I Advanced Concepts for Active Defense 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**
BG6: *Advanced Concepts for Active Defense Technology*	-	51.275	45.754	30.541	-	30.541	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding was partially realigned from this Project administratively to Program Element (PE) 0602144A Ground Technology / Project CG7 Ground Protection Concepts and Technologies.

A. Mission Description and Budget Item Justification

This Project researches advanced materials and mechanisms to defeat the most common and most dangerous threats that are expected to be encountered by our ground forces in the near, mid and far term. Work conducted in this Project will result in concepts for Adaptive and Cooperative Protection of ground combat vehicles. Additionally, research will focus on subcomponent/component models to predict performance of early concepts and the means to evaluate effectiveness on ground platforms. The Project will balance developments of active threat defeat measures with the necessary advanced passive and active components to provide solutions which will help meet the requirements of current and next generation ground tactical and combat vehicles.

This Project is coordinated with and transition to Projects in PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and builds upon weapon target interaction research in PE 0602144A (Ground Technology) and PE 0601102A (Defense Research Sciences) / Project AA7 (Mechanics and Ballistics).

The cited work is consistent with Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy. Work in this Project supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

Work in this effort is performed by the United States (US) Army Futures Command.

This work is done in coordination with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Computational and Experimental Capability	4.565	6.532	-
Description: This effort will develop computational design tools as well as computational and experimental capabilities that support development of advanced protection systems. Such systems include passive, active and hybrid solutions for defeating (multiple) anti-armor threats and exploiting solid-dynamic, explosive-driven and magneto-hydrodynamic target interactions. This work allows for predicting armor performance and understanding mechanisms, regardless of vehicle platform, with improved and quantified confidence. This effort leverages the Department of Defense and Department of Energy (DOE) Technical Coordination			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 *I Advanced Concepts for Active Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Group Memorandum of Agreement and directly leverages DOE investments in computational platforms for problems in solid dynamics and impact mechanics. ***FY 2021 Plans:*** Increase computational modeling capability to predict performance of hybrid armor protection mechanisms during threat impact; develop machine learning methods for terminal effects interaction with protection mechanisms; develop diagnostic capability to capture three-dimensional x-ray imagery of experimental threat impacts. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort has been realigned to PE 0602144A Project CG7 Ground Protection Concepts and Technologies.			
Title: Multi-Threat Armor Technologies ***Description:*** This effort develops multi-threat hybrid armor technologies incorporating both active and passive mechanisms for ground vehicle systems that are effective against future conventional weapons and evolving improvised threats including kinetic and chemical energy as well as blast threats. ***FY 2021 Plans:*** Design armor mechanisms and technologies to defeat a wide range of threats to include medium and large caliber projectiles, anti-tank guided missiles, and rocket propelled grenades through the use of high performance computing, analytic modeling, and laboratory experiments; design an optimized vehicle hull concept that includes adaptive and active protection concepts for a combined threat suite through computational and experimental methods. ***FY 2022 Plans:*** Will validate and mature passive and reactive armor mechanisms and concepts to defeat kinetic and chemical energy threats in support of next generation combat vehicles; validate and mature active lightweight kinetic energy penetrator defeat mechanism; explore lightweight materials for defeat of medium caliber projectile threats. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort for increased focus on kinetic and chemical energy threats.	9.110	7.213	8.060
Title: Advanced Armor and Protection Technologies ***Description:*** This effort enables development of next generation of lightweight protective concepts and technologies for defeat of current and future threats by utilizing real-time information, combined with threat knowledge, to provide ever-increasing protection. This effort funds research into the fundamental physics of new terminal effects concepts and provides a mechanistic understanding of threat platform interaction. The effort investigates the ability to analytically simulate complex threat interactions. Experiments will be conducted to validate the efficacy of the designs.	5.683	7.216	-

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 31 of 70

R-1 Line #12

Volume 1b - 174

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / Next Generation Combat Vehicle Technology	Project (Number/Name) BG6 / Advanced Concepts for Active Defense Technology	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Design and develop armor technologies to defeat top-attack munitions using modeling, simulation, and experimental techniques; conduct experiments to explore electro-magnetic protection mechanisms and associated physics for armor technologies and use modeling and simulation in conjunction with the experimental results to evaluate the integration of multiple technologies to provide electro-magnetic protection mechanisms. **FY 2021 to FY 2022 Increase/Decrease Statement:** In FY 2022, this effort has been realigned to PE 0602144A Project CG7 Ground Protection Concepts and Technologies.			
Title: Adaptive and Cooperative Protection **Description:** This effort pursues a holistic approach toward achieving significant weight reduction and protection from future threats by utilizing real-time information, combined with threat knowledge, to provide ever-increasing protection. This approach includes integrating individual vehicle capabilities of armor, underbody blast protection, active protection systems, and advanced soft kill methods into one layered solution to maximize survivability and minimize weight for combat and tactical vehicles. This effort will investigate modern protective technologies that implement complex kinematic mechanisms in order to bend, break and disperse threat projectiles before they can injure crew or disable vehicles. **FY 2021 Plans:** Design a countermeasure and launch mechanism to defeat anti-armor threat weapons implemented in a novel manner to increase protection coverage. Utilize modeling, simulation, and experimental capabilities to develop adaptive armor protection mechanisms to defeat current and emerging threats. **FY 2022 Plans:** Will validate adaptive protection threat interception concept experimentally with integrated sensors and control mechanisms; mature the adaptive armor mechanisms utilizing modeling, simulation, and experimental capabilities to ensure defeat of current and emerging threats; explore novel countermeasures to defeat threat Anti-Tank Guided Munitions (ATGMs) and top attack munitions; mature top attack protection mechanism to defeat emerging threats. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.	9.663	11.628	6.059
Title: Emerging Overmatch Technologies **Description:** This effort supports the development and demonstration of lethality and protection concepts that re-establish overmatch for the next generation of manned and unmanned combat platforms. It will tightly couple scientific research within a campaign of learning to form technology concepts for battlefield domination against current and future threats. This research will	1.752	2.220	2.267

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 32 of 70

R-1 Line #12

Volume 1b - 175

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 *I Advanced Concepts for Active Defense Technology*		

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
heavily leverage other efforts within PE 0602145A (Next Generation Combat Vehicle Advanced Technology) and PE 0603462A (Next Generation Combat Vehicle Advanced Technology). ***FY 2021 Plans:*** Conduct validation experiments to determine the effects of coupling of autonomy protection and lethality concepts. Partner with The Research and Analysis Center (TRAC) to conduct Advanced Warfighting Simulation scenario iterations and evaluate combat effectiveness of these concepts. ***FY 2022 Plans:*** Will develop autonomous behaviors specific to perimeter defense and pursuit-evasion to adversarial threats, accounting for team maneuver relative to agents and anticipated attrition; develop autonomous tactical behaviors using simulation with cooperative teaming of up to seven friendly agents engaging a similarly sized adversarial team; validate autonomous behaviors in physical experiments with a minimum of three robotic vehicles. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Survivability/Lethality/Vulnerability Analysis Tools and Methodology ***Description:*** This effort devises state-of-the-art survivability/lethality/vulnerability methodologies to dynamically model the interaction of conventional ballistic threats against future weapon systems. ***FY 2021 Plans:*** Complete development and validation of lethality and vulnerability analysis methods that account for multi-hit effects; models will be tailored to assess NGCV weapon systems and effects of direct fire ammunition on NGCV protection technologies; refine and demonstrate effectiveness of smart NGCV munitions in contested and degraded environments of multi-domain operations; investigate vulnerabilities of Artificial Intelligence associated with cognition capabilities provided by sensors which can be degraded when operating in contested environments and explore implications of these vulnerabilities on machine learning performance; investigate the implications of vulnerabilities to robotic combat vehicles on manned-unmanned teaming performance; validate models for active protection systems and extend them to investigate adaptive protection systems. ***FY 2022 Plans:*** Will complete development of methodologies for a ballistic lethality analysis capability for NGCV Smart Munitions in Electronic Warfare (EW) congested environments, an Active Protection System soft kill analysis capability for Vehicle Protection Systems, and probabilistic analysis capabilities for teamed autonomous Unmanned Ground Vehicle systems in support of Robotic Combat	4.768	5.224	5.167

R-1 Line #12

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 *I Advanced Concepts for Active Defense Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Vehicle effectiveness performance trades. Will continue developing, refining and validation of multi-discipline analysis capabilities for Active Protection Systems in EW contested environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Warrior Injury Assessment Manikin (WIAMAN) **Description:** This Project develops an improved demonstrator blast test manikin, data acquisition system, and injury prediction methods and tools that incorporate new medical research and which provides an improved capability to measure and predict skeletal injuries for vehicle occupants during under-body blast events.	1.136	-	-
Title: Ground Systems Active Defense Technology Research **Description:** This effort contributes to the Army's ground vehicle survivability by developing technologies which electronically or physically defeat an incoming threat before it contacts the vehicle. These technologies involve sensors and effectors interacting with an incoming threat to disrupt or destroy in while it is in flight or before it is even fired at a vehicle. This effort designs and develops modern armors that directly complement and are optimized to work with active defense technologies in order to implement sophisticated mass efficient mechanisms and leverage investments in materials to act as a system for the defeat of advanced threats and active protection system residuals. This effort designs and develops active blast mitigation technologies to counter the effects of underbody attacks to ground vehicles. This effort will also design and develop the required advanced structures required to accommodate active blast mitigation technologies into vehicles. The design of the structure and active defense technology is critical to an effective blast survivability solution. ***FY 2021 Plans:*** Conduct experiments to baseline current platform survivability solutions to determine effects of residual debris from an Active Protection System (APS) engagement on protection levels for ground platforms. Investigate if residual debris impacts to explosive reactive armor introduces a vulnerability to ground vehicles. Design armor solutions that balance requirements for protection from threat projectiles and APS residual projectiles and validate the concept to use armor and occupant protection technologies for vehicle survivability and soldier protection. Develop test methods for evaluating occupant protection technologies to mitigate injuries resulting from APS engagement residual effects. Leverage modeling and simulation to predict and potentially enhance performance of protection systems. ***FY 2022 Plans:*** Will investigate the integration of several novel survivability and protection technologies for emerging threats with complex defeat mechanisms. These technology concepts will be evaluated in advanced modeling and simulation (M&S) to create high fidelity integrated component concepts. The best performing concepts will be fabricated for physical testing to validate technology	14.598	5.721	5.783

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG6 *I Advanced Concepts for Active Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
performance. Will leverage internal modelling and simulation capability to determine path forward for protection system and enhancements. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Title: Advanced Threat APS Radar Technology **Description:** This effort develops ground combat vehicle survivability technologies including radar techniques to support hard-kill countermeasures as a part of an integrated survivability suite for ground combat platforms in all-weather, day or night conditions with 360 degree situational awareness and Kinetic Energy threat defeat. ***FY 2022 Plans:*** Develop tools to support characterization of techniques. Perform study to identify and harness open RF and radar specific interfaces applicable to the APS mission. Perform study on timeline to counter stressing threats (KE rods) in support of developing radar resource management techniques to enable KE defeat and additional missions without increasing vehicle signature or adversely impacting the engagement timeline. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change for this new effort in FY22 was realigned from PE 0602150 Project AE4 Collaborative ISR Sensors Technology.	-	-	3.205
Accomplishments/Planned Programs Subtotals	51.275	45.754	30.541

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 35 of 70

R-1 Line #12

Volume 1b - 178

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 **/** 2				**R-1 Program Element (Number/Name)** PE 0602145A **/** *Next Generation Combat Vehicle Technology*						**Project (Number/Name)** BG8 **/** *Obscuration 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
BG8: *Obscuration Technology*	-	3.903	2.620	2.576	-	2.576	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and evaluates obscurant technologies that degrade threat force surveillance sensors and defeat the enemy's target acquisition devices, missile guidance, and directed energy weapons. This Project focuses on advanced infra-red and multi-spectral obscurant materials that provide effective, affordable, and efficient screening of deployed forces, while being safe and environmentally acceptable.

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 supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this Project is related to and fully coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Obscuration Technologies for Active Protection Systems	1.407	-	-
Description: This effort investigates dissemination technologies for various obscurants.			
Title: Obscuration Enabling Technologies	2.496	2.620	2.576
Description: This effort investigates new materials and compounds to enable safe, effective screening of personnel and equipment across the electromagnetic spectrum. This effort also provides vulnerability assessments against enemy threat systems. *FY 2021 Plans:* Validate packing and dissemination techniques for advanced obscuration materials including bi-spectral, advanced microwave, and spectrally selective obscurants. Mature advanced bi-spectral materials for screening obscuration module. Perform threat modelling for unmanned ground and aerial systems sensor systems. Evaluate obscuration technologies against threat systems to determine probability-of-hit for vehicle platforms. *FY 2022 Plans:*			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BG8 *I Obscuration Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will investigate multi-spectral materials for obscuration use to defeat ground and aerial threats. Will develop and evaluate obscuration technologies for integration into the Air Domain (e.g., use obscuration to mask offensive aerial attacks, use obscuration to defend incoming aerial threats by masking/confusing guidance systems). ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	3.903	2.620	2.576

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 37 of 70

R-1 Line #12

Volume 1b - 180

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*					**Project (Number/Name)** BH2 *I C4ISR Modular Autonomy 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
BH2: *C4ISR Modular Autonomy Technology*	-	4.674	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project researches and develops multifunction mission command, sensing, and communications technologies and approaches to enable the required Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) capabilities for autonomous and semi-autonomous platforms. Efforts support Manned/Unmanned Teaming and combined arms maneuver in complex environments.

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 supports the Army Modernization Priority Next Generation Combat Vehicle.

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

Work in this effort is performed by the United States (US) Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: C4ISR Modular Autonomy Technology **Description:** Investigates and matures embedded processing algorithms utilized in soldier systems and platforms to improve the warfighter?s decision efficiency and ability to perform Intelligence, Surveillance, and Reconnaissance (ISR), Target identification and discrimination	4.674	-	-
Accomplishments/Planned Programs Subtotals	4.674	-	-

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

D. Acquisition Strategy
N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 38 of 70

R-1 Line #12

Volume 1b - 181

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602145A I *Next Generation Combat Vehicle Technology*				**Project (Number/Name)** BH5 I *Platform Electrification and Mobility Tech*			
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**
BH5: *Platform Electrification and Mobility Tech*	-	9.612	20.563	13.781	-	13.781	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding was partially realigned from this Project administratively to Program Element (PE) 0602144A Ground Technology / Project CG6 Ground Vehicle Power and Energy Concepts and Tech

A. Mission Description and Budget Item Justification

This Project researches and develops advanced power and energy technologies for combat ground vehicles that are necessary for parallel hybrid, series hybrid and all-electric vehicle systems.

This Project also continues the Advanced Vehicle Power Technology Alliance (AVPTA) between the Department of Energy and the Department of the Army with a focus on energy storage for electrification, providing an emphasis on developing advanced technologies that enable military ground vehicles to become significantly more energy efficient. The Alliance is chartered to accelerate the conceptualization and transition into deployment of inventive and creative energy-saving concepts that the Nation needs to achieve energy security. This Project researches energy storage technologies in support of lighter military vehicles which are more fuel-efficient and expeditionary with superior mobility and protection of both vehicles and occupants.

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 effort is performed by the United States (US) Army Futures Command.

Work in this Project supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: AVPTA - Energy Storage	0.762	-	-
Description: This effort develops and matures advanced energy storage technologies to improve power and energy performance and safety for vehicles. Higher energy stored with less space and weight increases vehicle efficiency and range. Ensures electrified ground vehicles have enough power for mobility, silent watch, and enables energy based capabilities including electromagnetic armor and directed energy weapons.			
Title: Novel Propulsion Research	1.476	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602145A I *Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH5 I *Platform Electrification and Mobility Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort performs research to assess and evaluate the optimal electrified propulsion system configuration for future military tactical and combat ground vehicle applications. This effort will investigate and model parallel hybrid-electric, series hybrid-electric, fuel cell and all-electric propulsion systems for the future military vehicle applications. Research is required to understand how electrified propulsion may impact future fleet mobility requirements, soldier operational scenarios, operational energy reduction, enablement of future lethality and defensive systems, sensors, and ancillary electrical loads. Novel propulsion systems such as fuel cells, high speed diesel engines, mega-watt generators, quad sprocket tracked and multi-drive wheeled mobility, as well as the logistic support and infrastructure requirements will be investigated.			
Title: Platform Electrification and Mobility Research	7.374	-	-
Description: This effort develops technologies required to electrify both manned and unmanned Next Generation Combat Vehicle platforms. The effort develops a modular and scalable electrification architecture. The effort develops technologies to increase electric power such as a high voltage/temperature generator, high power/ temperature power electronics, electric drive motors, and energy storage. Electrification of these platforms will enable advanced lethality and protection systems, reduced battlefield fuel consumption, and provide new capabilities such as burst acceleration, extended silent mobility and silent watch.			
Title: Scalable Electrification & Control Architecture	-	1.996	1.430
Description: This effort develops the power distribution and control components to implement a common, scalable, electrified vehicle power architecture to enable advanced lethality and protection capabilities, fast vehicle charging from the grid, and silent mobility on combat platforms across light to heavy weight classes. This power architecture enables the hybrid electric, fuel cell electric, and all-electric powertrains. *FY 2021 Plans:* Develop high voltage power distribution components that enable electrified powertrains. Develop the high voltage power converter to enable advanced lethality/protection capabilities and high voltage battery storage. Develop import/export power converter to enable fast vehicle charging from local power sources. *FY 2022 Plans:* Will mature high voltage power distribution component that enables electrified powertrains. Will validate the import/export power converter enabling fast vehicle charging from the grid. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding reflects reduced effort required to mature and evaluate components developed in FY21.			
Title: Platform Electrification Research	-	11.251	8.253

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH5 *I Platform Electrification and Mobility Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort designs and develops the electric power generation, energy storage and electrified components and sub-systems required to electrify combat vehicles across light to heavy weight classes. *FY 2021 Plans:* Design internal components for a high voltage power system electric generator and high power inverter. Design electric drive motors. Design thermal management system for a modular electrification architecture. Design electric turret drive. Investigate novel battery chemistries that could provide up to four times more energy storage density than current batteries. Design and develop modules for a modular high voltage energy storage system. Design mobility/silent watch range extender. *FY 2022 Plans:* Will mature designs for internal components for electric generator. Will mature designs for electric drive motors. Will mature designs for final drive component of a modular electrification architecture. Will develop cells for increased energy storage systems. Will characterize module performance for modular high voltage energy storage system. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned reduction of investment in electric turret drive.			
Title: Advanced Mobility Research *Description:* This effort develops a lightweight composite running gear system for medium combat vehicle applications which offers significantly reduced system weight, maintenance, noise and vibration over conventional running gear systems. Advanced composite tracks coupled with low cost, low complexity suspension systems improve operational capability via increased mobility. *FY 2021 Plans:* Research novel running gear systems using composite materials to reduce weight. Investigate new joining methods for rubber band track connections. *FY 2022 Plans:* Will design and conduct experiments on critical track components, materials and joints to validate performance. Will also design and conduct experiments on critical suspension components to validate performance. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects reduced amount of effort required for experimentation compared to the development activities in FY21.	-	3.322	2.054
Title: Advanced Distributed Power for Autonomous Systems *Description:* This effort develops technologies for electrification of both manned and unmanned Next Generation Combat Vehicle platforms. Electrification of these platforms enables advanced lethality and protection systems, reduced battlefield	-	1.563	-

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 41 of 70

R-1 Line #12

Volume 1b - 184

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021		
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / Next Generation Combat Vehicle Technology	Project (Number/Name) BH5 / Platform Electrification and Mobility Tech		

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
fuel consumption, and provides new capabilities such as burst acceleration, extended silent mobility, and silent watch. This effort investigates and develops electric conversion technologies to reduce size and weight while increasing performance and capabilities to support current and future mission loads and provide improved military vehicle mobility. Research focuses on high power/ temperature power electronics, magnetic gears, electric drive motors, and advanced artificial intelligence/machine learning (AI/ML) enabled autonomous control components and power management. Investigation of advanced control methods at the module and conversion component levels provides an understanding of the impact AI/ML and energy usage tracking can have on power optimization and mission effectiveness. The research enables the integration of components? status and behavior into system level management algorithms that support manned and autonomous operations while providing modular and scalable electrification architectures. This effort also investigates magnetic gear technologies that do not have physical connections connected to electrical motors and generators to reduce size and weight with increased reliability and performance providing increased torque, speed and range. Results of the research informs the Novel Propulsion Research effort in this Project. *FY 2021 Plans:* Perform experiments on electrical conversion design concepts from PE 0602145A (Next Generation Combat Vehicle Technology), Project BH7 (Enhanced VETRONICS Technology) to understand performance and operational parameters of the components; investigate techniques to improve power conversion component performance through advanced control techniques and methodologies; investigate methods to monitor energy use and losses in real time; analyze performance of power modules utilizing AI/ML control methods to experimentally determine performance improvement enabled by use of reinforcement machine learning algorithms; analyze performance of the 200:1 gear ratio magnetic gear; and initiate improvement for reduced weight design to determine performance envelope. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, this effort is administratively realigned to Project CG6 Ground Vehicle Power and Energy Concepts and Technologies under PE 0602144A.			
Title: Power Electronic Components and Materials *Description:* This effort investigates and develops electric conversion technologies to reduce size and weight while increasing performance and capabilities to support current and future mission loads and provide improved military vehicle mobility. Research focuses on semiconductor power switches, power switch modules and packaging, and power switch module thermal management. Investigation high voltage/high frequency power semiconductor materials and devices concentrates on efficient power switching under militarily relevant temperature ranges. Development of multi-disciplinary parametric design optimization software tools and multi-functional package structures provides advances in device packaging technology to fully realize device performance improvements. Results of the research will inform the Novel Propulsion Research effort in PE 0602145A (Next Generation Combat Vehicle Technology) / BH5 (Platform Electrification and Mobility Technology).	-	2.431	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH5 *I Platform Electrification and Mobility Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2021 Plans: Determine performance of Gallium Nitride based power device process enhancements through modeling and device performance analysis; develop fabrication processes to enable wide?band-gap and ultra-wide-band-gap semiconductor device technologies; incorporate magnetic material analysis algorithms to expand the design envelope for the parametric optimization simulation tool used in this effort; analyze and investigate the performance of metallic phase change thermal management techniques; determine performance of power module designs for 20 kiloWatts per Liter (kW/L) and 25 kiloWatts per kilogram (kW/kg) power ratings as well as examine concepts, designs, and processes to achieve objective goal of 40kW/L and 50 kW/kg power ratings. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, this effort is administratively realigned to Project CG6 Ground Vehicle Power and Energy Concepts and Technologies under PE 0602144A.			
Title: Robotic Combat Vehicle Silent Watch and Mobility Range Extension *Description:* This effort designs and develops the Jet Propellant 8 (JP8) reformer based silent watch and mobility extension subsystem required to electrify robotic combat vehicles. The Army's robotic combat vehicles are expected to have increased silent watch and silent mobility requirements that are not met by current technologies. *FY 2022 Plans:* Will mature metal supported solid oxide fuel cell technology and investigate approaches for increased density and faster start times on an integrated JP8 reformer and fuel cell technology. *FY 2021 to FY 2022 Increase/Decrease Statement:* This is a planned new effort in FY22 and the funding reflects the research required on JP8 reformer and fuel cell technology.	-	-	2.044
Accomplishments/Planned Programs Subtotals	9.612	20.563	13.781

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* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*					**Project (Number/Name)** BH7 *I Enhanced VETRONICS 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**
BH7: *Enhanced VETRONICS Technology*	-	3.455	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project addresses the development of materials and device designs for compact, high-efficiency, high-temperature, and high-power Army ground tactical and combat vehicles including hybrid-electric propulsion, electric power generation and conversion, and smart micro-grid power distribution. This Project investigates aluminum gallium nitride materials for high power applications.

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 supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this PE is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Electronic Components and Materials Research	3.455	-	-
Description: This effort investigates material, device and module technologies to reduce weight, volume and energy losses for ground tactical and combat vehicles electrification while providing enhanced mission effectiveness through smart operation. Technologies provide devices and modules for high power hybrid-electric propulsion, electric power generation and conversion, and smart power distribution. Research addresses current and future Army-unique performance and operational requirements for ground vehicle mobility.			
Accomplishments/Planned Programs Subtotals	3.455	-	-

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 44 of 70

R-1 Line #12

Volume 1b - 187

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602145A I Next Generation Combat Vehicle Technology							Project (Number/Name) BH9 I Protection for Autonomous Systems Tech	
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
BH9: *Protection for Autonomous Systems Tech*	-	2.443	1.444	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project analyzes the emerging requirements for the protection and survivability of future autonomous combat platforms. Studies will be conducted at both the platform and force level to identify unique survivability needs of these platforms. It will also mature component technologies to address identified capability gaps.

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 supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Protection for Autonomous Systems	2.443	1.444	-
Description: This effort contributes to the Army's ground platform risk reduction efforts which that seek to address technical challenges of survivability and protection for autonomous systems. Specifically, this effort focuses on developing protection concepts for unique unmanned systems to ensure autonomous ground vehicles can continue their mission in contested environments. *FY 2021 Plans:* Evaluate the vulnerability of autonomous ground system components such as sensors, enabling autonomous maneuver against threats to include electromagnetic effects. Evaluation will be conducted in order to understand potential threat-based mission impacts and degraded operation of unmanned system components to inform future hardening activities for military applications. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding was realigned to PE 633041 All Domain Convergence Advanced Technology / Project CM8 Convergence Battlefield Integration .			
Accomplishments/Planned Programs Subtotals	2.443	1.444	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BH9 *I Protection for Autonomous Systems Tech*

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 46 of 70

R-1 Line #12

Volume 1b - 189

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*			**Project (Number/Name)** BI2 *I Sensor Protection 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**
BI2: *Sensor Protection Technology*	-	10.149	10.340	5.878	-	5.878	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding was partially realigned from this Project administratively to Program Element (PE) 0602144A Ground Technology / Project CG5 Ground Vehicle Sensor Concepts and Technologies

A. Mission Description and Budget Item Justification

This Project investigates, designs, and develops techniques for masking friendly force capabilities and intentions. The Project pursues technologies to reduce the susceptibility of sensor systems to detection and targeting by threat forces, as well as to inform the development of next generation signature reduction schemas. This Project also designs, investigates, fabricates, evaluates and characterizes advanced sensor protection technologies, components, and concepts that will enable the future soldier to see and operate through a laser directed energy weapon attack. Both active and passive protection technologies will be investigated to protect Army sensors that operate in the visible, short-wave infrared, mid-wave infrared, and long-wave infrared spectra from battlefield laser threats. Areas of research include passive optical limiters such as nonlinear organic dyes, semiconductors, and meta-materials, as well as fast active switches and tunable filters. Technologies investigated include novel optics designs combined with signal processing, spectral filtering, and threat sensing algorithms.

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 supports the Army Science and Technology Next Generation Combat Vehicle, Soldier Lethality, and Future Vertical Lift modernization priorities.

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology), PE 0603118A (Soldier Lethality Advanced Technology), PE 0603465A (Future Vertical Lift Advanced Technology), and PE 0602143A (Soldier Lethality Technology)

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Sensor Protection Technology	6.494	6.189	5.878
Description: This effort will design and develop component technology to improve protection of sensors and sensor electronics from threats via techniques to harden optics, reduce sensor optical cross sections, novel coating approaches, filter improvements, and emerging signature reduction schemas.			
FY 2021 Plans:			

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 47 of 70

R-1 Line #12

Volume 1b - 190

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602145A / Next Generation Combat Vehicle Technology	Project (Number/Name) BI2 / Sensor Protection Technology

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Investigate new protective sensor coatings that maximize transmission for sensor frequency bands while minimizing energy transmission of other frequencies including lasers to protect sensor components while still meeting environmental performance and durability requirements. Develop and evaluate new designs to reduce optical cross section (OCS) and resist sensor damage for emerging large format electro-optical/infrared focal plane arrays. Evaluate concealment performance of camouflage technologies in all environments against reflective, emissive, and radar threat sensors. *FY 2022 Plans:* Will conduct experiments with high transmission optical coatings on operationally equivalent sensor components to validate performance against metrics. Will mature out-of-band protective window coatings and validate performance against a selection of emerging threats. Will develop protection approaches for uncooled sensors. Will investigate agile visible filter materials to determine protection thresholds. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle for this effort.			
Title: Laser Protection Technologies *Description:* This effort develops new materials and devices for the protection of Army sensors and eyes behind day-view optical sights from a variety of laser threats. This research utilizes a combination of technologies based on the nature of the different threats, as well as the fundamental differences in sensors operating over different frequency ranges. Passive optical limiting materials that block specific frequency bands of light will be investigated and developed for the visible and short-wave infrared (SWIR) spectrum, and active man-made material-based solutions will be investigated for uncooled sensors in the long-wave infrared. Vulnerability of sensors and optical sensor systems will be studied against high-power and ultra-short pulsed laser threats to determine protection requirements. *FY 2021 Plans:* Analyze results of study previously conducted on threats to sensor systems and develop optical system protection concepts to mitigate the impact of the study findings; validate ultrashort laser sensor focal plane array damage protection materials; conduct high-power laser experiments to test protection concepts; investigate the capabilities of tunable infrared filters coupled with shape memory alloy shutters for protection of uncooled infrared sensors. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, this effort has been administratively realigned to PE 0602144A Project CG5 Ground Vehicle Sensor Concepts and Technologies.	3.655	4.151	-
Accomplishments/Planned Programs Subtotals	10.149	10.340	5.878

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BI2 *I Sensor Protection Technology*

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 49 of 70

R-1 Line #12

Volume 1b - 192

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*					**Project (Number/Name)** BI4 *I Materials Application and Integration Tech*			
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**
BI4: *Materials Application and Integration Tech*	-	7.971	7.689	7.648	-	7.648	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs, develops, fabricates and evaluates a variety of materials (e.g. metals, ceramics, polymers and composites) to enable more survivable, lighter weight vehicle armor, chemical and biological protection, armaments and electronics for the next generation combat vehicle. Research focuses on unique and /or novel materials properties, developing physics-based models, materials characterization techniques, non-destructive testing methods and advanced fabrication/processing methodologies to transition candidate solutions for maturity, scale-up, and integration into systems.

This Project also continues the Advanced Vehicle Power Technology Alliance between the Department of Energy and the Department of the Army with a focus on materials, providing an emphasis on developing advanced technologies that enable military ground vehicles to become significantly more energy efficient. The Alliance is chartered to accelerate the conceptualization and transition into deployment of inventive and creative energy-saving concepts that the Nation needs to achieve energy security. This Project matures and integrates lightweight materials and joining technologies in support of lighter military vehicles which are more fuel-efficient and expeditionary with superior mobility and protection of both vehicles and occupants.

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

Work in this Project supports the Army Modernization Priority Next Generation Combat Vehicle.

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this Project leverages research from PE 0601102A (Defense Research Sciences) / Project AA7 (Mechanics and Ballistics) and 0602144A (Ground Technology) / Project BL1 (Materials and Manufacturing Research Technology). This work is also coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Lightweight Armor Materials and Processes for Vehicle Protection	3.817	-	-
Description: This effort conducts applied research to design, develop and evaluate lightweight armor materials and structures, investigate novel processing methodologies for cost effective manufacturing, use existing and emerging modeling and simulation tools to enable formulation of lightweight, frontal, and structural armor materials for current and future platform applications. This effort also explores ground vehicle structural mechanics and dynamics technologies to improve damage tolerance, durability, fatigue-resistance, and dynamic response (i.e., shock, vibration, harshness, and damping).			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BI4 *I Materials Application and Integration Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Novel Armor Materials and Processes for Vehicle Protection	2.387	7.689	7.648
Description: Develop novel metal alloys and associated processes through the scale-up and exploitation of revolutionary new metal alloys, which have demonstrated capabilities to overcome traditional engineering trade-offs (e.g., strength and ductility) with exceptional high temperature stability.			
FY 2021 Plans: Investigate performance of nanocrystalline and novel high-hardness metal alloys, validating their use for ballistic protection applications; investigate corrosion-resistant magnesium alloys and validate for ballistic protection and structural applications.			
FY 2022 Plans: Will conduct microstructural assessments with load-state testing to characterize Aluminum-Magnesium alloy to correlate microstructural changes to meso- and macro-scale mechanical behavior for ballistic protection; examine potential for adhesively bonded multilayer composite structures to deflect incoming threats; develop a high toughness, low cost high hard steel alloy for weldable, bendable structural applications using in-house casting/processing capabilities and prior characterization and assessment of commercial alloys to; and optimize the engineering and manufacturing principles of high energy ball milling to effectively generate sufficient quantities of powders to fabricate oxide dispersion strengthened alloy plates for ground combat vehicle ballistic applications.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Advanced Vehicle Power Technology Alliance Materials	1.767	-	-
Description: This effort develops and matures lightweight materials and joining technologies to enable lighter, more fuel-efficient tactical and combat vehicles with superior mobility and protection of both vehicles and occupants. Lighter materials and advances in joining technologies such as multi-material and dissimilar material joining will lead to lightweight military vehicle structures.			
Accomplishments/Planned Programs Subtotals	7.971	7.689	7.648

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

D. Acquisition Strategy
N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 51 of 70

R-1 Line #12

Volume 1b - 194

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*				**Project (Number/Name)** BI9 *I Vehicle System Security 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
BI9: *Vehicle System Security Technology*	-	2.829	2.676	2.359	-	2.359	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops ground vehicle cyber protection and resilience technologies to increase the cybersecurity of ground vehicles and ensure their continued operation in near-peer cyber contested environments. This Project will develop cybersecurity technologies at the vehicle platform level to defeat cybersecurity threats and maintain assured vehicle functionality and freedom of maneuver in the cyber warfighting domain. This effort is critical to address the continuous expanding vulnerability of military platforms to cyber threats due to their increasing reliance on computers, networks, data, digitization, and communications technology.

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

Work in this Project supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and 0602213A (C3I Applied Cyber).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Vehicle System Security Technology	2.829	2.676	2.359
Description: This effort develops cybersecurity technologies to defeat cybersecurity threats and maintain assured vehicle functionality and freedom of maneuver in the cyber warfighting domain. This effort develops technologies required to maintain operating tempo and overmatch capability during offensive digital attacks to ground vehicle systems. Additionally, the technologies developed will maintain critical vehicle functionality in peer and near-peer cyber-contested environments through robust cyber-defensive protections. The effort will also develop cyber-defensive technologies to mitigate risk of future and emerging enemy cyberattack vectors by designing highly assured systems with cybersecurity designed from the beginning. *FY 2021 Plans:* Develop resilient runtime functionality in vehicle electronic components in a security centered databus and Vehicle Integration of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)/Electronic Warfare Interoperability (VICTORY) architecture-compliant security protocols. *FY 2022 Plans:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BI9 *I Vehicle System Security Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Investigate and develop military vehicle resilient runtime hypervisor technology approaches to provide cyber-resiliency to military ground vehicles through the use of virtualized components to spin-up near instant replacements for compromised electronic control unit components. The hypervisor will provide full segmentation between operational and safety-critical vehicle databus messages. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort with the reduction in vehicle integration research.			
Accomplishments/Planned Programs Subtotals	2.829	2.676	2.359

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 53 of 70

R-1 Line #12

Volume 1b - 196

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*							**Project (Number/Name)** BJ2 *I Tactical and Navigation Lasers Sensors 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**
BJ2: *Tactical and Navigation Lasers Sensors Technology*	-	4.785	5.372	5.364	-	5.364	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops novel laser sensor technologies which provide improved maneuver, lethality, and survivability capabilities via manned and autonomous navigation, adversary sensor threat detection, and target detection and designation in all environments. It will deliver novel laser technologies which will provide low Size, Weight, and Power (SWaP) laser sources for optical augmentation detection systems; and compact Laser Detection And Ranging (LADAR) sources for situational awareness and air and ground vehicle operations and navigation in all environments. This Project is a critical enabler for autonomous operations in environments where other imaging technologies are not sufficient.

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 supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV), Soldier Lethality, and Future Vertical Lift (FVL).

Work in this effort is performed by the United States (US) Army Futures Command.

This effort is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology), 0603118A (Soldier Lethality Advanced Technology), 0603465A (Future Vertical Lift Advanced Technology), and 0602143A (Soldier Lethality Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Tactical and Navigation Lasers Sensors Technology	4.785	5.372	5.364
Description: This effort designs and develops novel low SWaP, compact, high peak power pulsed laser sources for optical augmentation detection systems; and compact LADAR sources for situational awareness and manned and unmanned air and ground vehicle operations and navigation in all environments. Effort delivers component technologies needed to support future Army autonomous, covert targeting approaches. *FY 2021 Plans:* Investigate emerging longwave infrared (LWIR) laser sources and integrate with a novel solid state laser in order to achieve a LWIR solution with sufficient power to meet battlefield needs. Design and build brassboard demonstrator for evaluation in a laboratory environment. *FY 2022 Plans:* Will continue development of a brass-board, solid-state longwave infrared (LWIR) laser; mature the components to allow testing in field-relevant environment. Will conduct experiments to evaluate LWIR laser performance, when combined with pulse-detecting			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BJ2 *I Tactical and Navigation Lasers Sensors Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
LWIR detector arrays, to determine effectiveness of detection of relevant threats, 3-dimensional imaging and targeting. Will demonstrate midwave infrared and LWIR pulse detection camera in laboratory environment. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	4.785	5.372	5.364

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 55 of 70

R-1 Line #12

Volume 1b - 198

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*					**Project (Number/Name)** BJ3 *I Hydrogen Based Combat System 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
BJ3: *Hydrogen Based Combat System Technology*	-	1.515	-	-	-	-	-	-	-	-	-	-

Note

In Fiscal Year (FY21) this Project is realigned to:
Program Element (PE) 0602145A Next Generation Combat Vehicle Technology:
* Project BH5 Platform Electrification and Mobility Tech

A. Mission Description and Budget Item Justification

This Project focuses on developing the controls required to integrate multiple fuel cell stacks in order to generate sufficient electrical power for combat systems both for mobility and to enable future lethality, protection, communications and sensor capabilities. This Project also identifies and develops the solutions for generating and moving hydrogen in a battlefield environment, enabling vehicles to take advantage of the efficiencies of fuel cell vehicles.

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

Work in this Project supports the Army Modernization Priority Next Generation Combat Vehicle.

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

This effort is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Hydrogen Based Combat System Technology	1.515	-	-
Description: This effort develops the required fuel cell controls and hydrogen generation technologies required to leverage commercial development in hydrogen based fuel cells to create energy efficient combat and tactical systems.			
Accomplishments/Planned Programs Subtotals	1.515	-	-

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

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 56 of 70

R-1 Line #12

Volume 1b - 199

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army	**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BJ3 *I Hydrogen Based Combat System Technology*

D. Acquisition Strategy

  N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 57 of 70

R-1 Line #12

Volume 1b - 200

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602145A I *Next Generation Combat Vehicle Technology*						**Project (Number/Name)** BJ7 I *Detection of Explosive Hazards 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**
BJ7: *Detection of Explosive Hazards Technology*	-	11.393	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops adaptive, modular sensing technologies for manned and unmanned vehicles with highly specialized emerging artificial intelligence/machine learning tools for the autonomous detection of mines, minefields and improvised explosive devices (IEDs) in high clutter environments as well as technology to defeat near peer mines, minefields and IEDs in all environments. This effort is a critical enabler of future complex breach operations.

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 supports Army Modernization Priority Next Generation Combat Vehicle, and Soldier Lethality.

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this Project is coordinated with PEs 0633462A (Next Generation Combat Vehicle Advanced Technology), 0603118A (Soldier Lethality Advanced Technology), and 0602143A (Soldier Lethality Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Detection of Explosive Hazards Technology	11.393	-	-
Description: This effort focuses on designing and developing novel component technology for detection and defeat of mines, minefields, IEDs and other explosive hazard threats for manned and unmanned vehicles. Artificial intelligence and machine learning tools will be exploited to provide autonomous capabilities and enable increased survivability through greatly increased mine detection standoff ranges.			
Accomplishments/Planned Programs Subtotals	11.393	-	-

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

D. Acquisition Strategy
N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 58 of 70

R-1 Line #12

Volume 1b - 201

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2					**R-1 Program Element (Number/Name)** PE 0602145A / *Next Generation Combat Vehicle Technology*					**Project (Number/Name)** BJ9 / *Autonomous Mobility Tech*		
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**
BJ9: *Autonomous Mobility Tech*	-	2.934	2.407	3.848	-	3.848	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and developsArtificial Intelligence and Machine Learning (AI/ML) technologies to increase autonomy and mobility to perform teamed operations with manned and unmanned air and ground vehicles in a military relevant environment through data collection on relevant platforms. Data collection investigates the usage of both simulation and live data. Simulation will provide a baseline to collect, clean, and analyze data that meets the need for developing algorithms to enable both intelligent formation control and Unmanned Aerial Systems (UAS) map input for unmanned ground vehicle Mobility. This Project will allow proper collection techniques, tools, and data to maximize embedded autonomy using ML and other AI methods before utilizing live data collection. The Project will use AI/ML techniques to develop intelligent formation control to be used on maintained roads and in complex terrain without the need for Global Positioning System. Data will be collected from mounted platforms utilizing special internal and external sensors to develop algorithms for exact positioning, undistributed formation control, and increased speeds of unmanned platforms. Also, the Project will use AI/ML techniques to develop intelligent autonomous ground platform planning through the use of UAS mapped areas. Data collected from the UAS will be converted to maneuverable information for manned ground platform with the identification of enemy positions, go/no-go areas, terrain classification, and optimal suggested paths.

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 supports the Army Modernization Priority Next Generation Combat Vehicle (NGCV).

Work in this effort is performed by the United States (US) Army Futures Command.

This work is coordinated with Program Element (PE) 0603462A (Next Generation Combat Vehicles Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Big Data Storage Techniques	2.891	-	-
Description: This effort develops techniques and technologies for storage of machine learning data sets to be used collaboratively for Army research.			
Title: Unmanned Aerial Vehicle (UAV) Mapping	0.043	-	-
Description: Develop a collaboration of UAV map input for ground vehicle mobility via artificial intelligence and machine learning.			
Title: Formation Control ? Novel Technique Investigation	-	2.407	3.848

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 59 of 70

R-1 Line #12

Volume 1b - 202

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BJ9 *I Autonomous Mobility Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort focuses on performing the applied research needed to investigate cutting edge ML techniques to be used for advanced collaborative movement. Areas of investigation here look to advance the utility of ML mobility beyond the current, widely utilized algorithms to allow for more natural coordination of autonomous vehicles and Soldiers. *FY 2021 Plans:* Perform thorough survey of cutting edge ML techniques, investigate the algorithms that apply to formation control, and conduct experiments to determine applicability to NGCV. *FY 2022 Plans:* Will improve and mature algorithms developed in FY21 that apply to formation control for autonomous maneuver in operationally relevant environments. Will conduct experiments to determine how well the ML data infrastructure and data sets support the autonomous system development and determine the applicability to NGCV. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort with increased experimentation on the data infrastructure support for autonomous systems.			
Accomplishments/Planned Programs Subtotals	2.934	2.407	3.848

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 60 of 70

R-1 Line #12

Volume 1b - 203

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 / 2				R-1 Program Element (Number/Name) PE 0602145A / Next Generation Combat Vehicle Technology						Project (Number/Name) BK2 / Virtual Prototyping 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
BK2: Virtual Prototyping Technology	-	5.203	8.295	8.169	-	8.169	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project matures an integrated Virtual Prototyping capability that investigates Next Generation Combat Vehicle (NGCV) technology integration into a range of novel ground vehicle design concepts that will be analyzed and evaluated through virtual experimentation to provide engineering data and operational feedback to inform NGCV analysis and requirements. Designs and analyzes novel NGCV system level ground vehicle concepts by integrating advanced mobility, survivability, lethality, sensing and electrical/electronic technologies to address emerging and future advanced threats. This Project provides system level ground vehicle design concepts and performance analysis, assesses cost and performance trades, and provides real-time soldier feedback on technology performance for the Army's NGCVs. Technologies to be evaluated include high efficiency advanced powertrains, power generation, active protection systems, active blast, advanced lethality and robotic control and autonomy technologies. The NGCV virtual experiments provide an efficient means to give warfighters an up-front, virtual hands-on operational evaluation of next generation ground vehicle concepts and emerging technologies. The Virtual Prototyping results provide critical inputs to the Army's NGCV program by providing independent technical and operational performance results, as well as assessing trades for the Army's next generation of ground combat vehicles.

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

Work in this Project supports the Army Modernization Priority NGCV.

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this Project is coordinated with PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Virtual Prototyping	5.203	8.295	8.169
Description: This effort addresses technical and integration challenges in the areas of mobility, survivability, lethality, vehicle architecture, and systems integration for the Army's next generation of ground combat vehicles. Specifically, this effort focuses on developing integrated design concepts, performance analysis, identifying and assessing trade space, and conducting virtual operational experiments for the NGCV. The combination of technical performance and operational feedback provides insights			
FY 2021 Plans: Design and develop new NGCV manned and unmanned ground vehicle concepts. Integrate new advanced technology components such as lethality and protection systems in a virtual environment. Conduct analyses, trade studies, and Soldier-in-the-loop virtual experiments to provide Warfighter feedback on design concepts and inform NGCV performance and suggest			

PE 0602145A: Next Generation Combat Vehicle Technolog...
Army

UNCLASSIFIED
Page 61 of 70

R-1 Line #12

Volume 1b - 204

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BK2 *I Virtual Prototyping Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
design paths to improve performance. Partner with industry to generate additional NGCV ground vehicle design concepts to expand the investigation of enabling technologies and performance for NGCV. ***FY 2022 Plans:*** Will use modeling and simulation to virtually design, develop, and assess new Next Generation Combat Vehicle (NGCV) manned and unmanned systems that include projected far term lethality, mobility, sensing, and protection technologies. Will integrate these technologies into multiple optionally manned tank (OMT) and heavy robotic combat vehicle (RCV-H) trade analyses and NGCV requirements. Will use knowledge and analyses for investments and inform NGCV acquisition planning. Will implement a public private partnership with industry to generate additional OMT vehicle design concepts to expand the knowledge of enabling technologies, obtain innovative design approaches, and provide additional data analyses for multiple NGCV efforts. Will conduct Soldier-in-the-loop feedback to assess the government and industry OMT concepts for mission performance, Soldier OMT Tactics, Techniques, and Procedures (TTPs) for the new technologies and capabilities. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	5.203	8.295	8.169

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army
UNCLASSIFIED
Page 62 of 70
R-1 Line #12
Volume 1b - 205

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602145A I Next Generation Combat Vehicle Technology						Project (Number/Name) BK3 I Next Gen Intelligent Fire Control (NG-IFC) Tech		
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
BK3: *Next Gen Intelligent Fire Control (NG-IFC) Tech*	-	1.007	4.043	0.987	-	0.987	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project will develop armament specific hardware, algorithms and architectures to support Next Generation Combat Vehicle (NGCV) with the necessary fire control on future manned and unmanned platforms.

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 supports the Army Modernization Priority NGCV.

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this Project is related to and fully integrated with the efforts funded in PE 0603462A (Next Generation Combat Vehicle Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Next Generation Intelligent Fire Control Technology	1.007	4.043	0.987
Description: This effort investigates image sets for computer vision algorithms, target acquisition validation schemes and experimentation of large caliber armament systems. *FY 2021 Plans:* Validate fire control system components and algorithms for implementing machine learning training; develop new algorithms and models to generate and validate prioritized target lists using documented battlefield metrics; and conduct experiments to collect fire control scenario data to support algorithm/model training and development. *FY 2022 Plans:* Will investigate various machine learning methods to process and prioritize target sets in a dynamic battlefield based on evolving mission objectives. Will conduct experiments to inform future fire control development, validation schemes, and evaluate platform components. *FY 2021 to FY 2022 Increase/Decrease Statement:* Reduction in funding reflects planned reduction of validation and experimentation efforts.			
Accomplishments/Planned Programs Subtotals	1.007	4.043	0.987

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BK3 *I Next Gen Intelligent Fire Control (NG-IFC) Tech*
C. Other Program Funding Summary ($ in Millions) N/A **Remarks** **D. Acquisition Strategy** N/A		

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 64 of 70

R-1 Line #12

Volume 1b - 207

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*						**Project (Number/Name)** BK5 *I Adv Direct In-Direct Armament Sys (ADIDAS) Tech*	
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**
BK5: *Adv Direct In-Direct Armament Sys (ADIDAS) Tech*	-	1.141	3.814	9.180	-	9.180	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project matures and conducts experiments on component technologies for large caliber direct fire light-weight armament systems that will exceed the current capability of 120mm direct fire and be optimized for future operational environment with cross-domain engagement capability. This Project also researches large caliber direct fire munitions to project overwhelming lethality while ensuring maneuver forces remains mobile and sustainable during close-combat engagements at extended ranges.

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 supports the Army Modernization Priority Next Generation Combat Vehicle.

Work in this effort is performed by the United States (US) Army Futures Command.

Work in this Project is related to and fully integrated with the efforts funded in PE 0603462A (Next Generation Combat Vehicle Advanced Technology) and PE 0602141A (Lethality Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advanced Direct In-Direct Armament System Technology	1.141	-	-
Description: This effort designs and develops technologies for large caliber direct fire light-weight armament systems that will exceed the current capability of 120mm direct fire cannons and be optimized for future operational environment, including dense urban, with cross-domain engagement capability. Specifically, this effort matures technologies for rapid fire on-the-move at all elevations (direct & indirect), compact ammunition design with advanced ignition, advanced recoil mitigation to reduce impulse and automated ammunition handling and reloading.			
Title: Advanced Lethality ? Kinetic Energy (AL-KE)	-	1.432	1.443
Description: This effort designs and develops component technologies for large caliber direct fire light-weight armament systems that will exceed the current 120mm direct fire cannon performance for future operational environments, including dense urban, with multi -domain engagement capability. The component technologies that support rapid fire on-the-move (direct & indirect) engagements include: compact ammunition design with advanced ignition, reduced gun impulse on platform through advanced recoil mitigation techniques, fire control and automated ammunition handling and reloading.			

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 65 of 70

R-1 Line #12

Volume 1b - 208

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BK5 *I Adv Direct In-Direct Armament Sys (ADIDAS) Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2021 Plans: Investigate range-extending technologies for direct fire kinetic energy ammunition with increased propulsion efficiency; Design and develop direct fire kinetic energy cartridge technologies to defeat future threats to ground vehicle systems. ***FY 2022 Plans:*** Will investigate technologies to improve kinetic energy delivery at extended ranges to increase engagement distance and decrease engagement time, including work to investigate sensor fusion, real time processing and penetrator diversion techniques. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort			
Title: NGCV Penetrator Technology for Decisive Lethality ***Description:*** This effort develops energy-efficient lethal mechanism technologies for next-generation warheads and projectiles for large-caliber ammunition launched from direct fire weapon systems that maximize the lethality against an array of targets and provide tactical advantage at extended ranges for next generation threats. The results of this research will provide the basis for the lethality required for the next generation of combat vehicles and enable the development of the next generation of ammunition to ensure lethal overmatch throughout the operational environment. ***FY 2021 Plans:*** Develop kinetic energy penetrator concepts for next generation armament systems to enable decisive lethality capabilities for the next generation of combat vehicles including tanks and unmanned platforms. ***FY 2022 Plans:*** Will explore suitability of higher energy launchers for next generation armament systems; continue to identify and develop promising kinetic energy penetrator concepts to enable decisive lethality capabilities for the next generation of combat vehicles. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase to support additional research in kinetic energy penetrator concepts in order to support Next Generation Combat Vehicle modernization priority goals.	-	2.382	3.086
Title: Advanced Lethality Armament System? Large Caliber (ALAS-LC) ***Description:*** Investigate increased lethality solutions for next generation large caliber direct fire armament systems that will ensure battlefield dominance of US ground forces. Design reduced recoil armament systems capable of increased rate of fire enabled by a compact autoloader with performance that exceeds current state of the art 120mm direct fire cannons for current and future Army platforms.	-	-	4.651

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BK5 *I Adv Direct In-Direct Armament Sys (ADIDAS) Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2022 Plans: Will investigate technologies for large caliber direct fire light-weight armament systems that exceed the performance of 120mm direct fire cannons. Will investigate technologies for rapid fire, on-the-move, compact ammunition design, accuracy and advanced recoil mitigation supporting future Army platforms. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY22, this is a planned new effort under the Project for development of next generation large caliber armament systems technologies in order to support Next Generation Combat Vehicle modernization priority goals.			
Accomplishments/Planned Programs Subtotals	1.141	3.814	9.180

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* 2				**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*				**Project (Number/Name)** BP5 *I Ground Vehicle Technology (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
BP5: *Ground Vehicle Technology (CA)*	-	44.500	43.000	-	-	-	-	-	-	-	-	-

Note
Congressional Interest Item funding provided for Ground Vehicle Technology.

A. Mission Description and Budget Item Justification
Congressional Interest Item funding provided for Ground Vehicle Technology.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Congressional Add: Prototyping Energy Smart Autonomous Ground Systems	10.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Prototyping Energy Smart Autonomous Ground Systems. Work executed by Army Futures Command.		
Congressional Add: Highly Electrified Vehicles	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Highly Electrified Vehicles. Work executed by Army Futures Command.		
Congressional Add: Additive Metals Manufacturing	3.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Additive Metals Manufacturing. Work executed by Army Futures Command.		
Congressional Add: RPG and IED Protection	3.000	-
FY 2020 Accomplishments: Program Increase supported applied research on RPG and IED Protection. Work executed by Army Futures Command.		
Congressional Add: Modeling and Simulation	3.000	-

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 68 of 70

R-1 Line #12

Volume 1b - 211

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BP5 *I Ground Vehicle Technology (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
FY 2020 Accomplishments: Program Increase supported applied research on Modeling and Simulation. Work executed by Army Futures Command.		
Congressional Add: Structural Thermoplastics	3.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Structural Thermoplastics. Work executed by Army Futures Command.		
Congressional Add: Advanced Materials Development for Survivability	10.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Advanced Materials Development for Survivability. Work executed by Army Futures Command.		
Congressional Add: Autonomous Vehicle Mobility	7.500	-
FY 2020 Accomplishments: Program Increase supported applied research on Autonomous Vehicle Mobility. Work executed by Army Futures Command.		
Congressional Add: Program increase - modeling and simulation	-	10.000
FY 2021 Plans: Conduct applied research in Modeling and Simulation. Work executed by Army Futures Command.		
Congressional Add: Program increase - silicon carbide electronics	-	6.000
FY 2021 Plans: Conduct applied research in Silicon Carbide Electronics. Work executed by Army Futures Command.		
Congressional Add: Program increase - highly electrified vehicles	-	5.000
FY 2021 Plans: Conduct applied research in Highly Electrified Vehicles. Work executed by Army Futures Command.		
Congressional Add: Program increase - additive metals manufacturing	-	10.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602145A *I Next Generation Combat Vehicle Technology*	**Project (Number/Name)** BP5 *I Ground Vehicle Technology (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
FY 2021 Plans: Conduct applied research in Additive Metals Manufacturing. Work executed by Army Futures Command.		
Congressional Add: Program increase - prototyping energy smart autonomous ground systems	-	12.000
FY 2021 Plans: Conduct applied research in Prototyping Energy Smart Autonomous Ground Systems. Work executed by Army Futures Command.		
Congressional Adds Subtotals	44.500	43.000

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

D. Acquisition Strategy
 N/A

PE 0602145A: *Next Generation Combat Vehicle Technolog...*
Army

UNCLASSIFIED
Page 70 of 70

R-1 Line #12

Volume 1b - 213

Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602146A / *Network C3I 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
Total Program Element	-	133.804	202.257	84.606	-	84.606	-	-	-	-	-	-
AM6: *Modular RF Communications Technology*	-	3.748	3.810	-	-	-	-	-	-	-	-	-
AM8: *Protected SATCOM Technology*	-	9.205	4.813	1.745	-	1.745	-	-	-	-	-	-
AN3: *Non Traditional Waveforms Technology*	-	3.155	-	0.492	-	0.492	-	-	-	-	-	-
AN5: *Protected SATCOM-WB Global SATCOM Inter Canc Tech*	-	0.384	-	-	-	-	-	-	-	-	-	-
AN7: *COE - Every Receiver is a Sensor Technology*	-	2.881	2.976	2.492	-	2.492	-	-	-	-	-	-
AN9: *UNT - Every Receiver is a Sensor Technology*	-	3.692	1.925	1.963	-	1.963	-	-	-	-	-	-
AO2: *Stand-In Advanced RF Effects (STARE)*	-	7.195	4.223	2.006	-	2.006	-	-	-	-	-	-
AO4: *Energy Efficient Devices Technology*	-	5.190	5.454	5.710	-	5.710	-	-	-	-	-	-
AO5: *Tag Track and Locate Small Satellites Technology*	-	4.267	3.737	-	-	-	-	-	-	-	-	-
AP4: *CEMA Camouflage Technology*	-	9.316	9.559	-	-	-	-	-	-	-	-	-
AP5: *Electronic Warfare Technology*	-	2.707	2.878	2.928	-	2.928	-	-	-	-	-	-
AP7: *Comms/Horiz Int for Army Mod Priorities Tech*	-	0.479	2.914	-	-	-	-	-	-	-	-	-
AQ2: *EW Techniques Technology*	-	-	0.482	0.494	-	0.494	-	-	-	-	-	-
AQ7: *High Tempo Data Driven Decision Tools Technology*	-	-	2.701	-	-	-	-	-	-	-	-	-

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*							
AQ9: *Expeditionary Data to Decisions Technology*	-	1.918	2.760	-	-	-	-	-	-	-	-	-
AR1: *Robust, Resilient and Intelligent C3I Technology*	-	8.342	13.600	10.510	-	10.510	-	-	-	-	-	-
AR3: *Intelligent Environmental Battlefield Awareness*	-	-	2.897	3.059	-	3.059	-	-	-	-	-	-
AR5: *Understanding the Environment as a Threat Technolo*	-	3.872	2.246	1.956	-	1.956	-	-	-	-	-	-
AR7: *Sensing in Contested Environments Technology*	-	-	1.820	1.192	-	1.192	-	-	-	-	-	-
AR9: *Persistent Geophysical Sensing-Infrasound Tech*	-	3.898	3.035	3.414	-	3.414	-	-	-	-	-	-
AT2: *Subterranean Detection and Monitoring Technology*	-	1.534	2.791	-	-	-	-	-	-	-	-	-
AT7: *Network-Enabled GeoSpatial-GEOINT Services Tech*	-	2.869	3.855	4.635	-	4.635	-	-	-	-	-	-
AT9: *Tactical GeoSpatial Information Capabilities Techn*	-	2.657	4.085	1.776	-	1.776	-	-	-	-	-	-
AU3: *Geospatially Enabled Operational Design Technology*	-	3.166	1.413	-	-	-	-	-	-	-	-	-
AU5: *Automated Analytics for Operational Environment*	-	3.932	-	-	-	-	-	-	-	-	-	-
AV3: *Foundational S&T for Network C3I Technology*	-	-	1.927	4.657	-	4.657	-	-	-	-	-	-
AV5: *Protective Technologies*	-	6.520	7.411	7.549	-	7.549	-	-	-	-	-	-
AV6: *Airborne Engineering Support Technology*	-	0.846	0.866	-	-	-	-	-	-	-	-	-
AV7: *Atmospheric Modeling and Meterological Technology*	-	5.573	5.918	5.931	-	5.931	-	-	-	-	-	-

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 2 of 86

R-1 Line #13

Volume 1b - 215

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*						
AV9: *Advanced PNT for GPS Independent Environments Tech*	-	6.687	6.656	10.129	-	10.129	-	-	-	-	-	-
AW1: *Autonomous Navigation Technology*	-	0.384	1.732	2.080	-	2.080	-	-	-	-	-	-
AW3: *DoD PNT M&S Collaborative Initiative (CI) Technolo*	-	1.918	1.925	-	-	-	-	-	-	-	-	-
AW5: *Modular GPS Independent Sensors Technology*	-	3.969	-	-	-	-	-	-	-	-	-	-
BP2: *Sensor and Electronic Network Initiatives (CA)*	-	23.500	90.500	-	-	-	-	-	-	-	-	-
BZ6: *Narrowband SATCOM Technology*	-	-	0.963	-	-	-	-	-	-	-	-	-
BZ8: *Aerial Teir Networking (High Altitude)*	-	-	0.385	-	-	-	-	-	-	-	-	-
CG3: *Assured PNT Communications Applied Research*	-	-	-	1.726	-	1.726	-	-	-	-	-	-
CI3: *Mobile and Survivable Command Post (MASCP) Tech*	-	-	-	6.236	-	6.236	-	-	-	-	-	-
CK1: *Assured PNT Enabling Technologies*	-	-	-	1.926	-	1.926	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This PE investigates technologies, techniques, components and tools to provide an Army tactical network and enabling infrastructure that support operations in any environment, to include where the electromagnetic spectrum is denied or degraded. This is accomplished through the design, and development of technologies and components (e.g., electronic components, software and protocols) that provide unified transport and are supportable, mobile and survivable; assured and secure positioning, navigation, and timing in all environments; converged and coordinated cyber and electronic warfare activities; resilient mission command on the move; and the collection, processing, and dissemination of information for intelligence, surveillance, and reconnaissance. Commercial technologies are continuously investigated and leveraged where possible.

Work in this PE complements PE 0602143A (Soldier Lethality Technology), PE 0602145A (Next Generation Combat Vehicle Technology), PE 0602147A (Long Range Precision Fires Technology), PE 0602148A (Future Vertical Lift Technology), PE 0602150A (Air and Missile Defense Technology), PE 0603118A (Soldier Lethalty

PE 0602146A: *Network C3I Technology*
Army
UNCLASSIFIED
Page 3 of 86
R-1 Line #13
Volume 1b - 216

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	

Advanced Technology), PE 0603462A (Next Generation Combat Vehicle Advanced Technology), PE 0603464A (Long Range Precision Fires Advanced Technology), PE 0603465A (Future Vertical Lift Advanced Technology), PE 0603466A (Air and Missile Defense Advanced Technology), PE 0603463A (Network C3I Advanced Technology).

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

Work is performed by the United States Army Futures Command, the United States Army Space and Missile Defense Command and the Army Engineer Research and Development Center.

B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	138.016	114.404	100.565	-	100.565
Current President's Budget	133.804	202.257	84.606	-	84.606
Total Adjustments	-4.212	87.853	-15.959	-	-15.959
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	90.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-4.212	-2.647			
• Adjustments to Budget Years	-	-	-15.959	-	-15.959

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Project: BP2: *Sensor and Electronic Network Initiatives (CA)*		
Congressional Add: *Small Satellite Technology*	3.000	-
Congressional Add: *Radioisotope Power Systems*	2.500	-
Congressional Add: *Anti-Tamper Technology Development*	10.000	-
Congressional Add: *Next Generation Synthetic Aperture*	5.500	-
Congressional Add: *Sensing Technologies for Rapid Hazard Detection*	2.500	-
Congressional Add: *Program increase - inertial navigation systems*	-	10.000
Congressional Add: *Program increase - APNT for autonomous vehicles*	-	5.000
Congressional Add: *Program increase - CHARM*	-	5.000
Congressional Add: *Program increase - energy efficient devices*	-	5.000

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 4 of 86

R-1 Line #13

Volume 1b - 217

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 2: *Applied Research*			**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Congressional Add: *Program increase - integrating energy and computing networks*	-	10.000
Congressional Add: *Program increase - artificial intelligence and machine learning electronic warfare sensor technology*	-	10.000
Congressional Add: *Program increase - APNT distributed antennae*	-	20.000
Congressional Add: *Program increase: Urban subterranean mapping technology*	-	4.000
Congressional Add: *Program increase: Unmanned sensors for biological and chemical hazards*	-	2.000
Congressional Add: *Program increase: Mobile environmental contaminant sensors*	-	8.000
Congressional Add: *Program increase: Multi?UAS integrated ISR technology*	-	3.000
Congressional Add: *Program increase: Autonomous platform threat detection sensors*	-	6.000
Congressional Add: *Program increase: Intelligent electronic protection technology*	-	2.500
Congressional Add Subtotals for Project: BP2	23.500	90.500
Congressional Add Totals for all Projects	23.500	90.500

Change Summary Explanation

FY2022 funding change due to a partial administrative realignment towards Program Element 0602182A (C3I Applied Research) for better alignment to the mid- to far term priorities of the Network portfolio.

$2.250 million of FY222 will be realigned to APE 622146AV3 from APE GA0750000, Abrams Upgrade Program.

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AM6 *I Modular RF Communications 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**
AM6: *Modular RF Communications Technology*	-	3.748	3.810	-	-	-	-	-	-	-	-	-

Note
 This project is terminated in Fiscal Year (FY) 2022.

A. Mission Description and Budget Item Justification

 This Project investigates and develops techniques, methods, and standards for automation and intelligence to optimally broadcast data among available radio frequency (RF) and networking technologies. This Project adds resiliency to the network through diversity and automation techniques to make automated network decisions (e.g., automated Primary, Alternate, Contingency, and Emergency (PACE)) for the tactical Army to maintain operation in continually changing environments.

 Work in this Project complements PE 0603463A Network C3I Advanced Technology Project AM7 (Modular RF Communications Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Modular Radio Frequency Communications Technology *Description:* This effort investigates and develops techniques, methods, and standards for automation and intelligence to optimally route data among available radio frequency and networking technologies. This effort adds resiliency to the network through diversity and automation techniques to make automated network decisions, (e.g., automated PACE) for the tactical Army to maintain operation in continually changing environments. *FY 2021 Plans:* Investigate techniques based on Artificial Intelligence (AI) and Machine Learning (ML) to sense anomalies and degradation due to contested and congested Radio Frequency (RF) environments, predict the cause based on trained ML models, and coordinate across the network to recommend successful mitigation actions/procedures; research applicability of these techniques in a distributed, resource constrained tactical edge where computing resources are limited, communication pipes are narrow, connectivity is intermittent, and power is restricted due to size and weight of the battery; and determine distributed computing	3.748	3.810	-

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 6 of 86

R-1 Line #13

Volume 1b - 219

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AM6 *I Modular RF Communications Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
techniques to process, reduce, and fuse data at the tactical edge enabling local actions and reduction in load on the bandwidth constrained, intermittently connected networks. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort ends in FY21.			
Accomplishments/Planned Programs Subtotals	3.748	3.810	-

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 2				R-1 Program Element (Number/Name) PE 0602146A I Network C3I Technology						Project (Number/Name) AM8 I Protected SATCOM 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
AM8: *Protected SATCOM Technology*	-	9.205	4.813	1.745	-	1.745	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates resiliency of Wideband Satellite Communications (SATCOM) in contested and congested electromagnetic environments. Wideband SATCOM is the primary high-bandwidth Beyond Line of Sight (BLOS) communications used by the tactical Army. This Project designs and develops technologies and components, such as interference cancellation, to increase availability and reliability of Wideband SATCOM in spectrum-challenged environments.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) AM9 (Protected SATCOM Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Protected Satellite Communication Technology	9.205	4.813	1.745
Description: This effort designs and develops technologies and components to increase resiliency of Wideband SATCOM in contested and congested electromagnetic environments. This effort develops resiliency through science and technology investigation. *FY 2021 Plans:* Develop satellite communications technology that automatically adapts to constantly changing, congested, and contested environments; conduct experiments to refine the baseline for future research of intelligent and diverse satellite communications (i.e., systems that automatically adapt and mitigate network problems); and investigate technology to mature components that support the control of the Army satellite networks in a contested environment. *FY 2022 Plans:* Will investigate and design adaptive digital interference cancellation technology that adapts to changing contested environments for advanced fast moving waveforms, to improve satellite communications throughput. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort transitions to PE 0603463A (Network C3I Advanced Technology), Project AM9 (Protected SATCOM Advanced Technology) in FY 2022. The remaining balance supports stated FY 2022 Plans.			
Accomplishments/Planned Programs Subtotals	9.205	4.813	1.745

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 8 of 86

R-1 Line #13

Volume 1b - 221

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AM8 *I Protected SATCOM Technology*
C. Other Program Funding Summary ($ in Millions) N/A **Remarks** **D. Acquisition Strategy** N/A		

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 9 of 86

R-1 Line #13

Volume 1b - 222

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 / 2					**R-1 Program Element (Number/Name)** PE 0602146A / Network C3I Technology				**Project (Number/Name)** AN3 / Non Traditional Waveforms 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
AN3: *Non Traditional Waveforms Technology*	-	3.155	-	0.492	-	0.492	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funds realigned from:
PE 0603463A Projects AM9 (Protected SATCOM Advanced Technology), and BZ8 (Aerial Tier Networking (High Altitude).

A. Mission Description and Budget Item Justification

This Project investigates non-traditional protocols and technologies to provide spectrum efficiency, high bandwidth, low latency, lower spectrum footprint, or anti-jam capabilities to tactical networks. This Project develops network resiliency for the dismounted and vehicular units through science & technology investigation.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) / Project AN4 (Non Traditional Waveforms Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Non Traditional Waveforms Technology **Description:** This effort investigates non-traditional protocols and technologies to provide spectrum efficiency, high bandwidth, lower spectrum footprint, anti-jam capabilities to tactical networks. This effort develops network resiliency for the dismounted and vehicular units through science & technology investigation.	3.155	-	-
Title: 5G Technologies **Description:** This effort investigates the use of 5G communication services and associated technologies to support high bandwidth, low latency communications for tactical environments with mobile infrastructures. **FY 2022 Plans:** Will investigate the use of software-defined networking and virtualization techniques for the development of a modular networks architecture using techniques, such as distributed 5G; develop methods for device-to-device communications to minimize required	-	-	0.492

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 10 of 86

R-1 Line #13

Volume 1b - 223

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AN3 *I Non Traditional Waveforms Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
infrastructure; and examine methods to improve low probability of intercept (LPI), low probability of detection (LPD), counter-geolocation, and anti-jam (AJ) performance of technologies, such as 5G cellular.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding in this effort was realigned from PE 0603463A Projects AM9 (Protected SATCOM Advanced Technology), and BZ8 (Aerial Tier Networking (High Altitude).			
Accomplishments/Planned Programs Subtotals	3.155	-	0.492

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 11 of 86

R-1 Line #13

Volume 1b - 224

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AN5 *I Protected SATCOM-WB Global SATCOM Inter Canc Tech*		
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**
AN5: *Protected SATCOM-WB Global SATCOM Inter Canc Tech*	-	0.384	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops interference cancellation technologies to allow uninterrupted and resilient communications over the Wideband Global Satellite constellation when operating in proximity to enemy threats.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) / Project AN6 (Prot SATCOM-WB Global SATCOM Interference Canc Adv Tech).

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: Protected Satellite Communication ? Wide Band Global Satellite Communication Interference Cancellation Technology **Description:** This effort develops interference cancellation technologies to allow uninterrupted and resilient communications over the Wideband Global Satellite constellation when operating in proximity to enemy threats.	0.384	-	-
Accomplishments/Planned Programs Subtotals	0.384	-	-

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 12 of 86

R-1 Line #13

Volume 1b - 225

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*				**Project (Number/Name)** AN7 *I COE - Every Receiver is a Sensor 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
AN7: *COE - Every Receiver is a Sensor Technology*	-	2.881	2.976	2.492	-	2.492	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates, designs, and codes advanced automated exploitation and fusion analysis tools, applications, and software services that harvest, correlate and fuse tactical receiver sources with new and emerging data sources to improve understanding of the threat picture and more efficiently support near-real time Situational Understanding of the battlefield.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) \ Project AN8 (COE - Every Receiver is a Sensor Advanced Tech) and PE 0602146A (Network C3I Technology) \ Project AN9 (UNT - Every Receiver is a Sensor Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Data Analytics for Situational Awareness ***Description:*** This effort investigates and designs spectrum sensing, electronic sensing and intelligence collection technologies and analytics to enhance overall situational understanding within a contested battlespace. Efforts focus on developing the analytics necessary to taking advantage of the expanding number of data sources available by leveraging existing tactical receivers and other tactical data feeds. ***FY 2021 Plans:*** Extend techniques to support fires and intelligence warfighting functions; develop target nomination mechanisms; and identify data to push forward to support the targeting process and inform Intelligence Preparation of the Battlefield and update enemy Common Operating Picture tools. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned conclusion lifecycle of this effort.	2.881	2.976	-
Title: Intelligence Surveillance and Recognizance (ISR) Optimization for MDO Support Technology ***Description:*** This effort investigates and designs Intelligence Surveillance and Recognizance (ISR) collection management technologies and analytics to enhance performance and optimize use of Army ISR resources during multi-domain operations (MDO). Efforts focus on developing the analytics necessary to increase situational awareness of non-organic collections across	-	-	2.492

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AN7 *I COE - Every Receiver is a Sensor Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
all domains (Air, Land, Maritime, Space, Cyber and Electromagnetic spectrum), determine highest payoff use of tactical ISR assets, and optimize sensor selection and placement to answer unit intelligence requirements. *FY 2022 Plans:* Will investigate threat forecasting technologies needed to drive prioritization of ISR collections based on unit intelligence requirements and threat tactics, techniques, and procedures (TTPs); research sensor performance models necessary to predict sensor performance in real-world environments. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned initiation lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	2.881	2.976	2.492

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 14 of 86

R-1 Line #13

Volume 1b - 227

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

Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602146A I Network C3I Technology	Project (Number/Name) AN9 I UNT - Every Receiver is a Sensor 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
AN9: UNT - Every Receiver is a Sensor Technology	-	3.692	1.925	1.963	-	1.963	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops the algorithms to enable every communication receiver in the tactical environment to operate as a sensor while maintaining the systems' original networking capability. This Project matures standards and protocols to expand the Cyber-Electromagnetic Activity (CEMA) situational understanding.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AO1 (UNT - Every Receiver is a Sensor Advanced Tech) and PE 0602146A (Network C3I Technology) \ Project AN7 (COE - Every Receiver is a Sensor Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Unified Network Technology (UNT) - Every Receiver is a Sensor Technology	1.763	-	-
Description: This effort develops software algorithms to enable commercial communications transceivers to operate in the tactical environment as Beyond Line of Sight communications while maintaining the systems' original networking capability.			
Title: Multi Intelligence Modernization Components and Architecture	1.929	1.925	1.963
Description: This effort investigates underlying architectures for dynamic resource management and technology underpinnings for advanced signal processing, exploitation, and novel sensor hardening to better understand our ability to detect, intercept, identify, and geo-locate radiated radio frequency (RF) energy to command our use of the electromagnetic spectrum while denying its use to our adversaries. **FY 2021 Plans:** Investigate dynamic resource management and technologies for advanced signal processing, conduct laboratory experiments of advanced multi-function capabilities exploiting RF emissions for adversaries; investigate high altitude, long range sensing to augment national surveillance assets bringing situational awareness and understanding to the tactical edge. **FY 2022 Plans:**			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AN9 *I UNT - Every Receiver is a Sensor Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will investigate high altitude, long, stand-off range Electronic Warfare capabilities to bring situational awareness and understanding to the tactical edge; and conduct laboratory experiments on advanced signal processing and antenna designs for use from high altitude, long-endurance platforms. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	3.692	1.925	1.963

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 16 of 86

R-1 Line #13

Volume 1b - 229

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602146A I *Network C3I Technology*					**Project (Number/Name)** AO2 I *Stand-In Advanced RF Effects (STARE)*		

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
AO2: *Stand-In Advanced RF Effects (STARE)*	-	7.195	4.223	2.006	-	2.006	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates distributed and synchronized electronic warfare (EW) techniques and applications for future distributed Army operations in complex environments, designs algorithms for synchronization, and investigates stable radio frequency transceivers and techniques for information distribution across dynamic channels.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AO3 (Stand-In Advanced RF Effects (STARE) Adv Tech).

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: STAND-IN Advanced RF Effects (STARE) *Description:* This effort investigates emerging technologies to enable EW applications in a grey environment. The goal is to develop software and reconfigurable radio frequency (RF) hardware in a low size, weight, and power form factor for distributed EW and communications. *FY 2021 Plans:* Investigate hardware limitations and mature component level technologies to improve stability within synchronized EW applications, this includes RF and signal processing hardware; research complex threat signal use cases with synchronized EW applications to determine additional limitations and further improvements for stability; and identify miniaturization strategies for motion- enabled reconfigurable circuits and tunable microelectromechanical systems components suitable for handheld, wide-bandwidth, adaptable EW applications. *FY 2022 Plans:* Will investigate hardware limitations at extremely high frequencies; design and develop a stable transceiver architecture with optimal component technologies; research scalable synchronization techniques for phase/clock/channel alignment between RF transceivers agnostic of use case; conduct RF transceiver synchronization experiments to explore the bounds of coherent multi-aperture beam forming; and investigate reconfigurable transceiver hardware to enable a widely-applicable architecture. *FY 2021 to FY 2022 Increase/Decrease Statement:*	1.886	1.925	2.006

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AO2 *I Stand-In Advanced RF Effects (STARE)*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding change reflects planned lifecycle of this effort.			
Title: Grey C3I Communications Technology	2.915	-	-
Description: This effort investigates techniques for secure transmission across network transport links and designs networking communications with low probability of detection and intercept technologies.			
Title: Grey C3 Exploitation Technology	2.394	2.298	-
Description: This effort investigates distributed EW techniques for grey-zone operations and designs algorithms for sparse detection and EW. *FY 2021 Plans:* Design and develop precise synchronization hardware technologies for EW systems to significantly improve the effectiveness of countermeasures against adversarial threats; conduct experiments in laboratory environments to validate synchronization limitations; and validate initial countermeasures on distributed sources. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort ends in FY21.			
Accomplishments/Planned Programs Subtotals	7.195	4.223	2.006

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 18 of 86

R-1 Line #13

Volume 1b - 231

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*				**Project (Number/Name)** AO4 *I Energy Efficient Devices 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**
AO4: *Energy Efficient Devices Technology*	-	5.190	5.454	5.710	-	5.710	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project addresses sustainment operations by unburdening the Soldier and reducing logistics requirements (e.g., fewer batteries) for communications, computing, and sensing. The objective is to improve the underlying energy efficiency of supply and demand for Soldier-portable and distributed sensor electronics to enable the dismounted Soldier to maintain communications, freedom of movement, and increase mission duration. The majority of the electronics power used by the dismounted Soldier and by distributed electronics is attributable to radio frequency (RF) communications. In addition, freedom of movement and action during sustained and high tempo operations requires seamless battery recharging. To address these challenges, energy efficient electronics research includes RF and optoelectronic circuits, devices, materials and wireless power (and data) transfer.

Work in this Project complements/supports PE 0602146A (Network C3I Technology) Project AN3 (Non Traditional Waveforms Technology), PE 0602143A (Soldier Lethality Technology) Project BD8 (Soldier and Small Unit Tactical Energy Independence Technology), PE 0601102A (Defense Research Sciences) Project AA9 (Information and Networking).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Energy Efficient Electronic and Photonic Components	5.190	5.454	5.710

Description: This effort investigates energy efficiency improvements in support of four key areas: radio frequency (RF) component devices, optoelectronic devices for alternative communications modes, long-lived and high efficiency power sources, and efficient wireless power and data transfer technologies. These components enable energy-efficient communications and networked energy, specifically leading to increased Soldier mission duration and long-lived networked electronics.

FY 2021 Plans:
Investigate and optimize the interplay between insulator materials to determine if transistor action provides significant power savings as theoretically predicted; investigate radiation tolerance of wide-band-gap semiconductors and compare to material dependent displacement energy, atomic number, bond strength, and lattice constant; develop optimized energy conversion semiconductor structures delivering 1mW power; understand and develop new materials for fast charge anodes with the objective to develop a material that can be scaled; explore chemistries to support fast charge batteries and investigate new electrolytes and additives to stabilize lithium plated on graphite; and study and develop RF component technologies, such as high efficiency materials, circuits, and neural network hardware for improved squad level communication efficiency.

FY 2022 Plans:
Will determine and resolve scale-up issues with fast charge anode materials; investigate tradeoffs in energy and rate capability for ultrafast charge graphite cells with high energy cathodes; explore additives and electrode coating techniques and improve power

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 19 of 86

R-1 Line #13

Volume 1b - 232

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AO4 *I Energy Efficient Devices Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
capability; design and develop batteries for fast charge systems to investigate concepts for Fast Efficient Energy Distribution; investigate coupled isotope/energy converter geometry and increased density packaging techniques to validate proof-of-principle isotope power source; explore the coupling of piezoelectric transformers with silicon integrated circuit envelope detectors and baseband electronics for wake-up receivers; design and develop two dimensional (2D) fabrication processes to reduce energy loss; investigate concepts to achieve responsivity for viable communications wavelength in the near-to-mid infrared (IR) regime in topological materials based devices; develop energy efficient electronic components based on silicon, gallium nitride, and diamond semiconductor materials. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	5.190	5.454	5.710

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army
UNCLASSIFIED
Page 20 of 86
R-1 Line #13
Volume 1b - 233

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AO5 *I Tag Track and Locate Small Satellites 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
AO5: *Tag Track and Locate Small Satellites Technology*	-	4.267	3.737	-	-	-	-	-	-	-	-	-

Note

 In FY22, work in this Project transitions to:
 Program Element (PE) 0602146A (Network C3I Technology) Projects CG3 (Assured PNT Communications Applied Research) and CK1 (Assured PNT Enabling Technologies).

A. Mission Description and Budget Item Justification

 Tag, Track, and Locate Small Satellites Technology develops and adapts technologies for Space-Based and High Altitude applications for Army tactical ground forces. Efforts include the design and development of sensors and electronic components for communications, signal and information processing, target acquisition, position/ navigation, and threat warning within space and high altitude environments. Evaluations conducted leverage other Department of Defense (DoD) space science and technology applications to support Army space force enhancement and cooperative satellite payload development. Funds research in quantum sciences based communications, sensing, and data teleportation to mature current technologies for small spacecraft applications.

 The work cited 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 Space and Missile Defense Command (USASMDC) in Huntsville, AL.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Tag Track and Locate Small Satellites	3.153	2.583	-
Description: This effort will design, develop, and adapt space-based technologies, components, and tools that lead to smaller, lighter, more responsive payloads and applications. These technologies allow for the rapid integration and development of tactical payloads in support of responsive space environments. *FY 2021 Plans:* Validates payload technologies for small spacecraft to provide tactical land component forces with space capabilities for force projection and maneuver during Multi-Domain Operations; designs and conducts experiments focused on terrestrial open air Quantum Entanglement Data Teleportation (QEDT) and space-to-ground QEDT; and qualifies and implements Quantum Key Distribution (QKD) components in order to validate satellite-to-satellite crosslink QKD. *FY 2021 to FY 2022 Increase/Decrease Statement:*			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AO5 *I Tag Track and Locate Small Satellites Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funds realigned to PE 0602146A Projects CG3 (Assured PNT Communications Applied Research) and CK1 (Assured PNT Enabling Technologies).			
Title: Space Components and Systems Assessment Technology *Description:* This effort supports experimentation and validation of hardware and software components and models to further anchor laboratory capabilities enabling small spacecraft and payload design and development. *FY 2021 Plans:* Designs and develops payload technologies for small spacecraft to provide tactical land component forces with space capabilities for force projection and maneuver during Multi-Domain Operations. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to PE 0602146A Projects CG3 (Assured PNT Communications Applied Research) and CK1 (Assured PNT Enabling Technologies).	1.114	1.154	-
Accomplishments/Planned Programs Subtotals	4.267	3.737	-

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 / 2					**R-1 Program Element (Number/Name)** PE 0602146A / Network C3I Technology					**Project (Number/Name)** AP4 / CEMA Camouflage 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
AP4: *CEMA Camouflage Technology*	-	9.316	9.559	-	-	-	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project is realigned to:
Program Element (PE) 0602182A (C3I Applied Research) Project CM9 (Convergent CEMA Deception), and CN5 (Network Vuln/Effectiveness Assess Methods (N-VEAM))

A. Mission Description and Budget Item Justification

This Project develops and characterizes hardware and software to enable electronic spoofing and cyber deception along with inconspicuous Cyber Electromagnetic Activity (CEMA) and network operations of Army platforms and dismounts, while maintaining freedom to maneuver, communicate, and sense. This research is critical to counter near-peer ability to geo-locate our troops and put indirect fires onto our positions. This effort develops a holistic cross-domain analysis and assessment methodology for network and communication technologies faced with advanced CEMA. These investigations are critical to identifying vulnerabilities of United States systems and technologies so that network and network-enabled systems can be hardened as early in development as possible.

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: Radio Frequency/Cyber Sensing and Deception	0.382	2.998	-
Description: This effort develops technologies to avoid geolocation of blue force RF emissions by peer/near-peer adversaries. Research will focus on developing low probability of detection (LPD) communications and decoys to increase freedom of maneuver while maintaining effective communications. *FY 2021 Plans:* Develop hardware for RF decoys, including compact antennas, wideband reconfigurable transceivers, and radio frequency frontend hardware; model performance of coherent beam-forming from dispersed emitters for RF decoys; investigate techniques for decoy emission waveforms and antennas for decoy development; investigate materials, device designs, and components for non-RF communication techniques; demonstrate initial chip-level active optical-phased array (OPA) for communication link using co-packaged external laser; conduct experimentation on native photonic integrated circuit (PIC) laser and co-packaging control electronics. *FY 2021 to FY 2022 Increase/Decrease Statement:*			

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 23 of 86

R-1 Line #13

Volume 1b - 236

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 **/** 2	**R-1 Program Element (Number/Name)** PE 0602146A **/** *Network C3I Technology*	**Project (Number/Name)** AP4 **/** *CEMA Camouflage Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
This effort is realigned to Program Element (PE) 0602182A (C3I Applied Research) CM9 (Convergent CEMA Deception).			
Title: Dynamic Intelligent Networks and Cyber Camouflage and Decoy for CEMA	3.349	2.398	-
Description: This effort investigates techniques and develops methods for combining the physical (RF) and network (cyber) layers for enhanced effects when coupled with electromagnetic camouflage and decoy methods. *FY 2021 Plans:* Implement and experimentally validate the use of unconventional spectrum, directional networking, and novel modulations to enhance the low-probability-of-detection features of the network; develop and characterize protocols for adapting networks to optimize performance under low-probability-of-detection constraints; and research adaptive cyber deception methodologies to provide defensive advantage by hiding mission critical assets (camouflage), misrepresenting a system (obfuscation), and luring the enemy to expend resources on fake nodes (decoys), while real systems remain safe and continue to execute mission critical tasks. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort is realigned to 0602182A (C3I Applied Research) CM9 (Convergent CEMA Deception).			
Title: Understanding, Protecting, and Enabling CEMA Effects	3.080	2.145	-
Description: This effort develops and continually improves methodology and approaches for estimating and predicting (CEMA) effects on networks and network-enabled systems during complex multi-domain operations when significant cross-domain effects can be expected. Methods include drawing upon past research concerning the interaction of cyber and electromagnetic threats on operational networks; anechoic chamber, laboratory, and field measurements; and first principles Modeling and Simulation (M&S) and engineering analysis. Abstracting, generalizing, and automating multi-domain CEMA operations will enable the development of analysis and assessment capabilities to anticipate the impact of future threats. Live, virtual, and simulated environments will be developed to estimate the potential operational impact of threat CEMA technologies on friendly systems. *FY 2021 Plans:* Develops and extends techniques to estimate the effect of cyber and electromagnetic activities across all functional layers (i.e., physical, electromagnetic, cyber, human, and operational); matures investigations and enhances scientific understanding of cross-domain synergies building upon those previously discovered; and validates tools for understanding cross-domain synergies and determine region of applicability before the tools are passed on to vulnerability analysts. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort is realigned to 0602182A (C3I Applied Research) CN5 (Network Vuln/Effectiveness Assess Methods (N-VEAM)).			
Title: Vulnerability Analysis Methodology for CEMA Threats	2.505	2.018	-

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 24 of 86

R-1 Line #13

Volume 1b - 237

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602146A / *Network C3I Technology*	**Project (Number/Name)** AP4 / *CEMA Camouflage Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Description: This effort investigates threat/target interactions to develop experimental and analytical methodology for separate and cross-domain cyber and electromagnetic threat attack so that assessed vulnerabilities in a multi-domain complex environment can be reduced or eliminated before fielding new networks and network-enabled systems. Experimental and analysis methodology will be developed to investigate vulnerabilities of specific configurations of complex future networks with multiple communications modalities, advanced decoy techniques in the cyber and electromagnetic areas, and advanced Positioning, Navigation, and Timing (PNT) systems. *FY 2021 Plans:* Investigates cross-domain vulnerability analysis with both simulation and experimental techniques that encompass cyber, electronic warfare, and other electromagnetic activities; cross-domain experiments will include hacking communications equipment at all relevant levels of hacker sophistication while that equipment is under Electronic Warfare (EW) attack in controlled (i.e. anechoic chamber) environment for tactically plausible waveforms, power levels, switching algorithms, etc; validates analysis techniques previously developed for novel communications modalities and techniques (e.g., ultraviolet, millimeter wave, situational adaptive controllers) and develops new experimental and analytical methodologies to assess and discover vulnerabilities; and researchs new vulnerability assessment methodology and techniques for new, non-Global Positioning System (GPS) PNT technologies (e.g., inertial navigation technology, chip-scale atomic clocks, optical time transfer, and video-based technologies). *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort is realigned to 0602182A (C3I Applied Research) CN5 (Network Vuln/Effectiveness Assess Methods (N-VEAM)).			
Accomplishments/Planned Programs Subtotals	9.316	9.559	-

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 25 of 86

R-1 Line #13

Volume 1b - 238

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AP5 *I Electronic Warfare 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**
AP5: *Electronic Warfare Technology*	-	2.707	2.878	2.928	-	2.928	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates emerging technologies related to electronic warfare (EW) applications, non-kinetic survivability/lethality, and emerging concepts of employment in the increasingly contested and congested electromagnetic environment, with the goal of enhancing the survivability/lethality of Army platforms through electronic attack (EA), electronic warfare support (ES), and electronic protection (EP).

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) / Project AO3 (Robust Grey C3I Advanced Technology), PE 0602146A / Project AO2 (STARE), PE 0602146A/ Project AP4.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Electronic Warfare Technology Research	2.129	2.231	2.290
Description: This effort investigates emerging technologies related to EW applications, non-kinetic survivability/lethality, and emerging concepts of operation in the increasingly contested and congested electromagnetic environment, with the goal of enhancing the survivability/lethality of Army platforms through EA, ES, and EP. **FY 2021 Plans:** Investigate signal processing techniques for detection, classification, and emitter geolocation from distributed radio frequency (RF) receivers; develop electronic attack and electronic protection techniques in an advanced hardware-in-the-loop electromagnetic environment by adding situational awareness sensor input into the cognitive RF algorithm to investigate deception and degradation of realistic threat capabilities; investigate techniques to identify and classify RF emitters based on generalized attributes and characteristics; develop hardware-in-the-loop resource manager to expand RF channel emulation; study cognitive EW integration into the hardware-in-the-loop laboratory environment; and develop approaches for radar and communications networks to co-exist in congested and contested electromagnetic environments. **FY 2022 Plans:** Will implement hardware-in-the-loop capability for multi-channel experiments with low-cost, distributed hardware; investigate spectrum analysis algorithms for Size, Weight, and Power (SwaP) constrained platforms; investigate techniques to characterize radio frequency (RF) emitter behavior; investigate implementation of cognitive radar threats in the hardware-in-the-loop laboratory environment; and develop tools to automate scenario generation in hardware-in-the-loop laboratory environment. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort.			
Title: Electronic Warfare Assessment Technologies	0.578	0.647	0.638

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AP5 *I Electronic Warfare Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This research investigates emerging technologies related to EW applications (e.g., digital RF memory, software defined radios, cognitive radars) and electromagnetic-enabled cyberspace operations in the increasingly contested and congested environment. Research is focused on near-peer and future threats to enhance survivability/lethality, and discover critical vulnerabilities, of Army technologies and systems through cyber and electromagnetic activities (CEMA). *FY 2021 Plans:* Continue to investigate novel EW approaches using unmanned aerial systems, software defined radios, digital RF memory, and cyber injection techniques; continue to investigate multi-domain technologies in advanced CEMA laboratories, anechoic chambers, field experiments, and with modeling and simulation so as to develop approaches and methodologies to assess friendly and enemy technologies and systems. *FY 2022 Plans:* Will converge EW and Cyber techniques into a comprehensive CEMA capability for assessment and analysis of advanced electromagnetic technologies. Apply advanced CEMA analytical capabilities to applicable network and horizontal integrated technologies and systems to assess defensive and cognitive EW in controlled environments, including hardware in the loop and linkage to operational mission simulations. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	2.707	2.878	2.928

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

D. Acquisition Strategy
N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 27 of 86

R-1 Line #13

| **Volume 1b - 240** |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*						**Project (Number/Name)** AP7 *I Comms/Horiz Int for Army Mod Priorities Tech*	

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
AP7: *Comms/Horiz Int for Army Mod Priorities Tech*	-	0.479	2.914	-	-	-	-	-	-	-	-	-

Note

In Fiscal Year 2022, Project terminates and funding is realigned to:
Program Element (PE) 0602213A (C3I Applied Cyber) Projects CY6 (Autonomous Cyber Technology) and 2CY (Information Trust Technology)
PE 0602146A (Network C3I Technology) Project AM8 (Protected SATCOM Technology)
PE 0603457A (C3I Cyber Advanced Development) Project 8CY (Information Trust Advanced Technology)
PE 0603463A (C3I Advanced Technology) Project AM9 (Protected SATCOM Advanced Technology)

A. Mission Description and Budget Item Justification

This Project investigates the communication architectures of each of the Army's modernization priorities and determines technologies and components to enable assured and resilient communications and horizontal integration.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AP8 (Comms/Horiz Int for Army Mode Priorities Adv Tech).

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: Communications Support to Army Modernization Priorities / Horizontal Integration Fields Technology	0.479	2.914	-
Description: This effort investigates the communication architectures of each of the Army?s modernization priorities and determines technologies and components to enable assured and resilient communications.			
FY 2021 Plans: Develop lab-based integration of the many varied technologies participating in the NGCV-themed NetModX21 and an Integrated Visual Augmentation System capstone investigation as risk reduction activities; and conduct end-to-end system of systems modeling and simulation of varied technologies that are planned to participate in the Integrated Tactical Network-themed NetModX22 as early risk reduction activities.			
FY 2021 to FY 2022 Increase/Decrease Statement:			

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 28 of 86

R-1 Line #13

Volume 1b - 241

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AP7 *I Comms/Horiz Int for Army Mod Priorities Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding realigned to the following projects in support of Field Based Risk Reduction (FBRR) experiments: PE 0602213A (C3I Applied Cyber Projects) CY6 (Autonomous Cyber Technology) Project 2CY (Information Trust Technology); PE 0602146 Project AM8 (Protected SATCOM Technology), PE 0603457A (C3I AdvancedDevelopment) Project 8CY (Information Trust Advanced Technology); and PE 0603463A (C3I Advanced Technology) Project AM9 (Protected SATCOM Advanced Technology).			
Accomplishments/Planned Programs Subtotals	0.479	2.914	-

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 29 of 86

R-1 Line #13

Volume 1b - 242

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AQ2 *I EW Techniques 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**
AQ2: *EW Techniques Technology*	-	-	0.482	0.494	-	0.494	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops countermeasures against adversarial counter-fire systems that obscure and create distractive blue force locations.

Work in this Project complements PE 0602146A (Network C3I Technology) Project AO2 (Stand-In Advanced RF Effects (STARE)), and PE 0603463A (Network C3I Advanced Technology) Projects AO7 (EW for Maneuver Operations (EMO) Adv Tech), and AO3 (Stand-In Advanced RF Effects (STARE) Adv Tech).

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 U.S. Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Simultaneous Counter Measures (CM) for Active Reconnaissance and Surveillance (SCARS)	-	0.482	0.494
Description: This effort will provide investments in Electronic Warfare (EW), against advancing counter-fire sensors. Research will investigate highly synchronized systems capabilities to achieve advanced effects. *FY 2021 Plans:* Conduct initial investigations and experiments against modeled or representative threats to validate technical approach feasibility for advanced EW effects. *FY 2022 Plans:* Will further investigate and experiment against modeled or representative threats to validate technical approach feasibility for EW effects against adversary counter-fire sensors and ISR. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of project.			
Accomplishments/Planned Programs Subtotals	-	0.482	0.494

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AQ2 *I EW Techniques Technology*

D. Acquisition Strategy

  N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*				**Project (Number/Name)** AQ7 *I High Tempo Data Driven Decision Tools 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
AQ7: *High Tempo Data Driven Decision Tools Technology*	-	-	2.701	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops data driven decision tools that help develop cyber Situational Understanding (SU) for Commanders and staff that will enable them to more quickly and accurately assess and integrate cyber impacts with all of the domains in Multi-Domain Operations (MDO) and to thereby enhance mission effectiveness by improving decision cycles.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AQ8 (High Tempo Data Driven Decision Tools Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: High Tempo Data Driven Decision Tools *Description:* Develops data driven decision tools that help develop cyber Situational Understanding (SU) for commanders and staff that will enable them to more quickly and accurately assess and integrate cyber impacts with all of the domains in Multi-Domain Operations (MDO) and to thereby enhance mission effectiveness by improving decision cycles. *FY 2021 Plans:* Investigate methods for improving Common Operating Picture (COP) decision time and quality; design visualizations for the exploration and understanding of the impact of the cyber domain on the current mission in order to improve the decision cycles. *FY 2021 to FY 2022 Increase/Decrease Statement:* Effort completes in FY21. Research continues in PE 0603463A (Network C3I Advanced Technology) Project AQ8 (High Tempo Data Driven Decision Tools Advanced Technology).	-	2.701	-
Accomplishments/Planned Programs Subtotals	-	2.701	-

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

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AQ7 *I High Tempo Data Driven Decision Tools Technology*

D. Acquisition Strategy
 N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*						**Project (Number/Name)** AQ9 *I Expeditionary Data to Decisions 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
AQ9: *Expeditionary Data to Decisions Technology*	-	1.918	2.760	-	-	-	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this Project program is realigned to:
Program Element (PE) 0602146A (Network C3I Technology) Project CI3 (Mobile and Survivable Command Post Tech)

A. Mission Description and Budget Item Justification

This Project investigates, codes and designs software, and algorithms that improve Mission Command by increasing situational understanding, via the intelligent sharing of data in degraded networks during high op-tempo missions or while under cyber-attack. This Project includes researching artificial intelligence techniques to improve decision making capacity across the battlefield by using software knowledge representation to model the mission, automate staff tasks, correlate and analyze information, and provide recommendations. These capabilities allow forces to maximize op-tempo and maintain strategic advantage.

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: Expeditionary Data to Decisions Technology **Description:** This effort investigates algorithms and software that dynamically identify and arrange the most accurate, useful, and timely information from across the warfighting network to optimize commander and staff decision cycles and enable Mission Command from anywhere on the battlefield. It matures artificial intelligence techniques that provide the most relevant and available data to support time-sensitive and critical decisions, and present information in context and in alignment with complex cognitive needs.	1.918	-	-
Title: Mission Command Technologies **Description:** This effort investigates and designs components and technologies for agile, survivable, modular, non-traditional Command Post platforms to enable decentralized and distributed mission command operations in the future operating environment. **FY 2021 Plans:** Identify a set of critical, time-constrained decisions that require data and information collection and analysis, map battlespace data and information to a set of important tactical decisions and identify the appropriate models for those decisions; and develop	-	0.890	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602146A I *Network C3I Technology*	**Project (Number/Name)** AQ9 I *Expeditionary Data to Decisions Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
a set of initial requirements for a concept demonstrator; conduct experiments on Command Post components for secure communications within a decentralized environment to validate component performance; and provide knowledge products that support development of future requirements. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In Fiscal Year (FY) 2022, this effort is realigned to Program Element (PE) 0602146A Project CI3 (Mobile and Survivable Command Post Tech)			
Title: Camouflage, Concealment and Decoys	-	1.870	-
Description: This effort investigates innovative camouflage, concealment and deception technologies for expeditionary high-value assets to defeat advanced current and emerging adversary Intelligence, Surveillance and Reconnaissance (ISR) threats, and to reduce the probability of detection in multi-domain operations. Designs physics-based models for material and system performance that support probability of detection metrics in the multi-domain operational environment, assisting in closing the capability gap between current camouflage, concealment and deception technologies and defeating enemy sensorial capabilities in future operating environments. ***FY 2021 Plans:*** Research performance of camouflage materials to identify promising solutions for Command Post survivability; research and evaluate performance effects of new materials against emerging threats; research hyperspectral and Laser Imaging, Detection, and Ranging (LIDAR) sensor defeat approaches; and evaluate candidate deception solutions. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort is realigned to Program Element (PE) 0602146A Project CI3 (Mobile and Survivable Command Post Tech)			
Accomplishments/Planned Programs Subtotals	1.918	2.760	-

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 35 of 86

R-1 Line #13

| Volume 1b - 248 |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*				**Project (Number/Name)** AR1 *I Robust, Resilient and Intelligent C3I 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
AR1: *Robust, Resilient and Intelligent C3I Technology*	-	8.342	13.600	10.510	-	10.510	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 partial funding realignment to:
Program Element (PE) 0602141A (Lethality Technology) Project CF7 (Solid-state Laser Concepts and Architectures).

A. Mission Description and Budget Item Justification

This Project develops and characterizes machine learning and artificial intelligence methods for processing, analysis and provisioning control of smart, distributed, networked sensors and devices. It provides situational understanding and decision support to enable fast, adaptive and interoperable C3I network-integrated applications, resilient to adversarial activity in contested and complex environments. Effective use of distributed networked sensors, autonomous agents and automated decision support tools is critical to address threats posed by peer competitors and more capable asymmetric forces, particularly in complex environments where traditional sensors provide an incomplete understanding of the tactical situation due to adversarial activity, occluded sightlines and small fields of regard.

Work in this Project complements PE 0602145A (Next Generation Combat Vehicle Technology) Project BF8 (Artificial Intelligence & Machine Learning Technology), PE 0603463A (Network C3I Advanced Technology) Project AQ5 (Sensor CE - Integrated Sensor Architecture), PE 0602146A (Network C3I Technology) Project AN7 (COE-Every Receiver is a Sensor Technology), and PE 0603463A (Network C3I Advanced Technology) Project AN8 (COE - Every Receiver is a Sensor).

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: Intelligent Signal and Image Analytics for C3I	6.250	6.283	3.250
Description: This effort designs and characterizes technologies for multi-modal (Electro-Optical/Infra-Red (EO/IR) imaging, acoustic, seismic, infrasound, electric and magnetic (E/H) field, and passive radio frequency (RF), low-cost networked sensors to enhance persistent sensing capabilities for increased probability of target localization, tracking, classification, and reduced false alarms. These combined sensors have unique capabilities that enable passive discrimination from deception and decoys, detection of electrical equipment operation, underground facilities, vehicles, weapons launch, gunfire, and explosions. The work includes development of learning algorithms to improve situational understanding. *FY 2021 Plans:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602146A I *Network C3I Technology*	Project (Number/Name) AR1 I *Robust, Resilient and Intelligent C3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Assess improved 3-D electric and magnetic-field sensors for electromagnetic imaging, target characterization, electric power analysis for fault detection, resilient supervisory control and data acquisition, and anomaly detection; improve ?processing at the edge? hardware and software reliability for novel low-size, weight, power and cost (SWaP-C) unattended sensor applications and assured Position, Navigation, and Time (PNT) applications; develop multi-functional algorithms to encompass multimodal sensors to detect targets in complex tactical scenarios; investigate the use of electric and magnetic field sensing arrays and inversion methods for new classes of extremely low frequency imager development; develop infrasound through audible frequency sensors, algorithmic and hardware solutions to automate the detection, tracking, and localization of transient and continuous-wave targets; incorporate advanced seismic sensing for enhanced detection and localization of ground targets; exploit coupled acoustic and seismic sensing to automatically differentiate and track ground and airborne targets. *FY 2022 Plans:* Will develop artificial intelligence and machine learning (AI & ML) based analytics to process multi-modal data, both imaging based (electro-optical, infrared) and non-imaging based (acoustic, seismic, electric, and magnetic field sensing), for automated detection, classification, and tracking of targets from both ground and airborne platforms; develop synthetic data generation techniques for algorithm training to augment limited availability of real world data for robust signal and image analytics in operationally-relevant settings; understand 3-D electric and magnetic-field sensors and sensing arrays for extremely low frequency imaging and electric power grid analysis for pattern of life analysis; continue research of infrasound through audible frequency sensors, algorithmic, and hardware solutions to automate target detection, tracking, and localization; and validate advanced seismic sensing for enhanced detection and localization of ground targets. *FY 2021 to FY 2022 Increase/Decrease Statement:* Partial funding and work realignment in FY22 to support High Energy Laser (HEL) Enabling Technologies for Tactical Directed Energy Weapons effort in PE 0602141A (Lethality Technology) Project CF7 (Solid-state Laser Concepts and Architectures).			
Title: Smart Networks and Distributed Sensing for C3I *Description:* This effort will develop and assess a concept to link physical sensors and information sources to Soldiers and small units. Specifically, the research focuses on (1) multi-modal sensor fusion for detection and classification of human activities and infrastructures such as personnel, vehicles, machinery, RF emissions, chemicals, and computers in hidden and confined spaces, (2) interoperability and networking of disparate sensors and information sources, (3) distributed information for decision-making, and (4) approaches for fusing results of processed outputs of multi-modal sensors, such as visible, infrared (IR), and hyperspectral imagers, and acoustic, magnetic, and electric field sensors. *FY 2021 Plans:*	0.280	5.336	5.259

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602146A I *Network C3I Technology*	Project (Number/Name) AR1 I *Robust, Resilient and Intelligent C3I Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Develop the framework for a reconfigurable network of fixed and re-locatable sensors for accurate detection and tracking of hostile forces and in support of reconnaissance activities. *FY 2022 Plans:* Will implement real-time scene perception based algorithms for optimal relocation of sensor assets for robust target detection, classification, and tracking; design approaches for optimally determining sensor modality, parameters, and energy requirements for carrying out scene perception tasks in resource-constrained distributed network environments; implement light-weight machine learning architectures for real-time inference at the edge on low size, weight, and power (SWaP) computing devices utilizing both centralized and distributed processing frameworks; research and validate novel adaptive real-time multimodal sensing and processing methods using low-SWaP edge processing and mobile user interfaces and controls; validate deep sensing concepts by characterizing remote employment of sensors in a strategic and tactical scenario to enable autonomous threat detection, localization, and high confidence classification. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Information Processing and Analysis *Description:* This effort investigates techniques that integrate local and external information sources and applies machine learning and artificial reasoning approaches to support automated intelligence analysis, command/control, and decision-making. The goal is to enable tactical users to cooperatively interact with relevant and timely tactical information supported by methods that are network-aware/adaptive and deliver transparent and uniform transport. *FY 2021 Plans:* Investigate and develop resilient information mediation and accelerated tactical and intelligence decision making tools through the use of virtualization and machine learning-augmented autonomous algorithms; develop intelligent Information Mediation and Immersive Common Operating Picture (COP) by applying resilient network protocols for adaptive information mediation; develop and assess prototype contextual policy-based and continuously learned information recommendation integrating Value-of-Information (VoI)/Quality-of-Information (QoI) network sensitivity; and integrate real-time multi-sensor and multi-domain battlefield information for accelerated exploration and decision making in an immersive COP that is tailorable and learns Soldier preferences. *FY 2022 Plans:* Will investigate and conduct experiments that explore methods for intelligent information mediation and adaptive information representation; identify methods for accelerating decision support and information synthesis in SWaP and time constrained systems and adversarial environments; determine feasibility, viability, and limitations of data-driven, physics-guided information interaction and its impact on situational awareness in multi-modal, multi-perspective information representations in 2D and	1.812	1.981	2.001

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AR1 *I Robust, Resilient and Intelligent C3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
immersive adaptive interfaces; continue to examine quantitative information recommendation and filtering approaches such as Vol/QoI for policy-based and continuously-learned multi- sensor and multi-domain battlefield information-interaction. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	8.342	13.600	10.510

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 39 of 86

R-1 Line #13

Volume 1b - 252

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

| Appropriation/Budget Activity
2040 I 2 | | R-1 Program Element (Number/Name)
PE 0602146A I *Network C3I Technology* | | Project (Number/Name)
AR3 I *Intelligent Environmental Battlefield Awareness* | | |

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
AR3: *Intelligent Environmental Battlefield Awareness*	-	-	2.897	3.059	-	3.059	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates, develops, and designs technologies to allow Soldiers to maneuver faster in dynamic environments as informed by physical, geological, and biological constraints. This Project enhances visualization tools for mission planning through delivery of web modules/software tools which contain crucial geo-chemical resources and advanced knowledge of geo-environmental infrastructure for mission planners.

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 Engineer Research and Development Center and coordinated with the United States Army Futures Command.

Research in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AR4 Intelligent Env Battlefield Awareness Adv Tech.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Arctic Threat **Description:** This effort delivers a geospatial decision aid to United States Army units conducting expeditionary operations to anticipate threats, hazards and dependencies posed by terrain and weather extremes in cold regions. **FY 2021 Plans:** Research to ensure high fidelity understanding of terrain conditions for improved threat (e.g., thaw vulnerability and ground state instability) and hazard (e.g., chem/bio fate and effects and pathogenicity) prediction to aid in preventing risks to operational effectiveness and efficiency in cold regions. **FY 2022 Plans:** Will generate new input parameters for geospatial overlays that represent soil mechanics representing thaw effects based on terrain conditions and temperature extremes. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects planned lifecycle of this effort, completing in Fiscal Year 2022.	-	1.442	0.888
Title: Geo-Forensics **Description:** This effort generates data to develop the data mining framework and software tools to generate geo-referenced predictive map layers to inform mission planning and operational assessments for area denied sites.	-	0.675	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AR3 *I Intelligent Environmental Battlefield Awareness*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
FY 2021 Plans: Develop preliminary framework by coalescing existing geo-forensic methodologies into a geochemical forensics tool that represent a high resolution geo-referenced soil type map layer of a specified Outside Continental United States (OCONUS) areas of interest, powered by soil-matching algorithms. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort, completing in Fiscal Year 2021.			
Title: Predictive Geographic Information System (GIS) Mapping (physical) *Description:* This effort develops a comprehensive GIS tool that integrates predictive models of soil, vegetation, hydrology, and permafrost conditions in OCONUS dark sites from the statistical analysis of known datasets and the application of geophysical principles. *FY 2021 Plans:* Design a unified framework that will integrate several independently derived geospatial tools with streamlined data analysis and mitigation of statistical errors. *FY 2022 Plans:* Will consolidate geophysical data and begin parameterization for data input into unified geospatial framework. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	-	0.780	0.789
Title: Hydrology Mapping *Description:* This effort provides data tools and models to support high-fidelity battlefield overlay maps that accurately show hydrologic/soil moisture threats (soil, hydrology, and snow/ice) not captured by current terrain mapping capabilities. *FY 2022 Plans:* Will develop predictions of soil moisture state, infiltration, and runoff that better reflect the high degree of spatial and temporal variability in ground and surface water. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort. Funds realigned from other efforts in the Project.	-	-	1.382
Accomplishments/Planned Programs Subtotals	-	2.897	3.059

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AR3 *I Intelligent Environmental Battlefield Awareness*

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602146A: *Network C3I Technology*
Army
UNCLASSIFIED
Page 42 of 86
R-1 Line #13
Volume 1b - 255

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*				**Project (Number/Name)** AR5 *I Understanding the Environment as a Threat Technolo*		

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
AR5: *Understanding the Environment as a Threat Technolo*	-	3.872	2.246	1.956	-	1.956	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and advances mission planning software enabling the Soldier to identify, track, and plan for industrial or commercial chemical/environmental threats. Software modules will increase capability of mission based planning technologies providing new operational routing options for mission execution with environmental threat overlays.

Work in this Project complements to PE 0603463A (Network C3I Advanced Technology) Project AR6 (Understanding the Environment as a Threat Adv Tech).

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 Engineer Research and Development Center and coordinated with the United State Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Environmental Threat Overlays for Operational Routing/Predictions of Lethal Environments *Description:* This effort develops tools enhancing operational route planning technologies. It will deliver a new capability informing the Solider of the risks associated with physical landscape, chemical exposure, and biological threats lethal to personnel and disruptive to equipment. Tools will support route planning and soldier mobility within a complex urban environment.	2.333	-	-
Title: Predictions of Lethal Environments/ Computational Prediction of Threats in the Operational Environment *Description:* This effort develops tools and models for the Soldier providing critical information of the operational environment allowing the Soldier to operate in, avoid, or prepare for contaminated battlefields. *FY 2021 Plans:* Conduct research to design software modules that support mission based planning technologies for improved operational maneuver routing (e.g., deep maneuver) using a threat overlay design. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort, ending in Fiscal Year 2021.	1.539	1.156	-
Title: Subsurface Forensics	-	1.090	1.956

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 43 of 86

R-1 Line #13

Volume 1b - 256

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AR5 *I Understanding the Environment as a Threat Technolo*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Develops effective and covert methods to collect data and transmit telemetric signal through solid media to advance chemical and biological sensing to prepare Soldiers for the risks of deliberate or accidental release of toxic industrial chemicals and materials. *FY 2021 Plans:* Investigate and assess chemical and biological sensing and sampling technologies to develop methods that identify risks of deliberate or accidental release of toxic industrial chemicals and materials in subterranean waste disposal networks. *FY 2022 Plans:* Will consolidate candidate sensor technologies based on effectiveness and form/fit design constraints that detect and characterize hazards including water quality, explosive constituents, and non-weaponized radiological hazards. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase in FY22 will support increased focused research in sensor technologies.			
Accomplishments/Planned Programs Subtotals	3.872	2.246	1.956

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army
UNCLASSIFIED
Page 44 of 86
R-1 Line #13
Volume 1b - 257

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*			**Project (Number/Name)** AR7 *I Sensing in Contested Environments 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
AR7: *Sensing in Contested Environments Technology*	-	-	1.820	1.192	-	1.192	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project characterizes through direct or inferential methods the identification of non-weaponized biological hazards posed to Soldiers in operational environments by advancing sensor technologies. Sensor technologies and software modules will detect and characterize hazards including water quality, heavy metals in soils, breath-ability, and non-weaponized radiological hazards within confined environments. This effort supports the Common Operating Environment LOE.

Work is complements PE 0603463A (Network C3I Advanced Technology) Project AR8 (Sensing in Contested Environments Adv Tech).

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 Engineer Research and Development Center and coordinated with the United States Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Non-Traditional Threat Detection in Contested Environment *Description:* This effort identifies, examines and prioritizes commercial of the shelf (COTS) capabilities from multiple sources that can accurately detect biological hazards relevant to operations in subterranean environments from point of ingress/egress to evaluate exposure potential and affects. *FY 2021 Plans:* Assess candidate sensor technologies for maturity and effectiveness and design demonstration scenarios to detect and characterize hazards including water quality, heavy metals in soils, breath-ability, and non-weaponized radiological hazards to provide immediate warning of natural, man-made, and biological hazards that impact operations. *FY 2022 Plans:* Will consolidate candidate sensor technologies based on effectiveness and form/fit design constraints that detect and characterize hazards including water quality, explosive constituents, and non-weaponized radiological hazards. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding decrease reflects planned lifecycle progression of transitioning work to advanced technology development PE 0603463A (Network C3I Advanced Technology) Project AR8 (Sensing in Contested Environments Adv Tech).	-	1.820	1.192
Accomplishments/Planned Programs Subtotals	-	1.820	1.192

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AR7 *I Sensing in Contested Environments Technology*

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 46 of 86

R-1 Line #13

Volume 1b - 259

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AR9 *I Persistent Geophysical Sensing-Infrasound Tech*		

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**
AR9: *Persistent Geophysical Sensing-Infrasound Tech*	-	3.898	3.035	3.414	-	3.414	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops algorithms, software, and hardware components to enable near-real-time battlespace awareness to persistently monitor (through non-line-of-sight sensing including infrasound) critical infrastructure conditions and threat activities in dynamic battlefields. These technologies provide near real time data collection, processing, and alerts of infrastructure go/no-go condition required for maneuver planning. This project also designs and develops methodologies to assign maneuver relevant engineering attributes to geospatial feature data such as bridge load classification, road condition, and bathymetry.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AS9 (Persistent Geophysical Sensing-Infrasound Tech Advanced Technology).

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

Work in this Project conducted at U.S. Army Engineer Research and Development Center and coordinated with U.S. Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Remote Assessment of Infrastructure for Ensured Maneuver (RAFTER) *Description:* This effort develops parameters for a suite of geophysical and geosensing technologies to persistently assess infrastructure capability and condition for large areas including urban terrain; develops complex terrain, topography, and meteorological models related to acoustic propagation detected by the sensor suite, as well as signal processing algorithms for detection and classification of transportation infrastructure.	3.898	-	-
Title: Battlefield Intelligence by Geophysical Sensing (BIGS) *Description:* This effort develops a suite of geophysical and geo-sensing technologies to persistently assess battlefield elements to include infrastructure and additional sources of interest such as explosive and fires events and various air platforms; refines terrain, topography, and meteorological models related to acoustic propagation detected by the employed sensor suite as well as detection and classification signal processing algorithms for a broader range of sources and/or threats. *FY 2021 Plans:*	-	3.035	3.414

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AR9 *I Persistent Geophysical Sensing-Infrasound Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Design and develop algorithms associated with non-traditional sensing methods (including infrasound) for detecting, classifying, and monitoring additional sources of interest (explosive events, air platforms, etc.) as well as refinement of the terrain, topographical, and meteorological models that feed into the analysis. *FY 2022 Plans:* Will focus on algorithm research and development based on down-selected sources of interest as prioritized by stakeholders/ transition partners and will complete a sensor placement optimization tool to evaluate alternate array geometries/sensor configurations. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase in FY22 will support development of sensor placement optimization tool.			
Accomplishments/Planned Programs Subtotals	3.898	3.035	3.414

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 48 of 86

R-1 Line #13

Volume 1b - 261

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AT2 *I Subterranean Detection and Monitoring 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**
AT2: *Subterranean Detection and Monitoring Technology*	-	1.534	2.791	-	-	-	-	-	-	-	-	-

Note
 This project is eliminated for Fiscal Year (FY) 2022.

A. Mission Description and Budget Item Justification

 This Project designs and develops an integrated suite of tunnel detection, subterranean monitoring solutions, and vulnerability assessment technologies to detect, identify, and monitor subterranean threat activities in urban environments through advanced sensing and rapid analysis capabilities. This Project also develops and investigates enhanced technologies to detect tunnels and tunneling activity in complex and varied environments.

 Work in this Project complements PE 0603463A (Network C3I Advanced Technology) / Project AT3 (Subterranean Detection and Monitoring Adv Tech).

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

 Work in this Project is conducted at the United States Army Engineer Research and Development Center and coordinated with the United States Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Subterranean Threat Assessment by Real-time Sensing ***Description:*** This effort designs and develops an integrated suite of tunnel detection and persistent surveillance technologies to detect, track, and identify subsurface activities; expedient underground municipal infrastructure detection system; urban source characterization and modeling algorithms; expedient void detection systems in urban areas, and vulnerability assessment tools for the urban subterranean domain. ***FY 2021 Plans:*** Design and develop ground-penetrating radar and seismic hardware for detection of underground municipal infrastructure; and develop sensing classifiers based on simulated urban source signatures. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding decrease in FY22 is part of the planned lifecycle for this effort, ending in in FY 2021.	1.534	2.791	-
Accomplishments/Planned Programs Subtotals	1.534	2.791	-

PE 0602146A: *Network C3I Technology*
Army
UNCLASSIFIED
Page 49 of 86
R-1 Line #13
Volume 1b - 262

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 **/** 2	**R-1 Program Element (Number/Name)** PE 0602146A **/** *Network C3I Technology*	**Project (Number/Name)** AT2 **/** *Subterranean Detection and Monitoring Technology*

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 50 of 86

R-1 Line #13

Volume 1b - 263

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AT7 *I Network-Enabled GeoSpatial-GEOINT Services Tech*		

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
AT7: *Network-Enabled GeoSpatial-GEOINT Services Tech*	-	2.869	3.855	4.635	-	4.635	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops a revolutionary, integrated capability to rapidly share mission critical 3-dimensional (3D) information that supports planning and execution at the Soldier level. This will be achieved through the maturation of next-generation geospatial analytical models for 3D complex urban environment data, delivering enriched understanding of dynamic Operational Environments and distributed to a tactical Common Operating Environment. This Project will result in improved situational awareness and autonomy at low echelons, contributing to increased maneuver and mobility during manned and unmanned teaming operations.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AT8 (Network-Enabled GeoSpatial and GEOINT Services AdvTech).

The work cited 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 Engineer Research and Development Center (ERDC) and coordinated with the United States Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Geo-registration, Analytical Tool Development and Visualization	2.869	2.897	2.415
Description: This effort investigates the design and formulation of new urban terrain data models, frameworks and processes to automate the geo-registration of 3D and 2-dimensional (2D) source data (e.g. light detection and ranging (LiDAR), imagery, Open Street Maps, and full motion video derived data) to new model constructs for rapid alerting to changes in the Operational Environment of interest. *FY 2021 Plans:* Complete research and design of an advanced 3D data processing framework and algorithms for co-registration of disparate sources of time sensitive, tactical unit generated 3D geospatial data for incorporating into the unit?s tactical foundation terrain dataset. *FY 2022 Plans:* Will advance the investigation of automated 3D data geo-registration techniques, and advance the development co-registration software algorithms applied to multi-temporal 3D terrain data sets. *FY 2021 to FY 2022 Increase/Decrease Statement:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AT7 *I Network-Enabled GeoSpatial-GEOINT Services Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Funding decrease reflects planned lifecycle progression of transitioning work to advanced technology development PE 0603463A Project AT8.			
Title: Geospatial Data for Tactical Visualization *Description:* This effort develops new open source software, data models and processes to generate a vision-based geospatial foundation layer to enable end-users systems to visualize real-time mission critical geospatial content at the required level-of-detail (LOD) and enable position-navigation self-localization capability applicable to end-user devices at required accuracies optimized for the device, application, and mission. *FY 2021 Plans:* Investigate new geospatial data models for 3D urban terrain supporting the generation of a vision-based foundation layer enabling end-user's systems to visualize real-time mission critical geospatial content at the required level-of-detail (LOD). *FY 2022 Plans:* Will develop lightweight tools consistent with the Common Operating Environment computing environments for analytics, tiling, and streaming of 3D data. Will investigate the integration of new geospatial data models that support 3D visualization, analysis and localization from a single source on tactical computing devices. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase will support focused development of 3D visualization, analysis and localization from a single source on tactical computing device.	-	0.958	2.220
Accomplishments/Planned Programs Subtotals	2.869	3.855	4.635

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 2				**R-1 Program Element (Number/Name)** PE 0602146A I *Network C3I Technology*						**Project (Number/Name)** AT9 I *Tactical GeoSpatial Information Capabilities Techn*	

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
AT9: *Tactical GeoSpatial Information Capabilities Techn*	-	2.657	4.085	1.776	-	1.776	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops next generation geospatial analytical tools for 3-dimensional complex environments for low echelon and tactical edge exploitation. Research focuses on improving geospatial and Geospatial Intelligence (GEOINT) aspects of situational awareness at the tactical edge in the complex environment by exploiting new data sources, automating analytical tasks, and testing new collection technologies, including interiors of infrastructure. Research develops capabilities to enhance/update provisioned (baseline) standard, sharable, geospatial foundation (SSGF) data through automated analytics on multi-sourced spatial data resulting in streamlined, enhanced high fidelity terrain analysis products. Reducing data gaps and processing timelines will greatly increase Soldier situational awareness and support faster decision making in complex terrain.

Work in this Project complements PE 0603463A Network C3I Advanced Technology Project AU1 (Tactical GeoSpatial Information Capabilities Adv. Tech).

The work cited 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 Engineer Research and Development Center (ERDC) and coordinated with the United State Army Futures Command

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: 3D Terrain Analysis	1.275	2.654	1.776
Description: This effort investigates and develops software models and workflows provisioned on the geospatial and GEOINT workstations for improved capabilities to generate, process and exploit terrain products enabling situational awareness and rapid decision making at the tactical edge. ***FY 2021 Plans:*** Research enhanced terrain processing algorithms to rapidly process higher resolution data (spatial and temporal), generating time sensitive geospatial products supporting tactical maneuver and protection in complex terrain. ***FY 2022 Plans:*** Will develop improved collection and processing of complex 3D urban terrain increasing processing time and accuracy, leveraging evolutionary improvements to airborne, ground-level, and interior, subterranean mapping collection capabilities. ***FY 2021 to FY 2022 Increase/Decrease Statement:***			

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 53 of 86

R-1 Line #13

Volume 1b - 266

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602146A I *Network C3I Technology*	**Project (Number/Name)** AT9 I *Tactical GeoSpatial Information Capabilities Techn*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Funding decrease reflects planned lifecycle progression in transitioning work to advanced technology development PE 0603463A Project AU1.			
Title: Airborne Light Detection and Ranging (LiDAR) *Description:* This effort investigates and develops enhanced Geiger-mode LiDAR hardware/software, for advanced testing of protocols, equipment, and products for improved high-altitude/wide area terrain data collection, to support tactical operations. *FY 2021 Plans:* Research airborne LIDAR signal processing algorithms and calibration model frameworks, tailored for higher resolution 3D data collections over large areas, providing for extended collection stand-off and enhanced surface feature classification accuracies. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding decrease reflects planned lifecycle progression of work to advanced technology development PE 0603463A Project AU1.	1.382	1.431	-
Accomplishments/Planned Programs Subtotals	2.657	4.085	1.776

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 54 of 86

R-1 Line #13

Volume 1b - 267

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602146A I *Network C3I Technology*						Project (Number/Name) AU3 I *Geospatially Enabled Operational Design 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
AU3: *Geospatially Enabled Operational Design Technology*	-	3.166	1.413	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates, advances and develops a geospatially enabled collaborative planning environment, accessible across echelons, with capabilities that support Army Design Methodology (ADM) by providing the ability to perform conceptual planning and problem framing, supporting a greater understanding and visualization of the dynamic operational environment, a shared understanding of the operations purpose across echelons, and enhanced products to drive detailed planning (Military Decision Making Process - (MDMP) and the operational assessment process, enhancing the collaborative interaction between commanders, staffs, and unified action partners.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AU4 (Geospatially Enabled Operational Design Advanced Technology).

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

Work in this Project is performed by the United States Army Engineer Research and Development Center (ERDC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Virtual Collaborative Operational Design (GEOD) Research	1.768	1.413	-
Description: This effort investigates automation technologies to digitally visualize, create and assess critical elements of the Operational Environment required to inform the Operational Design functions, including collaborative conceptual framing of the problem by examining the differences between the current state of an operational environment and the desired end state. **FY 2021 Plans:** Examine model approaches for visualizing differences between the natural tendency of an operational environment (OE) and desired future states of relevant actors with the desired end state (military objective) to include tensions (frictions, conflicts, and competitions) between relevant actors including geographic, demographic, economic, religious, and resource consumption trends. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding decrease reflects planned lifecycle progression to advanced technology development PE 0603463A Project AU4. Effort completed in FY 2021.			
Title: Tactical Data Analysis and Visualization	1.398	-	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AU3 *I Geospatially Enabled Operational Design Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort develops a suite of data aggregation analysis and visualization capabilities allowing commanders and staffs the capability to bridge conceptual planning to deliberate planning of the Military Decision Making Process (MDMP) at echelons down to battalion.			
Accomplishments/Planned Programs Subtotals	3.166	1.413	-

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 56 of 86

R-1 Line #13

Volume 1b - 269

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AU5 *I Automated Analytics for Operational Environment*		
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**
AU5: *Automated Analytics for Operational Environment*	-	3.932	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates, advances and develops algorithms for automated extraction of relationships between the population and the operational environment. Linking the data points across multiple domains to include patterns of life will result a greater understanding of the operational environment enabling the Mission Analysis phase of detailed planning (Military Decision Making Process).

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

Work in this Project is performed by the Army Engineer Research and Development Center and coordinated with the United States Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Simultaneous Multi-Domain Data Representation	1.838	-	-
Description: This effort investigates and develops advanced capabilities to provide commanders and staff with the ability to understand and operate in multiple domains simultaneously, by proposing and validating new data models and encoding for threat actors and actions, and operational environment characterization optimized across multiple domains in the battlespace, and represented geospatially.			
Title: Automated Analysis of Multi-Domain Data	2.094	-	-
Description: This effort investigates and develops data models to support automated understanding and analysis and advanced relevancy ranking approaches to identify and prioritize knowledge gaps and contextualized results.			
Accomplishments/Planned Programs Subtotals	3.932	-	-

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 57 of 86

R-1 Line #13

Volume 1b - 270

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2					R-1 Program Element (Number/Name) PE 0602146A I Network C3I Technology					Project (Number/Name) AV3 I Foundational S&T for Network C3I 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
AV3: *Foundational S&T for Network C3I Technology*	-	-	1.927	4.657	-	4.657	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops underlying technologies applicable to artificial intelligent agents and holistic network integration as applied to, but not limited to autonomous manned-unmanned teaming for ground and air platforms. This Project also matures emerging research leading to potential technology development in areas of strategic importance to the Army in network technologies, by bringing competitively selected Universities with research teams into Technical Alliances.

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).

This work is done in coordination with PE 0603463A (Network C3I Advanced Technology), Project AV4 (Foundational S&T for Network C3I Advanced Tech).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Development of Foundational technologies for holistic network integration *Description:* This effort develops underlying technologies applicable to next generation networks and integration of the same. *FY 2021 Plans:* Investigates and researches foundational technologies focusing on autonomy, Artificial intelligence/Machine Learning as applicable to, but not limited to, holistic network integration. Investigates autonomy-related machine learning technologies, advanced teaming, and navigation/routing necessary for the Ground and Air platforms in support of the Army Modernization Priorities *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort ends in Fiscal Year 2021. Funding is partially realigned towards Development of Disruptive, Innovative Research for Emerging (DIRE) Applied Network Capabilities within this same project.	-	1.927	-
Title: Development of Disruptive, Innovative Research for Emerging (DIRE) Applied Network Capabilities *Description:* This effort develops innovative network capabilities using a rapid and agile methodology to examine feasibility of incorporation into Army network problem sets. *FY 2022 Plans:*	-	-	4.657

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 58 of 86

R-1 Line #13

Volume 1b - 271

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AV3 *I Foundational S&T for Network C3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will investigate and research innovative emerging technologies focusing on network resiliency, artificial intelligence, and autonomy enabled machine learning technologies that will be integrated into a holistic network in support an MDO enabled environment. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY22, funding for this effort increases to support the rapidly changing need for innovative network solutions to an all domain battlefield. Funding was realigned from Abrams Recapitalization, APE GA0750000, Abrams Upgrade Program.			
Accomplishments/Planned Programs Subtotals	-	1.927	4.657

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 59 of 86

R-1 Line #13

Volume 1b - 272

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

Appropriation/Budget Activity
2040 / 2

R-1 Program Element (Number/Name)
PE 0602146A / Network C3I Technology

Project (Number/Name)
AV5 / Protective Technologies

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
AV5: Protective Technologies	-	6.520	7.411	7.549	-	7.549	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops tools, devices, and techniques to protect acquisition program systems and Critical Program Information (CPI) from adversarial threats.

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: Protective Technologies	6.520	7.411	7.549

Description: This effort develops tools, devices, and techniques to protect acquisition program systems and (CPI) from adversarial threats.

FY 2021 Plans:
Develop Rigor 1b second engineering model for laboratory characterization and application part qualification activities; develop initial designs for additional Rigor modules; evaluate commercial and other Government agency security solutions for AT enhancement; and develop next generation Systems Engineering Development tailored for DoD Rapid Acquisition systems.

FY 2022 Plans:
Will develop additional technologies focused on the latest adversarial threats being faced by Army programs. Evaluate the technology protection requirements of Army and DoD programs; and develop technologies to assist those programs in maintaining their technological overmatch capabilities.

FY 2021 to FY 2022 Increase/Decrease Statement:
Funding change reflects planned lifecycle of this effort.

Accomplishments/Planned Programs Subtotals	6.520	7.411	7.549

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

D. Acquisition Strategy
N/A

PE 0602146A: Network C3I Technology
Army

UNCLASSIFIED
Page 60 of 86

R-1 Line #13

Volume 1b - 273

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602146A I Network C3I Technology						Project (Number/Name) AV6 I Airborne Engineering Support 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
AV6: Airborne Engineering Support Technology	-	0.846	0.866	-	-	-	-	-	-	-	-	-

Note
Project terminated in Fiscal Year (FY) 2022 and funding is realigned to:
Program Element (PE) 0602463A (Network C3I Adv Technology) Project C17 (Mobile and Survivable Command Post (MASCP) Adv Tech)

A. Mission Description and Budget Item Justification
This Project supports advanced Command, Control, Communications, Intelligence, Surveillance and Reconnaissance (C3ISR) research and development technologies for airborne, and air-to-ground based testing of emerging Radio Frequency (RF) technologies.

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: Airborne Engineering Support Technology **Description:** This effort supports the experimentation of new and emerging C3ISR technologies. This venue performs technology assessments by evaluating candidate technologies in support of the Army Modernization Priorities. Events are determined by the maturity of the tech base programs across the Army?s Science and Technology (S&T) C3ISR portfolio. ***FY 2021 Plans:*** Evaluate performance of S&T technologies developed to provide robust and adaptive intelligence, electronic support, and electronic warfare capabilities. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort terminates in FY21, and funding is realigned to Program Element (PE) 0603463A (Network C3I Advanced Technology) Project CI7 Mobile and Survivable Command Post (MASCP) Adv Tech).	0.846	0.866	-
Accomplishments/Planned Programs Subtotals	0.846	0.866	-

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

PE 0602146A: Network C3I Technology
Army

UNCLASSIFIED
Page 61 of 86

R-1 Line #13

Volume 1b - 274

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AV6 *I Airborne Engineering Support Technology*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 62 of 86

R-1 Line #13

Volume 1b - 275

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 / 2				**R-1 Program Element (Number/Name)** PE 0602146A / *Network C3I Technology*						**Project (Number/Name)** AV7 / *Atmospheric Modeling and Meterological 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
AV7: *Atmospheric Modeling and Meterological Technology*	-	5.573	5.918	5.931	-	5.931	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops tactical atmospheric sensing, modeling, and decision support technologies. New atmospheric sensing technologies are developed that enable near-real-time, high-resolution measurements of atmospheric parameters via light-weight systems that can be employed in tactical domains. Efforts include high-resolution local assessments and forecasts of meteorological conditions that can accommodate the effects of dense urban and complex, mountainous terrain. Both physics-based and rule-based decision support systems are developed for assessing the impacts of weather/atmosphere across a spectrum of friendly and threat weapons systems, sensors, platforms, and operations. It provides detailed model applications for various effects of the atmosphere on electro-optical and acoustic target detection, location, and identification. Information can be applied to mission planning and execution, battlefield visualization, reconnaissance, surveillance, and target acquisition, route planning to maximize stealth and efficiency, web-enabled tactical decision aids, long-range precision fires, and modeling of environmental impacts for combat simulations and war games.

This work provides technologies for evaluation by and/or transitions to the Department of Defense weather and operations community including: Program Executive Office (PEO) Ammunition-PM Combat Ammunition Systems (CAS) and Marine Corps Systems Command (MCSC) for meteorological message input to field artillery targeting systems, Project Manager, Distributed Common Ground System-Army (DCGS-A), the US Air Force 557th Weather Wing, and the Air Force Life Cycle Management Center (AFLCMC) to improve their operational weather support to the Army.

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: Atmospheric Characterization, Modeling, and Impacts **Description:** This effort develops environmental situational understanding enabled though coupled sensing, modeling, and decision support technologies for data-sparse, computationally-limited, and network-constrained domains. **FY 2021 Plans:** Implement and assess machine learning techniques applied to path optimization (air and surface) through atmospheric hazards including strategic-level solutions (e.g. climatological time-scales) and obstacles; implement and assess machine learning techniques applied to environmental effects on directed energy propagation, including strategic-level solutions (e.g. climatological time-scales); conduct validation study of Atmospheric Boundary Layer Environment Lattice-Boltzmann Method (ABLE-LBM) forecast model over forested, complex terrain using observational data from the Perdig?o, Portugal field experiment; establish	5.573	5.918	5.931

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 63 of 86

R-1 Line #13

Volume 1b - 276

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AV7 *I Atmospheric Modeling and Meterological Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
robust radar and satellite data assimilation capabilities for use with numerical weather prediction models such as Weather Running Estimate - Nowcast (WRE-N); utilizing database of sub-km WRE-N model simulations over the Meteorological Sensor Array (MSA) and Design of Experiments expertise, quantify the primary sources of model uncertainty and loss of predictability in sub-km numerical weather prediction; optimize Doppler Light Detection and Ranging (LiDAR) wind retrieval algorithms for low-power and low-computer architectures/platforms; implement viable range-dependent environmental input techniques into a next-generation acoustic propagation decision support tool to augment threat detection; and employ surrogate models for physical self-awareness for autonomous flight of unmanned aerial vehicles (UAVs) to incorporate differing, static weather conditions; adapt surrogate models for use on resource-constrained usage on computer hardware on UAVs. *FY 2022 Plans:* Will conduct validation study of Atmospheric Boundary Layer Environment Lattice-Boltzmann Method (ABLE-LBM) in urban domains and mature LiDAR and radar assimilation methods building from initial Perdigo, Portugal field experiment data; develop and implement improved atmospheric acoustic propagation model with range dependence; investigate applicability of machine learning modeling based on heterogeneous sensor input to inform situational awareness; investigate machine algorithms to characterize and assess aerosols; experiment with the use of surrogate models to quantify uncertainty of impactful environmental conditions for autonomous flight of unmanned aerial systems (UASs); and investigate assimilation of multi-UAS sensing as constraints in simplified-physics or other surrogate models designed for low-resource platforms. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	5.573	5.918	5.931

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 64 of 86

R-1 Line #13

Volume 1b - 277

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2						**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** AV9 *I Advanced PNT for GPS Independent Environments Tech*	

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
AV9: *Advanced PNT for GPS Independent Environments Tech*	-	6.687	6.656	10.129	-	10.129	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops technologies that will enable precise and assured Positioning, Navigation, and Timing (PNT) in Global Positioning System (GPS)-denied environments. This Project develops technologies addressing the PNT's toughest Scenario - Scenario 4 (no available GPS signal during the mission duration) with a goal of enabling Soldier missions of up to seven days in a GPS denied environment. This is achieved with research addressing advanced quantum timing circuits, advanced inertial measurement unit (IMU) components, multi-sensor modalities, perception techniques, geo-location data, vision aided navigation sensors, and available radio frequency (RF) signals.

This research also addresses the PNT Scenario 1 (GPS operations that start well and have degraded GPS signals throughout the mission duration) through Scenario 3 (GPS operations that have bad or limited availability of GPS signals throughout the entire mission). This is achieved with research addressing the ability to transmit jam-resistant, precision timing synchronized signals using optical fibers, free-space using lasers, and in the RF domain using innovative RF antenna concepts to extend the reach of Soldier compatible capabilities in heavily contested GPS environments.

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: Precision Measurement Technology for Contested Environments	2.898	3.054	3.084
Description: This effort will develop technologies that will enable precise and assured PNT in GPS-denied environments for up to 1 hour. This research will improve the accuracy while also focusing on size, weight, power, cost (SWAP-C) of current IMUs through the design, fabrication, and assessment of novel micro-electromechanical system (MEMS) sensor designs and materials and the integration of multiple sensor modalities with the IMUs using sensor fusion and perception techniques to reduce drift and increase positional accuracy. Research will also include the ability to transmit jam-resistant precision position, navigation, and timing signals via electro-optical and/or RF transmission methods. *FY 2021 Plans:* Implement refined designs based on prior modeling for novel MEMS IMUs using advanced MEMS materials and micro-structures; develop and assess advanced micro-structures demonstrating improved MEMS IMU accuracy; validate algorithms enabling vision-based geo-localization, and improve drift correction techniques on the performance of MEMS IMU operations in representative operational environments (temperature and vibration); develop chip-scale, low-noise stabilized frequency source			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602146A / Network C3I Technology	Project (Number/Name) AV9 / Advanced PNT for GPS Independent Environments Tech

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
based on integrated electro-optic frequency combs for SWaP-C constrained timing methods; and develop system models for multi-node, anti-jam performance in the 600 MHz to 6 GHz and 24-86 GHz bands. *FY 2022 Plans:* Will iterate designs, fabricate, and validate performance of novel MEMS IMUs using advanced MEMS materials and micro-structures to develop path to low cost navigation grade MEMS IMUs accuracy and improved drift correction techniques in representative operational environments (temperature and vibration); study performance of chip-scale, low-noise stabilized frequency sources and integrated electro-optic frequency combs for low SWAP-C atomic clock designs to assess improved clock stability over relevant operating environments; develop algorithms to implement RF sources of opportunity and multi-sensor/multi-waveband vision-based geo-localization and validate their performance on the PNT testbed; perform laboratory and relevant environment performance validation of low SWAP multi-node, anti-jam reception/operations of both GPS and 5G operations. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Title: Quantum Effects for Assured PNT in Zero-GPS Environments *Description:* This effort will conduct research on size, weight, power, and cost (SWAP-C) quantum based timing sub-systems, incorporating advanced sensors, RF signals (beyond GPS), navigation databases, and advanced algorithms. This effort incorporates advanced quantum timing circuits, advanced IMU components, multi-sensor modalities, perception techniques, geolocation data, vision aided navigation sensors, and available RF signals in order to increase precise and assured PNT operations in a GPS denied environments for up to 7 days. *FY 2021 Plans:* Refines quantum based timing designs with modeled performance and representative operational environments, targeting improved performance for a chip-scale atomic clock; develops and assesses materials growth to enable blue laser required for quantum based timing design; integrates a minimum of three heterogeneous sensor modalities into an embedded hybrid multi-sensor fusion engine with continuous Inertial Navigation System (INS) calibration capable of interfacing with the Department of Defense PNT Open Architecture standards; and integrates and assesses a multi-modal, inertial navigation capability to validate the multi-sensor fusion engine and perform continuous INS calibration in a relevant environments. *FY 2022 Plans:* Will assess high performance and reasonable SWAP atomic clock for platform and increased performance network applications and iterate design to increase hardening and manufacturability; will validate initial designs of low cost (<$300 per unit) SWAP Chip-Scale Atomic Clock 2.0 (CSAC 2.0) for Soldier and small platform and munition applications; will iterate design, fabricate, and validate performance of first low cost SWAP CSAC 2.0; will investigate transition of government gyro designs (sub-component of high performance IMUs) to commercial partners to accelerate maturity of advanced government gyro capability; will validate a	3.789	3.602	7.045

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AV9 *I Advanced PNT for GPS Independent Environments Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
minimum of three heterogeneous sensor modalities into an embedded hybrid multi-sensor fusion engine with continuous Inertial Navigation System (INS) calibration capable of interfacing with the Department of Defense PNT Open Architecture standards; will validate multi-sensor fusion engine and perform continuous INS calibration in a relevant environment using the additional capability of the high performance and reasonable SWAP atomic clock to assess potential performance improvements of PNT calculations during GPS contested events. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Planned increase in funding to develop hardened and, manufacturable atomic clock technologies.			
Accomplishments/Planned Programs Subtotals	6.687	6.656	10.129

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 67 of 86

R-1 Line #13

Volume 1b - 280

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

Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*				**Project (Number/Name)** AW1 *I Autonomous Navigation 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**
AW1: *Autonomous Navigation Technology*	-	0.384	1.732	2.080	-	2.080	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates use of sensors on the platform and available navigation signals to the localization and decision making of Robotic/Autonomous Systems. Additionally, it examines the use of machine learning algorithms for cooperative navigation to aid in a Positioning, Navigation and Timing (PNT) solution. This will enable the user to achieve operational overmatch in a Global Positioning System (GPS) impeded environment as well as enhanced navigation (reducing dependence on GPS) through challenging terrains. This project investigates and develops techniques and algorithms to provide assured access to PNT in degraded electromagnetic (jamming), space, or cyber environments and notifiy Soldiers, Systems, and Platforms when PNT cannot be trusted for mission duration

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) / Project AV8 (Navigation Warfare Advanced Technology)

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Autonomous Navigation Technology	0.384	-	-
Description: This effort leverages Assured PNT efforts that improve localization and decision making of Robotic/Autonomous Systems by optimizing use of sensors on the platform and taking advantage of all available navigation signals. It examines the use of machine learning algorithms for cooperative navigation to aid in a PNT solution.			
Title: Intelligent Electronic Protect (IEP)	-	1.732	2.080
Description: This effort provides assured access to PNT in degraded electromagnetic (jamming), space, or cyber environments;notifies Soldiers, Systems, and Platforms when PNT cannot be trusted for mission duration; provides Soldiers, Systems, and Platforms a reduction in the likelihood of being spoofed for mission duration; provides unhindered access to military Global Positioning System (GPS) level of accuracy when access to military GPS is unavailable; and facilitates graceful degradation of PNT systems when military GPS is denied or degraded. *FY 2021 Plans:* Investigate assured access to PNT in degraded electromagnetic (jamming), space, or cyber environments; validate unhindered access to military Global Positioning System (GPS) level of accuracy when access to military GPS is unavailable. *FY 2022 Plans:*			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AW1 *I Autonomous Navigation Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will continue to investigate assured access to PNT in contested electromagnetic environments; and validate unhindered access to military Global Positioning System (GPS) level of accuracy. Will develop techniques to detect and identify radio frequency (RF) signals on a PNT system with minimal additional hardware. Will begin algorithm development to enhance integrity and graceful degradation in challenged environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned life cycle of this effort to begin algorithm development in challenged environments.			
Accomplishments/Planned Programs Subtotals	0.384	1.732	2.080

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 69 of 86

R-1 Line #13

Volume 1b - 282

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602146A I *Network C3I Technology*					**Project (Number/Name)** AW3 I *DoD PNT M&S Collaborative Initiative (CI) Technolo*		

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
AW3: *DoD PNT M&S Collaborative Initiative (CI) Technolo*	-	1.918	1.925	-	-	-	-	-	-	-	-	-

Note

This project efforts has concluded in Fiscal Year (FY) 2021 so there will be no funding request for FY 2022.

A. Mission Description and Budget Item Justification

This Project designs and develops Positioning, Navigation and Timing (PNT) modeling and simulation (M&S) frameworks and tools to provide Department of Defense (DoD) with the capability to conduct analysis and create quantifiable data on the impact of PNT technologies on warfighters and missions operating in a denied or degraded Global Positioning System (GPS) environment. Additionally, it provides senior leadership with the information required to understand the value of PNT investment versus the improvement in mission performance and operational effectiveness. This Project also assess the effectiveness and maturity of complementary PNT systems/sensors.

Work in this Project complements PE 0603463 (Network C3I Advanced Technology) / Project AW4 (DoD PNT M&S Collaborative Initiative Adv Tech).

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: DoD PNT M&S Collaborative Initiative (CI)	1.918	1.925	-
Description: This effort designs and develops PNT M&S frameworks and tools to provide DoD with the capability to conduct analysis and create quantifiable data on the impact of PNT technologies on warfighters and missions operating in a denied or degraded GPS environment. Additionally, it provides Senior leadership with the information required to understand the value of PNT investment versus the improvement in mission performance and operational effectiveness. This effort also assess the effectiveness and maturity of complementary PNT systems/sensors. *FY 2021 Plans:*			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** AW3 *I DoD PNT M&S Collaborative Initiative (CI) Technolo*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Complete the design and development of an architecture, framework, catalogue, repository and models for complementary PNT technologies; and produce final technical reports documenting the federated Tri-service M&S capability. Completed M&S capability will be integrated into Army, Navy, and Air Force M&S environments.			
FY 2021 to FY 2022 Increase/Decrease Statement: This effort completes in FY21.			
Accomplishments/Planned Programs Subtotals	1.918	1.925	-

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 71 of 86

R-1 Line #13

Volume 1b - 284

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

| Appropriation/Budget Activity
2040 *I* 2 | | | | R-1 Program Element (Number/Name)
PE 0602146A *I Network C3I Technology* | | | | Project (Number/Name)
AW5 *I Modular GPS Independent Sensors
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
AW5: *Modular GPS Independent Sensors Technology*	-	3.969	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project performs research and development of modular Global Positioning System (GPS)-independent sensors and an open architecture sensor fusion core enabling simple, plug-and-play sensor modules that can be tailored for any platform based on mission needs and requirements.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AW6 (Modular GPS Independent Sensors Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Modular GPS Independent Sensors *Description:* This effort performs research and development of modular GPS-independent sensors and an open architecture sensor fusion core enabling simple, plug-and-play sensor modules that can be tailored for any platform based on mission needs and requirements.	3.969	-	-
Accomplishments/Planned Programs Subtotals	3.969	-	-

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 / 2				**R-1 Program Element (Number/Name)** PE 0602146A / Network C3I Technology					**Project (Number/Name)** BP2 / Sensor and Electronic Network 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**
BP2: *Sensor and Electronic Network Initiatives (CA)*	-	23.500	90.500	-	-	-	-	-	-	-	-	-

Note
 Congressional Interest Item funding provided for Sensor and Electronic Network Initiatives.

A. Mission Description and Budget Item Justification
 Congressional Interest Item funding provided for Sensor and Electronic Network 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: Small Satellite Technology	3.000	-
FY 2020 Accomplishments: Program Increased to support applied research on Small Satellite Technology. Work executed under the direction of the Army Futures Command.		
Congressional Add: Radioisotope Power Systems	2.500	-
FY 2020 Accomplishments: Program Increased to support applied research on Radioisotope Power Systems. Work executed under the direction of the Army Futures Command.		
Congressional Add: Anti-Tamper Technology Development	10.000	-
FY 2020 Accomplishments: Program Increased to support applied research on Anti-Tamper Technology Development. Work executed under the direction of the Army Futures Command.		
Congressional Add: Next Generation Synthetic Aperture	5.500	-
FY 2020 Accomplishments: Program Increased to support applied research on Next Generation Synthetic Aperture.		

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** BP2 *I Sensor and Electronic Network Initiatives (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed under the direction of the Army Futures Command.		
Congressional Add: Sensing Technologies for Rapid Hazard Detection	2.500	-
FY 2020 Accomplishments: Program Increased to support applied research on Sensing Technologies for Rapid Hazard Detection. Work executed under the direction of the Army Futures Command.		
Congressional Add: Program increase - inertial navigation systems	-	10.000
FY 2021 Plans: Conduct applied research in Inertial Navigation Systems. Work executed by Army Futures Command.		
Congressional Add: Program increase - APNT for autonomous vehicles	-	5.000
FY 2021 Plans: Conduct applied research in APNT for Autonomous Vehicles. Work executed by Army Futures Command.		
Congressional Add: Program increase - CHARM	-	5.000
FY 2021 Plans: Conduct applied research in CHARM. Work executed by Army Futures Command.		
Congressional Add: Program increase - energy efficient devices	-	5.000
FY 2021 Plans: Conduct applied research in Energy Efficient Devices. Work executed by Army Futures Command.		
Congressional Add: Program increase - integrating energy and computing networks	-	10.000
FY 2021 Plans: Conduct applied research in Integrating Energy and Computing Networks. Work executed by Army Futures Command.		
Congressional Add: Program increase - artificial intelligence and machine learning electronic warfare sensor technology	-	10.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** BP2 *I Sensor and Electronic Network Initiatives (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
FY 2021 Plans: Conduct applied research in Artificial Intelligence and Machine Learning Electronic Warfare Sensor Technology. Work executed by Army Futures Command.		
Congressional Add: Program increase - APNT distributed antennae	-	20.000
FY 2021 Plans: Conduct applied research in APNT Distributed Antennae. Work executed by Army Futures Command.		
Congressional Add: Program increase: Urban subterranean mapping technology	-	4.000
FY 2021 Plans: Conduct applied research in Urban Subterranean Mapping Technology. Work executed by Army Futures Command.		
Congressional Add: Program increase: Unmanned sensors for biological and chemical hazards	-	2.000
FY 2021 Plans: Conduct applied research in Unmanned Sensors for Biological and Chemical Hazards. Work executed by Army Futures Command.		
Congressional Add: Program increase: Mobile environmental contaminant sensors	-	8.000
FY 2021 Plans: Conduct applied research in Mobile Environmental Contaminant Sensors. Work executed by Army Futures Command.		
Congressional Add: Program increase: Multi?UAS integrated ISR technology	-	3.000
FY 2021 Plans: Conduct applied research in Multi-UAS Integrated ISR Technology. Work executed by Army Futures Command.		
Congressional Add: Program increase: Autonomous platform threat detection sensors	-	6.000
FY 2021 Plans: Conduct applied research in Autonomous Platform Threat Detection Sensors. Work executed by Army Futures Command.		
Congressional Add: Program increase: Intelligent electronic protection technology	-	2.500

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 75 of 86

R-1 Line #13

Volume 1b - 288

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** BP2 *I Sensor and Electronic Network Initiatives (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
FY 2021 Plans: Conduct applied research in Intelligent Electronic Protection Technology. Work executed by Army Futures Command.		
Congressional Adds Subtotals	23.500	90.500

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 76 of 86

R-1 Line #13

Volume 1b - 289

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army							**Date:** May 2021					
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** BZ6 *I Narrowband SATCOM 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**
BZ6: *Narrowband SATCOM Technology*	-	-	0.963	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops technologies to enable Army Narrowband Satellite Communications (SATCOM) networks to control traditional military tactical SATCOM along with non-traditional networks, such as commercial networks, to enable adaptability of the narrowband SATCOM network in a contested environment.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology) Project AN2 (Narrowband SATCOM Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Narrowband Satellite Communication Technology	-	0.963	-
Description: This project designs and develops technologies to enable Army Narrowband Satellite Communications (SATCOM) networks to control traditional military tactical SATCOM along with non-traditional networks, such as commercial networks, to enable adaptability of the narrowband SATCOM network in a contested environment. *FY 2021 Plans:* Develop emulator configuration and develop an agile, network-defined architecture that enables gateway communications across Narrowband SATCOM networks; and develop system engineering documentation and user documentation for the architecture. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort completes in Fiscal Year (FY) 2021			
Accomplishments/Planned Programs Subtotals	-	0.963	-

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* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*				**Project (Number/Name)** BZ8 *I Aerial Teir Networking (High Altitude)*			
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**
BZ8: *Aerial Teir Networking (High Altitude)*	-	-	0.385	-	-	-	-	-	-	-	-	-

Note

Project terminates in Fiscal 2022, and funding is realigned to:
Program Element (PE) 0602146A (Network C3I Technology)
* Project AN3 (Non Traditional Waveforms)

This Project designs and develops technologies for aerial networking to establish line of sight and beyond line of sight communications.
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).

A. Mission Description and Budget Item Justification

This Project designs and develops technologies for aerial networking to establish line of sight and beyond line of sight communications.

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: Aerial Tier Networking (High Altitude)	-	0.385	-
Description: Develop a Wideband Global Satellite Communications (WGS) surrogate payload for usage on a High Altitude Platform (HAP) with seamless transition to existing ground terminals by modifying existing solutions to support Network Modernization Capability Sets (CS) beginning with CS23 - Capacity & Resiliency. **FY 2021 Plans:** Investigate the capability, performance parameters and operational requirements which can be achieved without changing existing SATCOM terminals and modems. **FY 2021 to FY 2022 Increase/Decrease Statement:** In FY22 funding realigned from PE 062146A Network C3I Technology Project AN3 (Non Traditional Waveforms Technology) for 5G Technologies research.			
Accomplishments/Planned Programs Subtotals	-	0.385	-

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 78 of 86

R-1 Line #13

Volume 1b - 291

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** BZ8 *I Aerial Teir Networking (High Altitude)*

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 79 of 86

R-1 Line #13

Volume 1b - 292

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602146A I Network C3I Technology					Project (Number/Name) CG3 I Assured PNT Communications Applied 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
CG3: Assured PNT Communications Applied Research	-	-	-	1.726	-	1.726	-	-	-	-	-	-

Note

In Fiscal Year 2022, this project is realigned from PE0602146A Project AO5 (Tag, Track, and Locate Small Satellites Technology).

A. Mission Description and Budget Item Justification

Tactical Land Component Forces require access to Space and High Altitude capabilities to enable force projection and maneuver during Multi-Domain Operations. Space and High Altitude sensors provide resilient communications, assured PNT and deep sensing capabilities required in the targeting process to enable rapid and responsive sensor-to-shooter applications to engage and defeat Anti-Access/Area Denial (A2/AD) forces.

Assured Positioning Navigation and Timing (APNT) Applied Research PE designs and develops technologies for Space-Based and High Altitude applications to support Army tactical ground forces. Efforts include the design and development of sensors and electronic components for communications, signal and information processing, target acquisition, position/ navigation, and threat warning within Space and High Altitude environments. Investigations conducted leverage other Department of Defense (DoD) space science and technology applications to support Army space force enhancement and cooperative satellite payload development.

Work complements PE 0603463A (Network C3I Advanced Technology) Project CJ8 (Assured PNT Communications Advanced Tech). The work cited 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 Space and Missile Defense Command (USASMDC) in Huntsville, AL.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Assured PNT Communications Applied Research Description: This effort will design, develop, and validate Space and High Altitude technologies, components, and tools that lead to smaller, lighter, more responsive payloads and applications. These technologies will allow for the rapid integration and development of tactical payloads in support of responsive Space or High Altitude environments. FY 2022 Plans: Validate payload technologies in the lab to provide tactical land component forces with Space and High Altitude capabilities for force projection and maneuver during Multi-Domain Operations.	-	-	1.726

PE 0602146A: Network C3I Technology
Army

UNCLASSIFIED
Page 80 of 86

R-1 Line #13

Volume 1b - 293

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** CG3 *I Assured PNT Communications Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Maturation of quantum science-based crosslink communications, sensing, and data teleportation. Conduct a series of progressive tests assessing and verifying photonic information components for Space/HA sensor or Deep Sensing capabilities. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In Fiscal Year 2022, this project is realigned from PE 0602146A Project AO5 (Tag, Track, and Locate Small Satellites Technology).			
Accomplishments/Planned Programs Subtotals	-	-	1.726

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 81 of 86

R-1 Line #13

Volume 1b - 294

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602146A I *Network C3I Technology*						**Project (Number/Name)** CI3 I *Mobile and Survivable Command Post (MASCP) Tech*	

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
CI3: *Mobile and Survivable Command Post (MASCP) Tech*	-	-	-	6.236	-	6.236	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project is realigned from:
Program Element (PE) 0602146A (Network C3I Technology) Project AQ9 (Expeditionary Data to Decisions Technology)
Program Element (PE) 0602213A (C3I Applied Cyber) Project CY8 (Cyber Security App Research and Exper Partner Tech)

A. Mission Description and Budget Item Justification

This Project develops and investigates emerging communications, tactical cloud, distributed computing, power management and storage, and shielding materials necessary to improve Command Post (CP) survivability and effectiveness for near-peer Multi-Domain Operations (MDO) engagements.

Work in this Project complements PE 0603463A (Network C3I Advanced Technology), Project CI7 (Mobile and Survivable Command Post (MASCP) Adv Tech).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: CP Modularity and Dispersion Technology	-	-	4.146
Description: Funds research to enable CP?s to reconfigure and reconstitute at speeds consistent with a near-peer MDO engagement. Investigates emerging low probability of interception (LPI)/low probability of detection (LPD) radio technologies, distributed computing, tactical data and security architectures, and distributed collaboration methods. Initiates analysis to develop mobile, and integrated power systems that enable CP?s to disperse geographically and create extended at-the-halt and on-the-move command and control.			
FY 2022 Plans: Will conduct gap and threat analysis of peer competitors; initiate market survey?s across the technology sectors applicable to CP survivability (e.g., resilient communications, adaptable computing infrastructure, advanced energy sources and smart distribution).			
FY 2021 to FY 2022 Increase/Decrease Statement:			

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 82 of 86

R-1 Line #13

Volume 1b - 295

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602146A I *Network C3I Technology*	**Project (Number/Name)** CI3 I *Mobile and Survivable Command Post (MASCP) Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding in this effort was realigned from Program Element (PE) 0602146A (Network C3I Technology) Project AQ9 (Expeditionary Data to Decisions Technology).			
Title: Signature Management and Reduction Technology *Description:* Develops electromagnetic spectrum (EMS) management tools to model CP signatures and optimize the employment of CP nodes and communication assets. *FY 2022 Plans:* Will validate threat capability and develop electromagnetic spectrum models of threat and friendly emissions. Implement a software model that visualizes CP emissions and conduct user design workshops that inform EMS signature management options. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding in this effort is realigned from Program Element (PE) 0602213A (C3I Applied Cyber) Project CY8 (Cyber Security App Research and Exper Partner Tech).	-	-	1.392
Title: Technology Supporting Camouflage, Concealment, and Deception *Description:* This effort matures innovative camouflage, concealment and deception technologies for expeditionary high-value assets to defeat advanced current and emerging adversary Intelligence, Surveillance and Reconnaissance (ISR) threats, and to reduce the probability of detection in multi-domain operations. Matures physics-based models for material and system performance that support probability of detection metrics in the multi-domain operational environment, assisting in closing the capability gap between current camouflage, concealment and deception technologies and defeating enemy sensorial capabilities in future operating environments. *FY 2022 Plans:* Will investigate the use of natural fibers for use in camouflage materials; investigate the use of various materials for use in the physical assets to achieve more accurate signatures; conduct a feasibility study of active sensor identification systems; and investigate improvements to current CP infrastructure through the development of material solutions that will enable rapid set-up/ tear down times, allow for longer loiter times and provide greater protection of command post structures and enclosures. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding in this effort was realigned from Program Element (PE) 0602146A Project AQ9 Expeditionary Data to Decisions Technology.	-	-	0.698
Accomplishments/Planned Programs Subtotals	-	-	6.236

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 83 of 86

R-1 Line #13

Volume 1b - 296

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** CI3 *I Mobile and Survivable Command Post (MASCP) Tech*

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 84 of 86

R-1 Line #13

Volume 1b - 297

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*					**Project (Number/Name)** CK1 *I Assured PNT Enabling Technologies*		
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**
CK1: *Assured PNT Enabling Technologies*	-	-	-	1.926	-	1.926	-	-	-	-	-	-

Note
Project is realigned from PE0602146A AO5 (Tag, Track, and Locate Small Satellites Technology).

A. Mission Description and Budget Item Justification

Tactical Land Component Forces require access to Space and High Altitude capabilities to enable force projection and maneuver during Multi-Domain Operations. Space and High Altitude sensors provide resilient communications, assured PNT and deep sensing capabilities required in the targeting process to enable rapid and responsive sensor-to-shooter applications to engage and defeat Anti-Access/Area Denial (A2/AD) forces.

Assured Positioning Navigation and Timing (APNT) Enabling Technologies PE investigates and matures technologies for Space-Based and High Altitude applications for Army tactical ground forces. Efforts include the development of sensors and electronic components for communications, signal and information processing, target acquisition, position/ navigation, and threat warning within Space and High Altitude environments. Investigations conducted leverage other Department of Defense (DoD) space science and technology applications to support Army space force enhancement and cooperative satellite payload development. Efforts include research to mature current technologies in quantum sciences based communications, sensing, and data teleportation for small spacecraft applications.

Work complements PE 0603463A (Network C3I Advanced Technology) Project CJ8 (Assured PNT Communications Advanced Tech)

The work cited 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 Space and Missile Defense Command (USASMDC) in Huntsville, AL.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Assured PNT Enabling Technologies	-	-	1.926
Description: This effort supports validation of hardware and software components and models to further anchor laboratory capabilities enabling Space/HA sensor or Deep Sensing capabilities, payload design and development. *FY 2022 Plans:* Will design and develop an advanced laboratory testbed with the Mult-Axis Simulator (MAS) system that will be utilized to mature payloads for APNT, and optical/quantum secure communications on multiple simulated platforms simultaneously with hardware and software in the loop. Flight hardware will be designed to support delivery in early 2024 and for launch in 2025 to conduct			

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 85 of 86

R-1 Line #13

Volume 1b - 298

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602146A *I Network C3I Technology*	**Project (Number/Name)** CK1 *I Assured PNT Enabling Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
experiments of the first US Army quantum entanglement transmission of data across free space for satellite-to-satellite and/or satellite-to-ground communications.			
FY 2021 to FY 2022 Increase/Decrease Statement: New start in FY22. In Fiscal Year 2022, this project is realigned from PE0602146A AO5 (Tag, Track, and Locate Small Satellites Technology).			
Accomplishments/Planned Programs Subtotals	-	-	1.926

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

D. Acquisition Strategy
 N/A

PE 0602146A: *Network C3I Technology*
Army

UNCLASSIFIED
Page 86 of 86

R-1 Line #13

Volume 1b - 299

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 2: Applied Research					R-1 Program Element (Number/Name) PE 0602147A I Long Range Precision Fires 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
Total Program Element	-	117.395	119.007	64.285	-	64.285	-	-	-	-	-	-
AE7: Land-Based Anti-Ship Missile (LBASM) Technology	-	10.951	21.849	14.053	-	14.053	-	-	-	-	-	-
AF1: Long Range Maneuverable Fires (LRMF) Technology	-	-	-	5.033	-	5.033	-	-	-	-	-	-
AF3: Extended Range Propulsion Technology	-	5.366	6.354	9.886	-	9.886	-	-	-	-	-	-
AF5: Simulation and Aerostructures Technology	-	1.319	-	-	-	-	-	-	-	-	-	-
AF6: Structures Technology	-	1.146	-	-	-	-	-	-	-	-	-	-
AF7: Warhead Integration Technology	-	1.612	-	-	-	-	-	-	-	-	-	-
AF8: Affordable Extended Range Precision Technology	-	0.277	8.181	8.684	-	8.684	-	-	-	-	-	-
AF9: Precision and Accuracy Technology	-	7.892	-	-	-	-	-	-	-	-	-	-
AG1: Missile Electronics Technology	-	2.897	-	-	-	-	-	-	-	-	-	-
AG2: Information and Signal Processing Technology	-	1.536	-	-	-	-	-	-	-	-	-	-
AG4: Extended Range Artillery Munition Suite Technology	-	6.526	8.351	11.151	-	11.151	-	-	-	-	-	-
AG6: Energetic Materials and Advanced Processing Techno	-	6.335	3.430	3.468	-	3.468	-	-	-	-	-	-
AG8: Advanced Energetics Technology	-	9.682	-	-	-	-	-	-	-	-	-	-
AG9: Multiple Simul Engagement Technologies (MSET) Tech	-	1.978	-	-	-	-	-	-	-	-	-	-

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*							
AH2: *Single Multi-mission Attack Missile (SMAM) Technol*	-	1.212	-	-	-	-	-	-	-	-	-	-
AH4: *Precision and Coop Weapons in a Denied Env Tech*	-	8.746	9.277	9.427	-	9.427	-	-	-	-	-	-
BN5: *Fuze and Power for Munitions*	-	0.920	1.065	2.583	-	2.583	-	-	-	-	-	-
BO9: *WEAPONS & MUNITIONS TECH PROGRAM INITIATIVE (CA)*	-	49.000	60.500	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

Work in this PE investigates and develops Long Range Precision Fires (LRPF) technologies to destroy, neutralize, or suppress the enemy by cannon artillery and missile fire and enable integration of fire support assets into combined arms operations. Major Focus Areas for LRPF Science and Technology include: Missiles, Cannon Artillery, and Supporting LRPF Technologies covering Strategic, Operational and Tactical Fires Lines of Effort. LRPF Missiles Applied Research investigates and develops a broad range of Missile technologies to enhance Army integrated LRPF capabilities at extended range. Cannon Artillery Applied Research investigates and develops critical technologies to increase range, precision, and both point and area effects for cannon artillery. Supporting LRPF Technologies Applied Research investigates and develops a broad range of component technologies to address weapon cost drivers and enhance performance of future LRPF munitions and systems.

Work in this PE complements PE 0603464A (Long Range Precision Fires Advanced Technology).

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

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

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 2 of 34

R-1 Line #14

Volume 1b - 301

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 2: *Applied Research*			**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*		

B. Program Change Summary ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Previous President's Budget	120.327	60.553	65.959	-	65.959
Current President's Budget	117.395	119.007	64.285	-	64.285
Total Adjustments	-2.932	58.454	-1.674	-	-1.674
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	60.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.932	-2.046			
• Adjustments to Budget Years	-	-	-1.674	-	-1.674

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Project: BO9: *WEAPONS & MUNITIONS TECH PROGRAM INITIATIVE (CA)*		
Congressional Add: *Composite Cannon Tubes and Propulsion Technology*	10.000	-
Congressional Add: *Hybrid Projectile Technology*	6.000	-
Congressional Add: *Additive Manufacturing to Support Optimized Fires*	5.000	-
Congressional Add: *Program Increase*	20.000	-
Congressional Add: *Novel Printed Armament Components*	8.000	-
Congressional Add: *Program increase - precision strike munitions*	-	4.000
Congressional Add: *Program increase - extended range hybrid and precision gun launched projectiles*	-	15.000
Congressional Add: *Program increase - novel printed armament components*	-	6.500
Congressional Add: *Program increase: Advanced materials for missile applications*	-	20.000
Congressional Add: *Program increase - phase changing hydrogen fuel program*	-	15.000
Congressional Add Subtotals for Project: BO9	49.000	60.500
Congressional Add Totals for all Projects	49.000	60.500

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 3 of 34

R-1 Line #14

Volume 1b - 302

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

Appropriation/Budget Activity 2040 I 2					R-1 Program Element (Number/Name) PE 0602147A I *Long Range Precision Fires Technology*					Project (Number/Name) AE7 I *Land-Based Anti-Ship Missile (LBASM) 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
AE7: *Land-Based Anti-Ship Missile (LBASM) Technology*	-	10.951	21.849	14.053	-	14.053	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating and developing critical technologies to detect, engage, and defeat moving land or maritime surface targets under all conditions, and developing technologies for Precision Strike Missile (PrSM) modular payloads for the delivery of dedicated Army intelligence, surveillance and reconnaissance (ISR) payloads and attack capabilities via long range missiles.

Work in this Project complements PE 0603464A (Long Range Precision Fires Advanced Technology) / AE8 (Land Based Anti-Ship Missile (LBASM) Advanced Tech.

The cited work is consistent with the Assistant 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 (US) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Land Based Anti-Ship Missile (LBASM) Technology *Description:* Investigate and develop critical technologies that enable High Mobility Artillery Rocket System (HIMARS) and Multiple Launch Rocket System (MLRS) rocket/missile artillery systems to destroy enemy air defenses in the land and the maritime domains. *FY 2021 Plans:* Evaluate the performance of the multi-mode seeker component technologies through conducting experiments with seeker hardware in the loop to mature tracking, identification and aim-point algorithms; design payload concept evaluation to determine lethality against both land and maritime targets. *FY 2021 to FY 2022 Increase/Decrease Statement:* Decrease in funding associated with the development of the seeker technologies ramping down, and integration and testing ramping up in PE603464A (Long Range Precision Fires) / AE8 (Land-Based Anti-Ship Missile (LBASM) Advanced Tech) effort.	10.951	9.710	-
Title: Precision Strike Missile Modular Payload Technology *Description:* Investigate and develop critical technologies for the delivery of dedicated Army intelligence, surveillance and reconnaissance (ISR) payloads and attack capabilities via long range missiles. Technology examples include: ISR sensor and associated signal processing technologies for target acquisition, identification, and engagement; datalink and communications	-	12.139	14.053

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 4 of 34

R-1 Line #14

Volume 1b - 303

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602147A / Long Range Precision Fires Technology	Project (Number/Name) AE7 / Land-Based Anti-Ship Missile (LBASM) Technology

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
technologies to transmit targetable data; compact propulsion technologies to enable loiter time on station; and payload dispensing technologies for deploying these payloads from high speed long range missiles. *FY 2021 Plans:* Conduct trade studies to develop the system concept and derive system level technology requirements for the payload subsystems including ISR sensor, datalink, propulsion, and deployment mechanization; identify critical technologies associated with each subsystem, and initiate the development of preliminary designs for each subsystem to support required payload capabilities. *FY 2022 Plans:* Will advance the designs for payload subsystems including ISR sensor, signal processing, datalink, propulsion, and deployment mechanization; will initiate hardware fabrication of payload subsystems including ISR sensor, signal processing, datalink, propulsion, and deployment mechanization; and will develop system and subsystem level high fidelity modeling and simulations to assess integrated performance. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase due to planned lifecycle of the project to enable additional development and fabrication of subsystems.			
Accomplishments/Planned Programs Subtotals	10.951	21.849	14.053

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

D. Acquisition Strategy
 N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army
UNCLASSIFIED
Page 5 of 34
R-1 Line #14
Volume 1b - 304

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*					**Project (Number/Name)** AF1 *I Long Range Maneuverable Fires (LRMF) 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**
AF1: *Long Range Maneuverable Fires (LRMF) Technology*	-	-	-	5.033	-	5.033	-	-	-	-	-	-

Note
 This is a new start in FY 2022.

 This is a new start for FY 2022.

A. Mission Description and Budget Item Justification
 This Project directly supports Long Range Precision Fires Modernization Priority capabilities by developing next generation Multi-Domain Operations extended range missile technology for Precision Strike Missile to increase survivability, penetration, and range in A2/AD and denied environments while maintaining compatibility with M142 HIMARS and M270 MLRS launchers.

 Work in this Project complements PE 0603464A (Long Range Precision Fires Advanced Technology) / AF2 (Long Range Maneuverable Fires Adv Tech).
 The cited work is consistent with the Assistant 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 (US) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Long Range Maneuverable Fires (LRMF) Technology	-	-	5.033
Description: Investigate and develop critical technologies that enable next generation Precision Strike Missile capabilities for extended range lethality up to or greater than 1000 km, increase survivability, and penetration in complex A2/AD and in GPS denied environments.			
FY 2022 Plans: Will determine system level technical requirements for next generation Precision Strike Missile capability; will develop system concepts; will identify subsystem functional and technical requirements; will determine critical technology requirements; and will investigate subsystem/component designs.			
FY 2021 to FY 2022 Increase/Decrease Statement: This project was programmed in POM19, with efforts beginning in FY22.			
Accomplishments/Planned Programs Subtotals	-	-	5.033

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 6 of 34

R-1 Line #14

Volume 1b - 305

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** AF1 *I Long Range Maneuverable Fires (LRMF) Technology*

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 7 of 34

R-1 Line #14

Volume 1b - 306

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602147A I *Long Range Precision Fires Technology*					**Project (Number/Name)** AF3 I *Extended Range Propulsion 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**
AF3: *Extended Range Propulsion Technology*	-	5.366	6.354	9.886	-	9.886	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by designing, fabricating, and investigating missile enabling propulsion technologies to enable range extension and/or block speed improvement for long range applications; and enables improvement in High Performance Propellants (HPP) via gains in energy density and burn rate control.

Work in this Project complements PE 0603464A (Long Range Precision Fires Advanced Technology) / Project AF2 (Long Range Maneuverable Fires (LRMF) Advanced Tech).

The cited work is consistent with the Assistant 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 (US) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Extended Range Propulsion Technology *Description:* Designs, fabricates, and investigates missile enabling propulsion technologies to enable significant range extension and/or block speed improvement for long range applications and enables improvement in HPP via gains in energy density and burn rate control. *FY 2021 Plans:* Design air breathing propulsion component technology for cannon and rocket/missile artillery systems range extension; investigate advanced technologies to increase the amount of energy delivered from the same form factor; investigate propellant processing techniques that can reduce manufacturing time and cost; investigate advanced propellant formulations and plume signature management technologies that can increase the survivability of long range fires platforms while maintaining or improving performance. *FY 2022 Plans:* Will conduct experiments and ground testing of semi-free jet air-breathing propulsion subsystems alternatives that can dramatically increase the range of rocket/missile artillery systems in the same form factor as traditional solid propellant rocket motor subsystems; will determine the viability of advanced propellant processing techniques via actual composite and minimum	5.366	6.354	9.886

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602147A I *Long Range Precision Fires Technology*	Project (Number/Name) AF3 I *Extended Range Propulsion Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
smoke propellant processing and static motor testing; will determine plume signature management technologies through static motor testing. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** FY22 funding increase due to planned lifecycle of the project; additional funding required to develop, design multiple/alternative technology subsystems, and perform ground testing; also will evaluate multiple advanced propellant formulations for increase range capability for missile systems			
Accomplishments/Planned Programs Subtotals	5.366	6.354	9.886

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* 2					**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*					**Project (Number/Name)** AF5 *I Simulation and Aerostructures 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**
AF5: *Simulation and Aerostructures Technology*	-	1.319	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating and developing novel aerodynamic modeling and aerostructures to support extended range and maneuvering missile applications in high aerodynamic and thermal loading environments.

Work in this Project complements PE 0603464A (Long Range Precision Fires Advanced Technology) / Project AE8 (Land Based Anti-Ship Missile (LBASM) Advanced Tech, and Project AF2 Long Range Maneuverable Fires (LRMF) Advanced Tech.

The cited work is consistent with the Assistant 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: Simulation and Aerostructures Technology	1.319	-	-
Description: Investigate and develop novel aerodynamic modeling and aerostructures to support extended range and maneuvering missile applications in high aerodynamic and thermal loading environments.			
Accomplishments/Planned Programs Subtotals	1.319	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 10 of 34

R-1 Line #14

Volume 1b - 309

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*					**Project (Number/Name)** AF6 *I Structures 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**
AF6: *Structures Technology*	-	1.146	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating advanced materials supporting survivable, high-speed missiles and identifying approaches of to reduce weight and size of missile structures using advanced materials and manufacturing techniques.

Work in this Project complements PE 0603464/AE8 LBASM Advanced Technology; PE 0602147/AF1 LRMF Technology, and PE 0603464/AF2 LRMF Advanced Technology.

The cited work is consistent with the Assistant 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: Structures Technology	1.146	-	-
Description: Investigate advanced materials supporting survivable, high-speed missiles; identify approaches of for reducing weight and size of missile structures using advanced materials and manufacturing techniques.			
Accomplishments/Planned Programs Subtotals	1.146	-	-

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* 2					**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*					**Project (Number/Name)** AF7 *I Warhead Integration 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**
AF7: *Warhead Integration Technology*	-	1.612	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating advanced warhead subsystem integration techniques for future missile systems.

Work in this Project complements PE 0603464A (Long Range Precision Fires Advanced Technology) / AE8 (Land-Based Anti-Ship Missile (LBASM) Advanced Tech); PE 0602147A (Long Range Precision Fires Technology) / AF1 (Long Range Maneuverable Fires (LRMF) Technology) and PE 0603464A (Long Range Precision Fires Advanced Technology) / AF2 (Long Range Maneuverable Fires (LRMF) Advanced Tech)

The cited work is consistent with the Assistant 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: Warhead Integration Technology	1.612	-	-
Description: Investigate advanced warhead subsystem integration techniques for future missile systems.			
Accomplishments/Planned Programs Subtotals	1.612	-	-

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

D. Acquisition Strategy
N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 12 of 34

R-1 Line #14

Volume 1b - 311

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*					**Project (Number/Name)** AF8 *I Affordable Extended Range Precision 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**
AF8: *Affordable Extended Range Precision Technology*	-	0.277	8.181	8.684	-	8.684	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating the design and fabrication of components and subsystems critical to produce affordable extended range precision missiles as well as critical component technologies including: advanced propulsion, seekers/sensors, fire control, datalink, guidance, navigation and controls, airframes, and additional high payoff areas.

Work in this Project complements PE 0603464A (Long Range Precision Fires Advanced Technology) / AE8 (Land-Based Anti-Ship Missile (LBASM) Advanced Tech); PE 0602147A (Long Range Precision Fires Technology) / AF1 (Long Range Maneuverable Fires (LRMF) Technology) and PE 0603464A (Long Range Precision Fires Advanced Technology) / AF2 (Long Range Maneuverable Fires (LRMF) Advanced Tech)

The cited work is consistent with the Assistant 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: Affordable Extended Range Precision Technology	0.277	-	-
Description: Investigate the design and fabrication of components and subsystems critical to produce affordable extended range precision missiles; Critical component technologies including: advanced propulsion, seekers/sensors, fire control, datalink, guidance, navigation and controls, and airframes.			
Title: LRPF High Payoff Missile Technology	-	8.181	8.684
Description: Identify and explore potential breakthrough technologies to mitigate or eliminate warfighter gaps in Long Range Precision Fires to gain overmatch against potential peer and near-peer adversaries. *FY 2021 Plans:* Analyze and develop integrated board level sensor-on-a-chip utilizing advanced thermal management techniques to improve signal processing and reduce size and weight of future missile seekers; investigate advanced materials modeling/optimization techniques and emerging high temperature materials to reduce weight and further extend the range of long range missiles; investigate advanced navigation and alternate navigation approaches that greatly reduce or eliminate the need for GPS for			

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 13 of 34

R-1 Line #14

Volume 1b - 312

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** AF8 *I Affordable Extended Range Precision Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
precision guidance of long range missiles in contested environments; and research long range, low altitude datalink technologies and communication architectures. *FY 2022 Plans:* Will continue to develop and mature integrated board level sensor-on-a-chip utilizing advanced thermal management techniques; will develop advanced materials modeling/optimization techniques and evaluate emerging high temperature materials to reduce weight and further extend the range of long range missiles; will design and develop advanced navigation and alternate navigation approaches; will refine concepts and evaluate through modeling and simulation long range, low altitude datalink technologies and communication architectures. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase due to planned lifecycle of the project; advance critical technologies required for future missile efforts in the Long Range Precision Fires Army Modernization Priority area.			
Accomplishments/Planned Programs Subtotals	0.277	8.181	8.684

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

D. Acquisition Strategy
 N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 14 of 34

R-1 Line #14

Volume 1b - 313

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

Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*						**Project (Number/Name)** AF9 *I Precision and Accuracy 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**
AF9: *Precision and Accuracy Technology*	-	7.892	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating and developing advanced missile seekers, sensors, and software/algorithms to increase affordability and performance of missiles for precision at extended ranges. This Project also investigates and develops advanced technologies for effective guidance and navigation of precision missiles through unique navigation technologies and algorithms aimed at reducing size, weight, power and cost.

Work in this Project complements PE 0603464A / AE8 (Land-Based Anti-Ship Missile Advanced Technology)

The cited work is consistent with the Assistant 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: Precision and Accuracy Technology	7.892	-	-
Description: Investigate and develop advanced missile seekers, sensors, and software/algorithms to increase affordability and performance of missiles for precision at extended ranges. This effort investigates and develops advanced technologies for effective guidance and navigation of precision missiles through unique navigation technologies and algorithms aimed at reducing size, weight, power and cost.			
Accomplishments/Planned Programs Subtotals	7.892	-	-

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* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** AG1 *I Missile Electronics 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**
AG1: *Missile Electronics Technology*	-	2.897	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating and developing technologies and techniques to miniaturize guidance electronics for advanced missile systems.

Work in this Project complements PE 0602147A (Long Range Precision Fires Technology) and PE 0603464A (Long Range Precision Fires Advanced Technology).

The cited work is consistent with the Assistant 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: Missile Electronics Technology	2.897	-	-
Description: Investigates and develops technologies and techniques to miniaturize guidance electronics for advanced missile			
Accomplishments/Planned Programs Subtotals	2.897	-	-

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

D. Acquisition Strategy
N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army
UNCLASSIFIED
Page 16 of 34
R-1 Line #14
Volume 1b - 315

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*						**Project (Number/Name)** AG2 *I Information and Signal Processing 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**
AG2: *Information and Signal Processing Technology*	-	1.536	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating and developing image processing technologies and techniques for enhanced target acquisition and engagement and investigating improved secure, digital missile communication with ground and other systems.

Work in this Project complements PE 0602147A (Long Range Precision Fires Technology) and PE 0603464A (Long Range Precision Fires Advanced Technology).

The cited work is consistent with the Assistant 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: Information and Signal Processing Technology	1.536	-	-
Description: This effort investigates and develops image processing technologies and techniques for enhanced target acquisition and engagement and investigates improved secure, digital missile communication with ground and other systems.			
Accomplishments/Planned Programs Subtotals	1.536	-	-

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

D. Acquisition Strategy
N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army
UNCLASSIFIED
Page 17 of 34
R-1 Line #14
Volume 1b - 316

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*				**Project (Number/Name)** AG4 *I Extended Range Artillery Munition Suite 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**
AG4: *Extended Range Artillery Munition Suite Technology*	-	6.526	8.351	11.151	-	11.151	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating critical enabling component technologies and designing high precision terminal guidance in denied environments, capable of surviving high gun shock loads, at extended ranges, and automated cannon artillery technologies to increase operational tempo and unburden the soldier.

Work in this Project complements PE 0603464A Long Range Precision Fires Advanced Technology / AG5 (Extended Range Artillery Munition Suite Advanced Technology).

The cited work is consistent with the Assistant 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: Precision At Range Technologies ***Description:*** Investigates technologies that provide affordable precision capabilities for projectiles fired into Global Positioning System (GPS) denied environments. ***FY 2021 Plans:*** Investigate critical passive seeker component technologies, including IR focal plane arrays and associated optics, for viability of operation in anticipated gun shock loading environments; develop terminal seeker component hardware for future integration with extended range artillery munitions; investigate target detection algorithms for terminal seeker development for extended range munitions (e.g. XM1155); conduct component level experiments to validate modeled performance through captive flight testing; design and develop component technologies to provide increased range, sensor optimization, improved algorithms and refined guidance and navigation system design concepts for future artillery munitions. ***FY 2022 Plans:*** Will investigate EO/IR Seeker performance including imaging detectors, optics trains, and supporting electronics for processing target recognition software integrated into a 155mm precision guided munition. Will conduct target data collections to inform algorithm development in advanced precision seekers. Will validate seeker sensor and algorithm M&S performance against	2.794	3.151	3.204

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 18 of 34

R-1 Line #14

Volume 1b - 317

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** AG4 *I Extended Range Artillery Munition Suite Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
real world data. Will design and develop component technologies such as tactical grade IMU hardware to ensure gun-launch survivability. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding reflects planned lifecycle for this effort.			
Title: Extended Range Artillery Munition Suite Enabling Technologies *Description:* This effort develops, matures and integrates a gun hardened suite of components (software, sensors, navigation and communications) to enable the application of distributed, cooperative and collaborative tactics for munitions and Radio Frequency (RF) seeking components. *FY 2021 Plans:* Mature component technologies for extended range artillery projectiles (e.g. XM1155) through improved algorithms and refined guidance and navigation system design concepts; conduct component level experiments to validate modeled performance; determine relevant conditions to enable intra-munition communications, enhancing probability of kill ratios and increasing effectiveness against targets in highly cluttered environments. *FY 2022 Plans:* Will mature component technologies for extended range artillery projectiles through novel and improved algorithms using refined guidance and navigation system design concepts; conduct component level experiments to validate modeled performance to determine SWaP allocations required for future munition systems; will investigate solutions to enable in-flight, intra-munition communications, enhancing performance against targets in highly cluttered environments. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding reflects planned lifecycle for this effort.	3.732	1.997	2.008
Title: Optionally Manned Artillery Platform Technology *Description:* This effort designs and develops cannon artillery automation technologies including automated fuze/fuze setting technologies, automated prognostics/diagnostics, automated and rapid rearm technologies, and automated ammunition inventory to increase operational tempo of current and future cannon artillery systems to unburden the soldier *FY 2021 Plans:* Investigate cannon artillery automation technologies; Investigate automated fuze/fuze setting technologies to decrease fuze setting times and increase the rate of fire for precision projectiles; Investigate automated prognostics/diagnostics to enable	-	3.203	2.892

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** AG4 *I Extended Range Artillery Munition Suite Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
automated operations; Investigate automated and rapid rearm technologies including automated ammunition inventory to decrease operational down-time and unburden the soldier. *FY 2022 Plans:* Will investigate sensing technologies to improve spatial awareness for optionally manned artillery loading operations. Will investigate and design solutions to increase the speed of automated fuze setting for artillery autoloader applications. Will design solutions for prognostic systems to unburden the soldier during artillery loading operations and investigate an open architecture to enable connection to an optionally manned hull. Will design automated resupply component technologies and conduct experiments to define requirements for automated resupply. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding reflects planned lifecycle for this effort.			
Title: Large Caliber Cannon Technologies *Description:* This effort will advance the current state of the art in cannon and barrel technology for compatibility with higher velocity and precision munitions, harder rotating bands, high temperature operation, robustness against non-firing loads, and minimized weight and imbalance. This effort will investigate cannon concepts focused on residual stress & dynamic strain reduction, coating metallurgy, and barrel cooling to increase tube life and performance in high demand environments. *FY 2022 Plans:* Will investigate technologies to improve the life and performance of large caliber cannons. Will investigate: novel materials and impacts on dynamic strain using multiscale modeling, residual stress through triaxial stress/strain measurements of cannon tubes, novel refractory coating technologies, and barrel cooling techniques to reduce temperature rise at high rates of fire. Will conduct experiments and modeling to mature component technologies for future armament systems. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY22 funding for this project is to investigate new technologies to increase the life and improve performance of large caliber cannons firing higher velocity projectiles.	-	-	3.047
Accomplishments/Planned Programs Subtotals	6.526	8.351	11.151

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

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** AG4 *I Extended Range Artillery Munition Suite Technology*

D. Acquisition Strategy
 N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 21 of 34

R-1 Line #14

Volume 1b - 320

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2					R-1 Program Element (Number/Name) PE 0602147A I Long Range Precision Fires Technology					Project (Number/Name) AG6 I Energetic Materials and Advanced Processing Techno		
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
AG6: Energetic Materials and Advanced Processing Techno	-	6.335	3.430	3.468	-	3.468	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating critical component technology of propellants and energetic materials to increase the range of artillery and mortar rocket assisted projectiles.

Work in this Project complements PE 0602141A (Lethality Technology) / AH9 (Advanced Warheads Technology) and PE 0603464A (Long Range Precision Fires Advanced Technology) / AG5 (Extended Range Artillery Munition Suite Advanced Technology).

The cited work is consistent with the Assistant 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: Novel Propulsion	3.191	-	-
Description: This effort explores propellant technologies such as powder co-extrusion and grain coatings, while retaining insensitive properties, for employment in gun launch environments as well as directional thrusters including those that deliver a broad spectrum of effects. It also conducts experiments with these propellants to increase the range of artillery and mortar rocket assisted projectiles.			
Title: Scale-up of Insensitive Energetic Materials	3.144	3.430	3.468
Description: Conduct research to advance the maturity of disruptive energetic materials. **FY 2021 Plans:** Design synthesis processes for the fabrication of energetic materials applicable to a wide range of additive manufacturing technologies; design embedded ignition for additively manufactured gun propulsion charges; conduct experiments of ECEM formulations; investigate next generation post launch propulsion concepts to achieve extended range. **FY 2022 Plans:** Will develop synthesis processes and fabrication of energetic materials applicable to a wide range of additive manufacturing technologies, and conduct experiments of additive energetic components; will develop embedded ignition concepts for additively manufactured gun propulsion charges and conduct advanced ignition experiments; will continue to conduct experiments of			

PE 0602147A: Long Range Precision Fires Technology
Army

UNCLASSIFIED
Page 22 of 34

R-1 Line #14

Volume 1b - 321

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** AG6 *I Energetic Materials and Advanced Processing Techno*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Electrically Controlled Energetic Materials (ECEM) formulations; will design and develop next generation post launch propulsion on gun launched concepts for extended range. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	6.335	3.430	3.468

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

D. Acquisition Strategy
 N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 23 of 34

R-1 Line #14

Volume 1b - 322

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*				**Project (Number/Name)** AG8 *I Advanced Energetics 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**
AG8: *Advanced Energetics Technology*	-	9.682	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating critical component technology of materials and novel processing techniques for future explosives and propulsion applications that enable an increase in range, lethality, and utility of ammunitions.

Work in this Project complements PE 0602141A (Lethality Technology) / AH9 (Advanced Warheads Technology), PE 0602147A (Long Range Precision Fires Technology) / AG6 (Energetic Materials and Advanced Processing Techno), and PE 0603464A (Long Range Precision Fires Advanced Technology) / AG7 (Energetic Materials and Adv Processing Adv Tech).

The cited work is consistent with the Assistant 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: Advanced Energetics	9.682	-	-
Description: This effort develops advanced energetic materials and novel processing techniques for future explosives and propulsion applications that enable an increase in range, lethality, and utility of ammunitions.			
Accomplishments/Planned Programs Subtotals	9.682	-	-

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* 2					**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*				**Project (Number/Name)** AG9 *I Multiple Simul Engagement Technologies (MSET) Tech*		

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
AG9: *Multiple Simul Engagement Technologies (MSET) Tech*	-	1.978	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating critical component technology and designs for future missiles that provide simultaneous multiple launch, control, and supervised autonomous terminal engagement of multiple missiles against stationary and moving hard/soft targets, image-based target discrimination/shared SA/lock-on, and multi-missile control digital datalink with inter-missile cooperative networked communications.

Work in this Project complements PE 0603464A (Long Range Precision Fires Advanced Technology) / AF4 (Missile Simulation Advanced Technology).

The cited work is consistent with the Assistant 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: Multiple Simultaneous Engagement Technologies (MSET) Technology	1.978	-	-
Description: Investigate critical component technology and designs for future missiles that provide simultaneous multiple launch, control, and supervised autonomous terminal engagement of multiple missiles against stationary and moving hard/soft targets, image-based target discrimination/shared situation awareness/lock-on, and multi-missile control digital datalink with inter-missile cooperative networked communications.			
Accomplishments/Planned Programs Subtotals	1.978	-	-

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* 2				**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*				**Project (Number/Name)** AH2 *I Single Multi-mission Attack Missile (SMAM) Technol*			

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**
AH2: *Single Multi-mission Attack Missile (SMAM) Technol*	-	1.212	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating critical component technology and designs for future missiles that provide expeditionary, scalable, precision strike and loiter capability to rapidly defeat hard targets and swarming or disbursed threats; Provides the missile technology path to supervised autonomous target detection and cooperative engagement/manned-unmanned teaming for offensive, multiple simultaneous engagement capabilities.

Work in this Project complements PE 0603464A (Long Range Precision Fires Advanced Technology) / AH3 (Single Multi-mission Attack Missile Adv Tech) and PE 0603464 (Long Range Precision Fires Advanced Technology) / AH1 (Multiple Simultaneous Engagement Technologies (MSET) Advanced Technology).

The cited work is consistent with the Assistant 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: Single Multi-mission Attack Missile (SMAM) Technology	1.212	-	-
Description: This effort investigates critical component technology and designs for future missiles that provide expeditionary, scalable, precision strike and loiter capability to rapidly defeat hard targets and swarming or disbursed threats; Provides the missile technology path to supervised autonomous target detection and cooperative engagement/manned-unmanned teaming for offensive, multiple simultaneous engagement capabilities.			
Accomplishments/Planned Programs Subtotals	1.212	-	-

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* 2				**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*					**Project (Number/Name)** AH4 *I Precision and Coop Weapons in a Denied Env Tech*		
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**
AH4: *Precision and Coop Weapons in a Denied Env Tech*	-	8.746	9.277	9.427	-	9.427	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates technologies to deliver accurate fires from extended ranges in denied environments and informs future close- and deep-range Long Range Precision Fires capabilities (e.g., Extended Range Cannon Artillery, Precision Strike Missile). Work in this PE researches technologies for navigation of munitions without Global Positioning System (GPS) and flying munitions to much greater distances against advanced threat Area Denial Assets by delivering navigation technology for multiple munitions with complementary sensors and maneuverability technology for munitions with enhanced lift and control characteristics.

Work in this Project transitions foundational research obtained in PE 0601102A (Defense Research Sciences) / AA7 (Mechanics and Ballistics) and complements PE 0602141A (Lethality Technology) / AH5 (Projectile and Multi-Function Warhead Technologies), Project AH6 (Disruptive Energetics and Propulsion Technologies), Project AH7 (Lethal and Scalable Effects Technologies), and Project AH8 (Lethality Materials and Processes Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Munition Navigation Technology in Contested Environments	4.641	4.919	4.999
Description: This effort investigates, designs, and transitions technologies to improve navigation (e.g., better accuracy, more information/aim-point refinement, reduce GPS dependency) of munitions subject to denied environments (e.g., electro-magnetic spectrum contested, counter-measures). Key technologies include algorithms for image processing, state estimation, and communications, embedded processing and electronics, and sensors (e.g., inertial, imagers with optics, software-defined radios and antennae). *FY 2021 Plans:* Design collaborative navigation and guidance algorithms with improved realism of collaborative munitions engagement modeling and simulation; develop sensor fusion state estimation and machine learning algorithms for object detection using image databases on real-time processors to provide mid-course navigation and terminal guidance in contested environments; validate mid-course and terminal guidance technologies during cannon-launched Global Positioning System -guided flights characteristic of future Long Range Precision Fires missions. *FY 2022 Plans:*			

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 27 of 34

R-1 Line #14

Volume 1b - 326

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** AH4 *I Precision and Coop Weapons in a Denied Env Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will conduct experiments on collaborative engagements to include multiple unmanned aerial systems equipped with imagers, software-defined radios, inertial measurement units, and embedded processors for validation of unanchored multi-agent localization (UMAL), UMAL-Aided anchored localization, formation control, multi-agent tracking, and weapon-target assignment; will conduct experiments on mid-course navigation technologies and data collection for terminal guidance algorithms.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.			
Title: Munition Maneuvering Technology in Extreme Environments *Description:* This effort investigates and designs technologies to improve maneuverability (e.g., extended range glide, intercept moving target, course- correct to imperfectly located target, perform evasive terminal maneuver to increase survivability) of munitions subject to extreme environments (set- back, set-forward, and balloting loads encountered during gun launch and thermal loads encountered during high speed/long time flights). These technologies include the maneuvering airframe, control actuation, and flight control algorithms. ***FY 2021 Plans:*** Design munition guidance algorithms and required system characteristics to improve terminal survivability against integrated air defense system targets; design model-based optimal flight control automation to reduce gain tuning cycle time; develop aerodynamic control actuation with increased hinge loads, rise time/delay, packaging, and launch survivability; design airframe flight characterization and design tools to improve accuracy and shorten design cycle time; validate airframe, control actuation, and flight control technologies during cannon-launched GPS guided flights characteristic of future Long Range Precision Fires missions. ***FY 2022 Plans:*** Will conduct experiments to validate spiral technologies for long range precision fires airframe design concepts and characterization, control actuation, guidance and flight control algorithms; will conduct analysis of unique ballistic launch and flight system simulations to characterize hypersonic flight behaviors. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.	4.105	4.358	4.428
Accomplishments/Planned Programs Subtotals	8.746	9.277	9.427

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

UNCLASSIFIED

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** AH4 *I Precision and Coop Weapons in a Denied Env Tech*

D. Acquisition Strategy
 N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 29 of 34

R-1 Line #14

Volume 1b - 328

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2					**R-1 Program Element (Number/Name)** PE 0602147A / *Long Range Precision Fires Technology*						**Project (Number/Name)** BN5 / *Fuze and Power for Munitions*	
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**
BN5: *Fuze and Power for Munitions*	-	0.920	1.065	2.583	-	2.583	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Long Range Precision Fires Modernization Priority capabilities by investigating critical component technologies and designs capable to enable advanced lethality and scalable warheads for future munitions as well as exploring new power technologies for extended run time and extended range munitions.

The cited work is consistent with the Assistant 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: Advanced Energetics	0.920	1.065	2.583

Description: This effort develops advanced fuze and power technologies for future munition applications that enable an increase in range and lethality, of ammunitions.

FY 2021 Plans:
Investigates enabling technologies for improved lethality in munition applications while ensuring operation during extended range flight; develops algorithms and explore advance capabilities for fuze proximity sensors to track targets and resist countermeasures; conducts component level experiments for breadboard design architectures of of electronic safe and arm device; designs interfaces for secure wireless data setting in advanced auto-loader systems; investigates wireless technology protocols to enable high speed data transfer; investigates novel power approaches for long range munitions and hypersonics technologies. This effort continues to leverage the OSD Joint Munitions Program TCG-5 and TCG-10 and the OSD Joint Fuze Technology Program.

FY 2022 Plans:
Will conduct experiments to mature components and algorithms for tracking proximity sensors; will design fuze breadboards for wireless setting and advanced multi-point initiation architectures; will conduct power source performance predictions and investigations of experimental materials. This effort will continue to leverage the OSD Joint Munitions Program TCG-3 and the OSD Joint Fuze Technology Program.

FY 2021 to FY 2022 Increase/Decrease Statement:

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*	**Project (Number/Name)** BN5 *I Fuze and Power for Munitions*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Increase to support the increased development of component and sub-component technologies critical to timed munitions.			
Accomplishments/Planned Programs Subtotals	0.920	1.065	2.583

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* 2				**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires Technology*					**Project (Number/Name)** BO9 *I WEAPONS & MUNITIONS TECH PROGRAM INITIATIVE (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**
BO9: *WEAPONS & MUNITIONS TECH PROGRAM INITIATIVE (CA)*	-	49.000	60.500	-	-	-	-	-	-	-	-	-

Note

Congressional Interest Item funding provided for Weapons and Munitions Tech Program Initiative.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Weapons and Munitions Tech Program Initiative.

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: Composite Cannon Tubes and Propulsion Technology	10.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Composite Cannon Tubes and Propulsion Technology. Work executed under the direction of the Army Futures Command.		
Congressional Add: Hybrid Projectile Technology	6.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Hybrid Projectile Technology. Work executed under the direction of the Army Futures Command.		
Congressional Add: Additive Manufacturing to Support Optimized Fires	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Additive Manufacturing to Support Optimized Fires. Work executed under the direction of the Army Futures Command.		
Congressional Add: Program Increase	20.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Long Range Precision Fires Technology.		

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 32 of 34

R-1 Line #14

Volume 1b - 331

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires* *Technology*	**Project (Number/Name)** BO9 *I WEAPONS & MUNITIONS TECH* *PROGRAM INITIATIVE (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed under the direction of the Army Futures Command.		
Congressional Add: Novel Printed Armament Components	8.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Novel Printed Armament Components.		
Work executed under the direction of the Army Futures Command.		
Congressional Add: Program increase - precision strike munitions	-	4.000
FY 2021 Plans: Conduct applied research in Precision Strike Munitions.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - extended range hybrid and precision gun launched projectiles	-	15.000
FY 2021 Plans: Conduct applied research in Extended Range Hybrid and Precision Gun Launched Projectiles.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - novel printed armament components	-	6.500
FY 2021 Plans: Conduct applied research in Novel Printed Armament Components.		
Work executed by Army Futures Command.		
Congressional Add: Program increase: Advanced materials for missile applications	-	20.000
FY 2021 Plans: Conduct applied research in Advanced Materials for Missile Applications.		
Work executed by Army Futures Command.		
Congressional Add: Program increase - phase changing hydrogen fuel program	-	15.000
FY 2021 Plans: Conduct applied research in Phase Changing Hydrogen Fuel Program.		
Work executed by Army Futures Command.		
Congressional Adds Subtotals	49.000	60.500

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602147A *I Long Range Precision Fires* *Technology*	**Project (Number/Name)** BO9 *I WEAPONS & MUNITIONS TECH* *PROGRAM INITIATIVE (CA)*

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602147A: *Long Range Precision Fires Technology*
Army

UNCLASSIFIED
Page 34 of 34

R-1 Line #14

Volume 1b - 333

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602148A I *Future Verticle Lift 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**
Total Program Element	-	94.888	169.536	91.411	-	91.411	-	-	-	-	-	-
AI5: *Next Gen Tactical UAS TD Technology*	-	-	7.518	-	-	-	-	-	-	-	-	-
AI7: *Alternative Concept Engine Technology*	-	3.507	-	-	-	-	-	-	-	-	-	-
AI9: *Future UAS Engine Technology*	-	2.769	2.939	3.153	-	3.153	-	-	-	-	-	-
AJ2: *Next Generation Rotorcraft Transmission Technology*	-	3.879	3.971	4.153	-	4.153	-	-	-	-	-	-
AJ4: *Digital Vehicle Management and Control Technology*	-	4.618	6.222	-	-	-	-	-	-	-	-	-
AJ6: *Advanced Rotors Technology*	-	2.265	2.377	2.447	-	2.447	-	-	-	-	-	-
AJ8: *Experimental and Computational Aeromechanics Techn*	-	4.972	5.076	6.135	-	6.135	-	-	-	-	-	-
AK1: *UAS Survivability Technology*	-	0.959	-	-	-	-	-	-	-	-	-	-
AK2: *Aviation Survivability Technology*	-	20.895	21.158	2.177	-	2.177	-	-	-	-	-	-
AK4: *Multi-Role Small Guided Missile Technology*	-	5.853	7.463	3.736	-	3.736	-	-	-	-	-	-
AK6: *Advanced Rotorcraft Armaments Protection System Te*	-	5.094	-	-	-	-	-	-	-	-	-	-
AK9: *Adv Teaming for Tactical Aviation Operations Tech*	-	13.024	13.531	13.978	-	13.978	-	-	-	-	-	-

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 1 of 56

R-1 Line #15

Volume 1b - 334

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 2: *Applied Research*						**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*						
AL2: *High Performance Computing for Rotorcraft App Tech*	-	1.121	1.148	1.200	-	1.200	-	-	-	-	-	-
AL4: *High Speed and Efficient VTOL Vehicle Technology*	-	1.438	1.444	1.466	-	1.466	-	-	-	-	-	-
AL5: *Air Vehicle Structures and Dynamics Technology*	-	2.652	2.792	2.823	-	2.823	-	-	-	-	-	-
AL8: *Holistic Situational Awareness and Dec Making Tech*	-	1.673	1.757	0.889	-	0.889	-	-	-	-	-	-
AM2: *Aircraft and Aircrew Protection Technology*	-	1.459	-	-	-	-	-	-	-	-	-	-
AM4: *Opt Energy Stg & Therm Mgmt for FVL Survivability*	-	4.710	8.531	-	-	-	-	-	-	-	-	-
BP7: *Future Vertical Lift Air Platform Tech (CA)*	-	14.000	75.000	-	-	-	-	-	-	-	-	-
BZ7: *Future Vertical Lift Medical Technologies*	-	-	7.911	7.818	-	7.818	-	-	-	-	-	-
CC3: *FVL Radar Technologies*	-	-	0.698	0.444	-	0.444	-	-	-	-	-	-
CG9: *Adapt & Resilnt Tact Autnmy Cont & Struct Tech*	-	-	-	6.507	-	6.507	-	-	-	-	-	-
CH2: *Air Launched Effects Technology*	-	-	-	7.567	-	7.567	-	-	-	-	-	-
CH3: *Holistic Team Survivability Technology*	-	-	-	11.217	-	11.217	-	-	-	-	-	-
CH4: *Power & Thermal Management for FVL Tech*	-	-	-	7.175	-	7.175	-	-	-	-	-	-
CI5: *High Speed Maneuverable Missile (HSMM) Tech*	-	-	-	8.526	-	8.526	-	-	-	-	-	-

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 2 of 56

R-1 Line #15

Volume 1b - 335

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 2: *Applied Research*		**R-1 Program Element (Number/Name)** PE 0602148A I *Future Verticle Lift Technology*

A. Mission Description and Budget Item Justification

This PE conducts air vehicle and mission system component design, fabrication, and evaluation to enable Army Future Vertical Lift. Emphasis is on developing aviation platform and mission system technologies to enhance manned and unmanned air vehicle combat and combat support operations for attack, reconnaissance, air assault, survivability, logistics, and command and control missions.

Work in this PE contributes to the Army Science and Technology (S&T) air systems portfolio and is fully coordinated with efforts in PE 0603465A (Future Vertical Lift Advanced Technology Development), PE 0602183A Air Platform Applied Research and PE 0603043A Air Platform Advanced Technology

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

Work in this PE is performed by the United States Army Futures Command (AFC) and the Army Engineering Research and Development Center (ERDC).

B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	98.359	96.484	96.734	-	96.734
Current President's Budget	94.888	169.536	91.411	-	91.411
Total Adjustments	-3.471	73.052	-5.323	-	-5.323
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	75.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-3.471	-1.948			
• Adjustments to Budget Years	-	-	-5.323	-	-5.323

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Project: BP7: *Future Vertical Lift Air Platform Tech (CA)*		
Congressional Add: *Flight Control Technology Safety and Survivability*	3.000	-
Congressional Add: *Rotary Wing Adaptive Flight Control Technology*	6.000	-
Congressional Add: *Technology Transfer and Innovation*	5.000	-
Congressional Add: *Program increase - high strength functional composites*	-	5.000
Congressional Add: *Program increase - additive manufacturing of multifunctional composite aerospace components*	-	5.000
Congressional Add: *Program increase: Advanced rotary wing materials and structures*	-	5.000

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Congressional Add: *Program increase: Adaptive flight control technology*	-	4.000
Congressional Add: *Program increase: Lightweight hybrid composite medium caliber barrels*	-	20.000
Congressional Add: *Program increase: Technology transfer and innovation*	-	5.000
Congressional Add: *Program increase - self-sealing fuel tanks technology*	-	6.000
Congressional Add: *Program increase - high density eVTOL power source*	-	15.000
Congressional Add: *Program increase - individual blade and higher harmonic control*	-	10.000
Congressional Add Subtotals for Project: BP7	14.000	75.000
Congressional Add Totals for all Projects	14.000	75.000

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

Appropriation/Budget Activity 2040 *I* 2				R-1 Program Element (Number/Name) PE 0602148A *I Future Verticle Lift Technology*						Project (Number/Name) AI5 *I Next Gen Tactical UAS TD 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
AI5: *Next Gen Tactical UAS TD Technology*	-	-	7.518	-	-	-	-	-	-	-	-	-

Note
In FY22, funding in this Project is realigned to:
Program Element (PE) 0602148A Future Vertical Lift Technology
* Project CH2 Air Launched Effects Technology

A. Mission Description and Budget Item Justification
This Project utilizes improved computer modeling fidelity to investigate the effects that potential Future Unmanned Aircraft System (FUAS) capabilities could have on air vehicle design considerations and operational concepts. This project improves government capability to design and assess novel Unmanned Aircraft System (UAS) concepts. This Project develops and investigates the ability to launch a UAS from a manned or unmanned future vertical lift aircraft at tactical altitudes and to control the UAS from the cockpit or a crew station. This Project will assess the enabled capabilities and determine their relevance to current Army Aviation engagement and survivability portfolios.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Systems Concepts Studies for Air Launched Effects *Description:* Investigates and models air vehicle concepts to understand the effects that potential operational Air Launched Effects capabilities will have on air vehicle properties. *FY 2021 Plans:* Investigate and model the effect that overwatch, decoy, and electronic warfare capabilities will have on unmanned air vehicle designs including size, weight, system performance, power, survivability, and unit cost; will develop and assess concept air and ground launch vehicle designs to support reconnaissance, surveillance, electronic warfare, and lethal attack. *FY 2021 to FY 2022 Increase/Decrease Statement:*	-	7.518	-

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 5 of 56

R-1 Line #15

Volume 1b - 338

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AI5 *I Next Gen Tactical UAS TD Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funds are realigned in FY22 to PE 0602148A (Future Vertical Lift Technology) / CH2 (Air Launched Effects Technology).			
Accomplishments/Planned Programs Subtotals	-	7.518	-

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 6 of 56

R-1 Line #15

Volume 1b - 339

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** AI7 *I Alternative Concept Engine 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**
AI7: *Alternative Concept Engine Technology*	-	3.507	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops Future Vertical Lift (FVL) engine component technologies that could significantly improve platform performance, reliability, and operational capability.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Alternative Concept Engine Technology	3.507	-	-
Description: Design and evaluate advanced turboshaft engine component technologies to support goals of reduced fuel consumption, engine size, weight, and cost, as well as improved reliability and maintainability.			
Accomplishments/Planned Programs Subtotals	3.507	-	-

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 7 of 56

R-1 Line #15

Volume 1b - 340

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*				**Project (Number/Name)** AI9 *I Future UAS Engine 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
AI9: *Future UAS Engine Technology*	-	2.769	2.939	3.153	-	3.153	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and evaluates current and Future Unmanned Aircraft Systems (FUAS) advanced engine/power system component technologies to support the goals of multi-fuel capability, reduced fuel consumption, engine size, weight, and cost, as well as improved reliability, survivability, and maintainability.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Multi-fuel Capable Hybrid Electric Propulsion *Description:* Applied research to enable intelligent and robust propulsion performance and noise signature reduction via multi-fuel and optimized hybrid electric capability for small engines (20kW to 150kW) powering future aircraft systems. The research focuses on the establishment of concepts to enable reduced fuel consumption, engine size, weight, and cost as well as improved group 3 and 4 FUAS reliability, survivability, and maintainability. *FY 2021 Plans:* Design and develop robust energy assistance probe and controls, and real-time fuel property detection technology. The energy assistance probe will assist with combustion instability derived from low ignition quality fuels. Validate improved turbocharger designs to minimize identified resonances and thrust oil-less bearing. Investigate thermal and power management module in the hybrid-electric tool for the optimization and integration of engine power plants and high-performance electric machines to enable efficient delivery and management of power in Army unmanned air vehicles. *FY 2022 Plans:* Will combine robust ignition assistant, non-intrusive ignition sensing method, and real-time fuel property sensor to prove the concept of external energy assisted ignition of low ignition quality jet fuels; will complete reduced-order design tool for aviation	2.769	2.939	3.153

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AI9 *I Future UAS Engine Technology*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
turbocharger and design of aviation turbocharger, will investigate the major components for lightweight compact aviation electrified turbocharger; will validate the hybrid-electric optimization tool with experimentally obtained data. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort to focus on concept proveout of external energy-assisted ignition of low ignition quality jet fuels			
Accomplishments/Planned Programs Subtotals	2.769	2.939	3.153

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 9 of 56

R-1 Line #15

Volume 1b - 342

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** AJ2 *I Next Generation Rotorcraft Transmission 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**
AJ2: *Next Generation Rotorcraft Transmission Technology*	-	3.879	3.971	4.153	-	4.153	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates Future Vertical Lift (FVL) advanced drive train technologies that increase performance and double current drivetrain life cycles while improving their reliability and maintainability.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Next Generation Rotorcraft Transmission Technology	3.879	-	-
Description: Design and evaluate advanced drive system component technologies to support Variable multi-speed (50-100%), while doubling current transmission life cycles and improving platform reliability and maintainability.			
Title: High Reduction Ratio Transmission Components	-	3.971	4.153
Description: Effort investigates advanced materials and component designs that allow a 60:1 reduction ratio two-stage gearbox design that provides significant weight and volume reduction for extended range and component life for manned and unmanned applications. *FY 2021 Plans:* Investigate new materials that allow higher contact stresses to enable high-reduction ratio gears that operate at high speeds. Use the materials selected for development of component designs for HRT. *FY 2022 Plans:* Will develop and fabricate corrosion resistant steel transmission components and advanced seals that improve reliability for High Reduction Ratio Transmission (HRT) design. Will begin testing of components to verify material performance under high loads, high speeds, and corrosive environments *FY 2021 to FY 2022 Increase/Decrease Statement:*			

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 10 of 56

R-1 Line #15

Volume 1b - 343

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AJ2 *I Next Generation Rotorcraft Transmission Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	3.879	3.971	4.153

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 11 of 56

R-1 Line #15

Volume 1b - 344

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** AJ4 *I Digital Vehicle Management and Control 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**
AJ4: *Digital Vehicle Management and Control Technology*	-	4.618	6.222	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates potential manned Future Vertical Lift (FVL) and Future Unmanned Aircraft System (FUAS) fly-by-wire & fly-by-light rotor/flight control and autonomy for active rotor and compound concepts. It also investigates, matures, and harmonizes leap-ahead autonomy, structures, controls technologies, concepts, and capabilities which enable combat mission success across the family of manned/unmanned FVL platforms.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Digital Vehicle Management & Control Technology *Description:* Investigate manned and unmanned advanced rotor/flight control concepts and vehicle management technologies focused on advanced aircraft configurations and complex missions. This effort will develop handling qualities requirements, mature simulation and optimization methods, and support goals of improved robustness, reduced weight, and collaborative teaming of FVL and FUAS platforms.	4.618	-	-
Title: Adaptive and Resilient Tactical Autonomy, Controls, and Structures Tech *Description:* Develop autonomy, controls, and structures technologies to ensure mission success for manned/unmanned, multiple capability set Future Vertical Lift platforms in the contested environment of multi-domain operations. *FY 2021 Plans:* Develop structural dynamics analytical tool enhancements based on more accurate analytical prediction of rotorcraft internal structural loads. Develop adaptive, weight-efficient structural concepts enabling on-the-fly configuration adaptation for near-optimal performance across various flight conditions. Apply validated, full-flight-envelope simulation methods to Future Vertical Lift configurations. Develop mission-adaptive and damage tolerant control technologies aimed at advanced configurations with redundant controls. Develop agility and maneuverability criteria, response types, and mission task elements for high speed.	-	6.222	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AJ4 *I Digital Vehicle Management and Control Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Improve the functionality and robustness of autonomy algorithms and develop machine-learning-augmented technologies to enhance autonomous and optionally piloted flight operations, including the preservation of vehicle and mission capability. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort is administratively realigned in FY22 to PE 0602148A (Future Vertical Lift Technology) / CG9 Adaptive & Resilient Tactical Autonomy Controls & Structures Tech.			
Accomplishments/Planned Programs Subtotals	4.618	6.222	-

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 13 of 56

R-1 Line #15

Volume 1b - 346

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*						**Project (Number/Name)** AJ6 *I Advanced Rotors 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
AJ6: *Advanced Rotors Technology*	-	2.265	2.377	2.447	-	2.447	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates Future Vertical Lift (FVL) technologies that mature high speed and highly efficient rotor and hub system designs.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

The cited work is consistent with the Under Secretary of Defense for 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Advanced Rotors Technology	2.265	2.377	-
Description: Investigate advanced rotor blade and hub technologies to support goals of increased speed and reduced drag by developing low weight rotors and hub configurations that increase hover and cruise efficiency. ***FY 2021 Plans:*** Conduct individual blade control actuator performance and thermal management testing. Investigate durability performance of Unmanned Aerial Systems (UAS) rotors to determine robustness ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY22, this effort is realigned to the Advanced Hubs effort (622148/AJ6) within this project to focus more on rotor hubs.			
Title: Advanced Hubs	-	-	2.447
Description: Investigate advanced rotor system and hub technologies to support goals of increased speed and lift by developing configurations and technologies that reduce drag and enable more efficient rotor system performance. ***FY 2022 Plans:*** Will conduct design trades to start technology down-selection for advanced rotor system hubs; and will commence conceptual design studies. ***FY 2021 to FY 2022 Increase/Decrease Statement:***			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AJ6 *I Advanced Rotors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
In FY22, this effort is realigned from the Advanced Rotors Technology (622148/AJ6) effort within this project.			
Accomplishments/Planned Programs Subtotals	2.265	2.377	2.447

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* 2					**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** AJ8 *I Experimental and Computational Aeromechanics Techn*		
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**
AJ8: *Experimental and Computational Aeromechanics Techn*	-	4.972	5.076	6.135	-	6.135	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates new high fidelity computational methods to simulate aerodynamic effects and test methods of emerging rotorcraft lift technologies that could be incorporated into Future Vertical Lift (FVL) designs.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

Work in this effort is performed by the United States (US) Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Experimental Aeromechanics for FVL	2.942	2.909	3.873
Description: Develop and explore new methods to simulate aerodynamic effects for future FVL configurations.			
FY 2021 Plans: Leverage results from FY20 research to perform interactional aerodynamic investigation of winged-compound configurations incorporating auxiliary propulsion. Investigate interactional aerodynamic effects of multi-rotor configurations. Continue experimental efforts aimed at extending the state of the art for measurement & diagnostics techniques for rotor blade structural deformation using embedded sensor networks and digital image correlation, wake flow measurements using advanced optical techniques.			
FY 2022 Plans: Will conduct test of new winged compound rotorcraft configurations at high speed with auxiliary propulsion to provide fundamental understanding and validation data for computational tools; will investigate state of the art of measurement & diagnostics techniques for rotorcraft; will test rotor blade structural deformation and boundary layer transition using embedded sensor.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding increase in FY22 will support increased testing of rotor blade and new winged compound rotorcraft.			
Title: Computational Aeromechanics for FVL	2.030	2.167	2.262

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AJ8 *I Experimental and Computational Aeromechanics Techn*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Investigate experimental aeromechanics technologies and test methods for FVL. *FY 2021 Plans:* Verify and validate high-fidelity computational tools for full-vehicle aeromechanics analysis of FVL rotorcraft engineering problems. Use these computational tools to help reduce expensive and time-consuming flight testing to rectify unforeseen deficiencies in new FVL aircraft. *FY 2022 Plans:* Will verify and validate new high-fidelity computational tools for aeromechanics analysis of FVL rotorcraft with a focus on interactional aerodynamics problems that are seen in these new FVL designs. Will automate the application of these computational tools in order to maximize their impact on FVL aircraft development. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	4.972	5.076	6.135

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 17 of 56

R-1 Line #15

Volume 1b - 350

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** AK1 *I UAS Survivability 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**
AK1: *UAS Survivability Technology*	-	0.959	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates Future Unmanned Aircraft System (FUAS) with mission tailored survivability capabilities that enable operations in contested environments against future peer/near peer threats.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Unmanned Aerial Systems Survivability *Description:* Investigate innovative methods to design FUAS with tailored signature management and enhanced survivability.	0.959	-	-
Accomplishments/Planned Programs Subtotals	0.959	-	-

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

D. Acquisition Strategy
N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 18 of 56

R-1 Line #15

Volume 1b - 351

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** AK2 *I Aviation Survivability 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
AK2: *Aviation Survivability Technology*	-	20.895	21.158	2.177	-	2.177	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding was partially realigned from this Project administratively to Program Element (PE) 0602183A Air Platform Applied Research / Project CN1 Disruptive Countermeasure Concepts for Aviation

A. Mission Description and Budget Item Justification

This Project investigates advanced technologies to reduce Future Vertical Lift (FVL) platform susceptibility and vulnerability to damage from guided and unguided threats, as well as technologies to defeat small arms, rocket and missile threats. It also investigates and develops an integrated team-based system of systems survivability approach for Integrated Air Defense
Systems breaching through purpose driven mix of improved survivability situational awareness, signature management, vulnerability reduction, route and maneuver optimization, expendables, advanced sensors, and Electro-optical (EO) & Radio Frequency (RF) jamming across distributed platforms.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Signature Reduction for Advanced Threat **Description:** Investigate advanced technologies to reduce susceptibility and vulnerability of aircraft to damage from threats or accidents, as well as technologies to defeat small arms, rocket, and missile threats.	3.887	-	-
Title: Cognitive Countermeasures Technology Development **Description:** This effort investigates and matures novel materials, components, and techniques to counter legacy and emerging threats to FVL platforms. Emphasis will be placed on technologies and approaches to enable a robust, holistic countermeasure (CM) capability for target defeat, regardless of threat characteristics or guidance mode. **FY 2021 Plans:**	1.802	1.991	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AK2 *I Aviation Survivability Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Develop preliminary sensor model for detection of specific targets studied from FY18 - FY20 and validate its performance against select targets; characterize ultra-short pulse Laser Induced Direct Damage (LIDD) of optical materials and detectors for physical and electronic damage/disruption; investigate the previously developed (in FY20) in-band MWIR laser source with surrogate-diode pumping and conduct the required research and development towards major performance optimization.			
FY 2021 to FY 2022 Increase/Decrease Statement: In FY 2022, this effort is administratively realigned to PE 0602183A Project CN1.			
Title: Reconfigurable Transformational Optics/Task based Display	5.955	5.283	-
Description: This effort will deliver reconfigurable micro- and nano-scale filtering devices enabling frequency agile multi-task sensors. This will permit enhanced survivability of the FVL platforms with restored visual overmatch in any (day/night) environment. This will allow visual penetration of natural obscurants (e.g. brownout, white out) or custom man-made obscurants (e.g. engineered smokescreens) from a single sensor, as well as narrowband filtering for active imaging through obscurants. Improved detection and identification capability will result from filtering out scattered light and enabling 3-dimensional ranging through environmental obscurants. Wavelength agile imaging systems will be delivered that are capable of penetrating and imaging through a variety of obscurants and that are compatible with the FVL platforms. ***FY 2021 Plans:*** Design and develop tunable filter designs in the midwave and longwave infrared for simultaneous on/off filter switching between broad and narrow bands, and tunability of the filter center wavelength. Down select filter designs that maintain sufficient throughput. Validate pulsed infrared laser illumination and ranging sources that will be incorporated into filter designs. Design and develop new optical material design concepts to increase damage resistance and minimize lens count.			
FY 2021 to FY 2022 Increase/Decrease Statement: This effort is administratively realigned in FY22 to PE 0602148A Project AK9 Advanced Teaming for Tactical Aviation Operations Tech.			
Title: Multispectral Threat Warning and Countermeasures	6.949	0.997	-
Description: This effort investigates and evaluates software and warning sensor/counter measure components to increase probability to detect and defeat current and evolving small arms and man-portable air defense system (MANPADS) type threats for FVL platforms using modeling and simulation (M&S) and hardware in the loop (HWIL) simulations. ***FY 2021 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AK2 *I Aviation Survivability Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Investigate the incorporation of distributed sensor data into the threat declaration algorithm; assess the optimal combination of sensors to perform high detection of multiple classes of unexploited threats; analyze impact of threat progression on measured performance.			
FY 2021 to FY 2022 Increase/Decrease Statement: This effort is administratively realigned in FY22 to PE 0602148A Project CH3 Holistic Team Survivability Technology.			
Title: Tunable Pyrotechnics Technologies	2.302	2.612	2.177
Description: Develop and investigate technologies for nano, reactive, and advanced/novel materials to enable, customize and ? tune? a family of Countermeasure Decoys for FVL platforms. ***FY 2021 Plans:*** Investigate novel countermeasure designs and miniaturize component technologies for Radio Frequency performance in the EM spectrum to address emerging threats for current and future aviation platforms; develop and assess the performance of new pyrotechnic formulations for Advanced Seeker Countermeasures through static and functional experiments. ***FY 2022 Plans:*** Will design and develop novel miniaturized Radio Frequency Countermeasure (CM) components. Will conduct experiments to verify radio frequency output from pyrotechnic sub-component. Will design and develop new pyrotechnic formulations, validate existing models through simulations, and update models as required for Advanced Seeker Countermeasures. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding decrease due to realignment to PE 0602141A Lethality Technology/Project AH9 Advanced Warheads Technology for exploration of novel pyrotechnics technologies for application across all Army priorities.			
Title: Advanced Survivability Concepts	-	4.148	-
Description: This effort will provide analysis of the rapidly evolving and emerging threat environment and impacts to FVL platforms. This effort will also provide advanced teaming algorithms for survivability. ***FY 2021 Plans:*** Define integrate team survivability capability requirements. Perform preliminary research on full spectrum susceptibility and vulnerability reduction technologies that enhance team based survivability. Begin investigation into team based algorithms and behaviors for survivability. ***FY 2021 to FY 2022 Increase/Decrease Statement:***			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AK2 *I Aviation Survivability Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
This effort is administratively realigned in FY22 to PE 0602148A Project CH3 Holistic Team Survivability Technology.			
Title: Electronic Warfare Air Sensors / Countermeasure	-	6.127	-
Description: This effort investigates and develops Electronic Warfare (EW) survivability technologies to enable the detection and defeat of advanced threats. It provides algorithms, sensors, and effectors that are robust to advanced threat characteristics and operate effectively across the distributed team of FVL aircraft. *FY 2021 Plans:* Research technical approaches to detect and defeat advanced threat characteristics; develop technical design for detection and defeat technology incorporating advanced signal processing features; create digital and hybrid hardware models of advanced sensor and countermeasure (CM) payload and analyze functionality. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort is administratively realigned in FY22 to PE 0602148A Project CH3 Holistic Team Survivability Technology.			
Accomplishments/Planned Programs Subtotals	20.895	21.158	2.177

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 22 of 56

R-1 Line #15

| **Volume 1b - 355** |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*				**Project (Number/Name)** AK4 *I Multi-Role Small Guided Missile 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
AK4: *Multi-Role Small Guided Missile Technology*	-	5.853	7.463	3.736	-	3.736	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

The Project investigates, designs, and evaluates modular missile component technologies compatible with Future Vertical Lift (FVL) and Future Unmanned Aircraft Systems (FUAS) aviation platforms in a Multi-Domain Battle/Cross-domain Maneuver operational environment. Also investigates critical component technologies and designs for future missiles that can be launched simultaneously, can operate autonomously and/or under human supervision, and can form advanced, cooperative teams to defeat one or more hard/soft targets which are stationary and/or moving.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Modular Missile Technology ***Description:*** Evaluate critical technology and designs components compatible with Manned and Unmanned Aviation environments to provide scalable and tailorable improved lethality. Provides open architecture external and internal interfaces.	1.565	-	-
Title: Multi-Role Guided Missile - Extended Range Technology ***Description:*** Identify, demonstrate, analyze, and assess key component technologies to support non-line-of-sight missile development providing man-in-the-loop situational awareness, targeting, and high value target defeat for Aviation platforms that can successfully operate in A2AD/IADS environments. ***FY 2021 Plans:*** Develop form factors and interfaces for critical components including navigation sensors, warheads, fire control, and digital missile datalinks. Complete preliminary integrated missile system design; perform stand-alone experiments with component technology hardware and software to verify performance; perform experiments to determine adequate operation in a lab environment. ***FY 2021 to FY 2022 Increase/Decrease Statement:***	4.288	4.362	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AK4 *I Multi-Role Small Guided Missile Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Beginning in FY22 funding has been realigned into PE 0602148A/CI5 to support acceleration of the High Speed Maneuverable Missile effort.			
Title: Multiple Simul Engagement Technologies (MSET) *Description:* Investigate critical missile and fire control component technologies and designs for future missiles that can be launched simultaneously, can operate autonomously and/or under human supervision, and can form advanced, cooperative teams to defeat one or more hard/soft targets which are stationary and/or moving targets. *FY 2021 Plans:* Perform detailed design of target detection and tracking algorithms, multi-missile communications datalink, and multi-missile command and control algorithms; develop laboratory environment for component experimentation and perform investigations of component technical performance. *FY 2022 Plans:* Will combine lower-level component simulations to form system-level simulation. Will verify component performance predictions to aid in design refinement and overall performance predictions. Will mature component designs based on simulation results. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle for this effort for increased focus on performing higher-level simulation.	-	3.101	3.736
Accomplishments/Planned Programs Subtotals	5.853	7.463	3.736

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 24 of 56

R-1 Line #15

Volume 1b - 357

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** AK6 *I Advanced Rotorcraft Armaments Protection System Te*		
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**
AK6: *Advanced Rotorcraft Armaments Protection System Te*	-	5.094	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates holistic lethality technologies for Future Vertical Lift (FVL) offensive and defensive applications. Develops components for use in multi-role armament solutions for fire control, armament systems, munitions, and integration of threat agnostic countermeasures.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

Work in this effort is performed by the United States (US) Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advanced Rotorcraft Armament & Protection System (ARAPS)	5.094	-	-
Description: The ARAPS effort designs and develops FVL technologies for lightweight armament systems and multi-role munitions with enhanced lethality at extended ranges. The effort investigates and determines the feasibility of a holistic fire control system that integrates all aspects of offensive and defensive capabilities for advanced protection and enhanced survivability.			
Accomplishments/Planned Programs Subtotals	5.094	-	-

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* 2					**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*			**Project (Number/Name)** AK9 *I Adv Teaming for Tactical Aviation Operations Tech*				
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**
AK9: *Adv Teaming for Tactical Aviation Operations Tech*	-	13.024	13.531	13.978	-	13.978	-	-	-	-	-	-

Note

 In Fiscal Year (FY) 2022, funding was partially realigned from this Project administratively to Program Element (PE) 0602183A Air Platform Applied Research / CL8 Aviation Teaming Autonomy Concepts & Technologies

A. Mission Description and Budget Item Justification

 This Project investigates and develops subsystem and component level technologies that enable advanced teaming behaviors for mixed platform formations in combined arms operations. Primary component technologies to develop are in the areas of resilient autonomy algorithms, team-based communications and situational awareness management, decision aiding for weapons systems engagement, autonomous terrain and collision avoidance, and human autonomy interface design.

 Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advanced Teaming Concepts	9.525	9.643	8.357
Description: Investigates and develops subsystem and component level technologies that enable advanced manned and unmanned teaming behaviors for mixed air and ground platform formations in combined arms operations. *FY 2021 Plans:* Develop mission systems teaming architectures and subsystem technologies focused on collaborative mission planning and execution, enhanced own-ship autonomy, shared team situational awareness using distributed sensor systems, and advanced effector employment; enhance simulation models for evaluation of multi-Unmanned Aircraft System (UAS) coordinated attack and decoy behaviors in Global Positioning System (GPS) denied conditions. *FY 2022 Plans:*			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602148A / *Future Verticle Lift Technology*	Project (Number/Name) AK9 / *Adv Teaming for Tactical Aviation Operations Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will further develop and enhance technologies that provide UAS team of teams coordinated mission planning and execution, fused team situational awareness for autonomous mission adaptation, and electronic warfare employment all while operating in GPS denied and communications degraded conditions. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort with reduced development of simulation models.			
Title: Micro/Small Scale Unmanned Aerial Systems **Description:** Enables micro/small Future Unmanned Aircraft System (FUAS) concepts for experimental prototypes to discover behaviors that can be scaled up to group 3 platforms to support advanced manned and unmanned air and ground teaming, and the maturation of basic research in the area of intelligent unmanned air systems. This includes controls that can adapt to damage or environmental conditions, models to perform aggressive maneuver in complex environments, reduction of noise signature, and adaptive structures.	3.499	-	-
Title: Intelligent Unmanned Aerial System Teaming Technologies **Description:** Enables the establishment of component technologies to support resilient, multi-modal, survivable UAS teams that can plan and act on time-scales beyond human capability and have a robust shared understanding of contested and dynamic environments to support effective tactical engagement. Specific topics include 1) novel artificial-intelligence algorithms and methods for adaptive team composition and control, 2) increased team knowledge base and understanding of local and global world models, 3) hierarchical, composable, and adaptive learning methods for increased mission resilience, and 4) understanding interaction and scalability between, amongst, and across heterogeneous team members and the environment. ***FY 2021 Plans:*** Investigate and develop novel control schemes that will enable homogeneous and heterogeneous groups of UAS to perform advanced teaming operations in complex environments; investigate and mature higher fidelity methods into computationally efficient physics-based modeling tools to enhance the understanding and effectiveness of tactical group behaviors against a capability-matched adversarial force utilizing game theoretic principles; perform research to progress methods for advanced teaming simulation environments to fully incorporate full vehicle flight dynamics models for a single platform and investigate methods for multi-agents. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort is administratively realigned to PE 0602183A Project CL8 Aviation Teaming Autonomy Concepts & Technologies.	-	3.888	-
Title: Enhanced Optics for Long Range Targeting	-	-	5.621

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AK9 *I Adv Teaming for Tactical Aviation Operations Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort will deliver advanced airborne optics and reconfigurable filtering devices to enable agile, multi-task sensors for compact, long-range targeting, enhanced survivability and lethality of the Future Vertical Lift (FVL) and Future Unmanned Aircraft System (FUAS). This effort will restore visual overmatch in any (day/night) environment through visual penetration of all obscurants (e.g. brownout, white out, engineered smokescreens) from a single sensor, as well as narrowband filtering for active imaging through obscurants while maintaining advanced target acquisition. Improved detection and identification and long range target acquisition capability will result from filtering out scattered light and enabling 3-dimensional ranging through environmental obscurants. *FY 2022 Plans:* Will investigate materials and efficiency of non-traditional off-axis style optical systems for range performance; will design and develop field-selectable spectral bandpass filters for operation near cryogenic dewars to penetrate obscurants while minimizing photon noise, enabling multi-task sensing (e.g. long range targeting, brownout penetration, disturbed earth detection) from a single sensor; will investigate active sensor components for 3-D Imaging; will conduct experiments on the material growth process for a new optical lens for multi-band targeting sensors to enable greater sensitivity and range performance. *FY 2021 to FY 2022 Increase/Decrease Statement:* This research effort was administratively realigned from PE 0602148A (Aviation Technology) / Project AK2 (Aviation Survivability Technology) in FY22			
Accomplishments/Planned Programs Subtotals	13.024	13.531	13.978

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* 2					R-1 Program Element (Number/Name) PE 0602148A *I Future Verticle Lift Technology*						Project (Number/Name) AL2 *I High Performance Computing for Rotorcraft App Tech*	

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
AL2: *High Performance Computing for Rotorcraft App Tech*	-	1.121	1.148	1.200	-	1.200	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and validates aeromechanics modeling and simulation tools for Future Vertical Lift (FVL) platforms. Research efforts in this Project are also applicable to the family of FVL manned and unmanned platforms.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: High Performance Computing for Rotorcraft App Tech *Description:* Investigate new high performance and parallel computing efforts in support of FVL platforms. *FY 2021 Plans:* Develop and demonstrate new automated high-fidelity computational tools for full-vehicle rotorcraft aeromechanics analysis and design. Automate the setup and execution of these computational models to improve turnaround and to build in best practices for consistently accurate results. *FY 2022 Plans:* Will develop new computational software tools for rotorcraft aeromechanics analysis that leverage the power of high-performance computers to produce high-accuracy results for vehicles with complex aerodynamic interactions among their component parts. Will improve the computational speed of these high-fidelity simulations so that they can be routinely used in rotorcraft design and optimization processes for FVL vehicles. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort.	1.121	1.148	1.200
Accomplishments/Planned Programs Subtotals	1.121	1.148	1.200

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AL2 *I High Performance Computing for Rotorcraft App Tech*

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 30 of 56

R-1 Line #15

Volume 1b - 363

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602148A I *Future Verticle Lift Technology*					**Project (Number/Name)** AL4 I *High Speed and Efficient VTOL Vehicle 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
AL4: *High Speed and Efficient VTOL Vehicle Technology*	-	1.438	1.444	1.466	-	1.466	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project establishes component technologies in the area of materials, design, and dynamic models to enable next generation capability for Future Vertical Lift (FVL) platforms. Objectives of this Project are focused on improving both performance (i.e. range, payload, endurance) and reliability/maintainability metrics, where outcomes from these efforts are applicable to the Family of Future Vertical Lift manned and unmanned platforms.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: High Speed & Efficient Vertical Take-off and Landing	1.438	1.444	1.466
Description: This research effort establishes concepts in vertical take-off and landing in the area of propulsion to enable improved, efficient hover and high-speed cruise at longer range without added weight. *FY 2021 Plans:* Investigate lightweight materials and designs for transmission gears; establish, by experimental means, the bounds at oil-out conditions for lightweight gear designs. Characterize and validate the dynamics of candidate hybrid gears. *FY 2022 Plans:* Will apply deep learning methods to build a diagnostic analytical tool for UH-60 Black Hawk; will select materials and design for a half-weight hybrid transmission gear. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding decrease reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	1.438	1.444	1.466

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* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AL4 *I High Speed and Efficient VTOL Vehicle Technology*
C. Other Program Funding Summary ($ in Millions)		
Remarks		
D. Acquisition Strategy N/A		

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 32 of 56

R-1 Line #15

Volume 1b - 365

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*						**Project (Number/Name)** AL5 *I Air Vehicle Structures and Dynamics 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**
AL5: *Air Vehicle Structures and Dynamics Technology*	-	2.652	2.792	2.823	-	2.823	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project establishes validated modeling tools needed to develop aeroelastically stable rotor technologies to enable high speed flight and longer flight envelopes in Future Vertical Lift (FVL) platforms. Efforts in this Project are also applicable to the family of FVL manned and unmanned platforms.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

Work in this effort is performed by the United States (US) Army Futures Command

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Air Vehicle Structures and Dynamics Technology *Description:* Establish improved experimentally validated modeling tools and methodologies that can be used to understand the physics of aeroelastic stability and design in next generation rotorcraft platform configurations for FVL platforms. This involves the development of an experimental capability, the Tiltrotor Aeroelastic Stability Test-bed (TRAST), which would be used to generate novel experimental data. This data will be used to increase fundamental understanding of the whirl flutter instability, which currently limits the high speed performance of tiltrotor rotorcraft. This effort mitigates risk for the Joint Multi-Role Technology Demonstrator (JMR-TD) effort and informs FVL requirement definition and technology maturation. The experimentally validated models will also be used to investigate concepts to reduce the vibration and improve stability of future aircraft.	1.715	-	-
Title: Probabilistic and Damage Tolerance Methodologies *Description:* Advancement of probabilistic analytical algorithms and methods to enable air platform performance and availability. Probabilistic analytical methodologies resulting from this effort are expected to impact a broad range of air structure vehicle and dynamic technologies including enhanced damage tolerance.	0.937	-	-
Title: Aeromechanics and Aeroelasticity of Future Air Vehicle Platforms *Description:* Establish improved experimentally validated modeling tools and methodologies that can be used to understand the physics of aeroelastic stability and design in next generation rotorcraft platform configurations for FVL platforms. This involves	-	2.792	2.823

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AL5 *I Air Vehicle Structures and Dynamics Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
the development of an experimental capability, (TRAST), which will be used to generate novel experimental data. This data will be used to increase fundamental understanding of the whirl flutter instability, which currently limits the high speed performance of tiltrotor rotorcraft. This effort will inform FVL requirement definition and technology maturation. This effort also establishes low noise rotor concepts and investigates the intersection of artificial intelligence and classical mechanics to enable novel mechanics and new approaches in structural dynamics for FVL applications to enable higher Operating Tempo (OPTEMPO) operations. ***FY 2021 Plans:*** Conduct wind tunnel experiments of idealized tiltrotor configurations to understand the effects of rotor, wing, control parameters, and dynamic and aerodynamic coupling on aircraft stability to enable faster, more efficient, and sustainable tiltrotor aircraft. Increase understanding of aerodynamic and acoustic interactions through simulation and experiments; validate modeling capabilities for multi-rotor and compound vertical lift concepts to enable quieter operations. Advance knowledge of underlying mechanics through exploration of materials for vibrational damping, actuation, and sensing through experiments and artificial intelligence/machine learning to enable the development of massively reconfigurable air vehicle configurations. ***FY 2022 Plans:*** Will investigate fluid-structure interaction models to inform the structural design of an adaptive unmanned aerial system (UAS) with enhanced aerodynamic performance; will develop tools and methods for multi-disciplinary and multi-dimensional design optimization of future and non-traditional UAS and assessment of emergent technologies; will conduct wind tunnel experiments to investigate the effects of hinge-less rotor and control parameters on tiltrotor aircraft stability to enable faster, more efficient, and sustainable tiltrotor aircraft; will perform analysis and wind-tunnel experimentation to assess passive and active whirl-flutter mitigation technologies; will perform high-fidelity computational aeromechanics modeling of novel blade concepts to enable rotor with improved performance and noise characteristics; will couple acoustics prediction models with the comprehensive analysis codes to enable acoustics characterization of rotorcraft configurations at conceptual design stage. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	2.652	2.792	2.823

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 34 of 56

R-1 Line #15

| **Volume 1b - 367** |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** AL8 *I Holistic Situational Awareness and Dec Making Tech*		
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**
AL8: *Holistic Situational Awareness and Dec Making Tech*	-	1.673	1.757	0.889	-	0.889	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project focuses on modeling and simulation of pilotage and decision aiding system technology that allows for care free operations in complex and hostile environments.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

Work in this effort is performed by the United States (US) Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Radar Sensing and Phenomenology **Description:** This effort develops the technical underpinnings of radar and other active and passive radio frequency (RF) sensing modalities for several key Army requirements. Focus in on cost effective radar concepts to enhance the situational awareness and navigation capabilities of US Army rotorcraft, allowing safe operation in Degraded Visual Environment (DVE). This research uses a combination of advanced computational electromagnetic models and algorithms, radar measurements, active and passive RF sensing technologies, and advanced signal processing.	1.673	-	-
Title: Wideband RF Sensors **Description:** This effort develops the technical underpinnings of radar and other active and passive RF sensing modalities for several key Army requirements, with a focus on cost effective radar concepts to enhance the situational awareness and navigation capabilities of US Army rotorcraft to operate safely in DVE. This research uses a combination of advanced computational electromagnetic models and algorithms, radar measurements, active and passive RF sensing technologies, and advanced signal processing. **FY 2021 Plans:**	-	0.892	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AL8 *I Holistic Situational Awareness and Dec Making Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Investigate and explore FLSAR design options and develop instrumentation to collect outdoor data. Implement fast 3-D SAR imaging algorithm for signal processor that leverages the architecture and capability of advanced Graphics Processor Units (GPUs). ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, effort is realigned to PE 0602141/CG4 Advanced Radar Concepts and Technologies for consolidation of efforts across the modernization priorities			
Title: Situational Awareness Radar for DVE mitigation *Description:* This effort investigates technologies and algorithms for compact radars that will provide a hazard warning capability to airborne platforms in all environmental conditions, including those with zero visibility. This hazard warning capability will detect collision threats and specific projectile hazards around the entire aircraft using a suite of small form-factor radars. Algorithms are created to interpret the data produced by these radars and distinguish threats from benign clutter. Innovative radar architectures and device technologies are investigated and demonstrated to enhance and extend performance. ***FY 2021 Plans:*** Investigate waveforms to minimize interference between the radars on different platforms and reduce their susceptibility to detection and electronic attack. ***FY 2022 Plans:*** Will investigate forward looking synthetic aperture radar (FLSAR) technology to assess capabilities for terrain navigation in Degraded Visual Environments (DVE); will conduct experiments in relevant field conditions using laboratory radar testbed; develop and implement signal processing for creating 3-D imagery of ground obstacles. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort to focus on experiments using laboratory radar testbed.	-	0.865	0.889
Accomplishments/Planned Programs Subtotals	1.673	1.757	0.889

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 36 of 56

R-1 Line #15

Volume 1b - 369

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602148A I *Future Verticle Lift Technology*					**Project (Number/Name)** AM2 I *Aircraft and Aircrew Protection 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
AM2: *Aircraft and Aircrew Protection Technology*	-	1.459	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and develops leap-ahead structures technologies, concepts, and capabilities that enable break-through improvements in weight efficiency, performance, and extreme-environment operational durability, as well as enhanced platform design, qualification, and fleet structural integrity management for application to Future Vertical Lift (FVL) platforms. Technologies also have applicability to Future Unmanned Aircraft Systems (FUAS).

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Aircraft & Aircrew Protection	1.459	-	-
Description: Enables survivable, sustainable rotorcraft configurations by conceiving of and evaluating critical aviation technologies using design and analysis methods with greater modeling fidelity with an ultimate goal of reducing the timelines associated with overall design of FVL and FUAS platforms. Introduces high fidelity methodology for improved performance and design predictions earlier in the development and acquisition process. Use physics of failure modeling and coupled discipline analysis to drastically improve component and system reliability.			
Accomplishments/Planned Programs Subtotals	1.459	-	-

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

D. Acquisition Strategy
N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 37 of 56

R-1 Line #15

Volume 1b - 370

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

Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602148A I *Future Verticle Lift Technology*					Project (Number/Name) AM4 I *Opt Energy Stg & Therm Mgmt for FVL Survivability*		

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
AM4: *Opt Energy Stg & Therm Mgmt for FVL Survivability*	-	4.710	8.531	-	-	-	-	-	-	-	-	-

Note

In FY22, this Project is administratively realigned under PE 0602148A (Future Vertical Lift Technology / CH4 (Power and Thermal Management for FVL Tech)

A. Mission Description and Budget Item Justification

This Project investigates emerging power generation, energy storage, and thermal management technologies needed for future Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR), and survivability equipment that could be incorporated onto Future Vertical Lift (FVL) and other Army platforms. Provides power capability for advanced electric aeromechanical effectors, advanced mission systems algorithms for route planning and teaming and advanced electronic warfare devices.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Optimized Energy for C5ISR Platforms	4.710	4.867	-
Description: This effort investigates power and thermal management associated with high power C5ISR capabilities on ground and air platforms enabling enhanced mobility and mission flexibility. This effort funds research to improve FVL aircraft and other Army platforms power efficiency through the use of on-demand hybrid power architectures, while also researching ways to eliminate platform thermal constraints. This effort will also investigate very high density power sources and energy storage for high rate pulsed power, power management, and thermal management for dynamic high rate pulsed power. *FY 2021 Plans:* Investigate power requirements for emerging C5ISR. Explore use of models based on size, weight, and power requirements and aircraft platform constraints, which include architectures and intelligent control variants for management of these loads. Conduct experiments on the modularization of the storage technology needed to support high power, short duration burst loads. Investigate thermal implications of waste heat generated from inefficiencies in power conversion and its impact on the aircraft. Conduct			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** AM4 *I Opt Energy Stg & Therm Mgmt for FVL Survivability*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
experiments on hybrid energy storage technologies to support cyclical loads such as hybrid batteries or ultra-capacitor technology. Validate models of intelligent controls for platform-integrated power systems to conduct experiments on control strategies. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY22 the work for this project is administratively realigned under PE 0602148A (Future Vertical Lift Technology / CH4 (Power and Thermal Management for FVL Tech)			
Title: Power & Thermal Management Components *Description:* This effort develops power and thermal management component technologies to meet the power and thermal demands of Future Vertical Lift aircraft while minimizing system size and weight. Technology will be validated through component level test. *FY 2021 Plans:* Develop and perform component level validation testing on advanced power generation technologies such as lightweight, efficient turbo-generators and advanced thermal management technologies specifically designed for application to FVL aircraft. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY22 the work for this project is administratively realigned under PE 0602148A (Future Vertical Lift Technology / CH4 (Power and Thermal Management for FVL Tech)	-	3.664	-
Accomplishments/Planned Programs Subtotals	4.710	8.531	-

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 39 of 56

R-1 Line #15

Volume 1b - 372

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602148A I *Future Verticle Lift Technology*				**Project (Number/Name)** BP7 I *Future Vertical Lift Air Platform Tech (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**
BP7: *Future Vertical Lift Air Platform Tech (CA)*	-	14.000	75.000	-	-	-	-	-	-	-	-	-

Note

Congressional Interest Item funding provided for Future Vertical Lift Air Platform Technology.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Future Vertical Lift Platform 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**
Congressional Add: Flight Control Technology Safety and Survivability	3.000	-
FY 2020 Accomplishments: Conducted applied research in Flight Control Technology Safety and Survivability. Work executed by Army Futures Command.		
Congressional Add: Rotary Wing Adaptive Flight Control Technology	6.000	-
FY 2020 Accomplishments: Conducted applied research in Rotary Wing Adaptive Flight Control Technology. Work executed by Army Futures Command.		
Congressional Add: Technology Transfer and Innovation	5.000	-
FY 2020 Accomplishments: Conducted Technology Transfer and Innovation activities of high potential applied research outcomes. Work executed by Army Futures Command.		
Congressional Add: Program increase - high strength functional composites	-	5.000
FY 2021 Plans: Conduct applied research in High Strength Functional Composites.		

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602148A I *Future Verticle Lift Technology*	Project (Number/Name) BP7 I *Future Vertical Lift Air Platform Tech (CA)*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Work executed by Army Futures Command.		
Congressional Add: Program increase - additive manufacturing of multifunctional composite aerospace components	-	5.000
FY 2021 Plans: Conduct applied research in Additive Manufacturing of Multifunctional Composite Aerospace Components. Work executed by Army Futures Command.		
Congressional Add: Program increase: Advanced rotary wing materials and structures	-	5.000
FY 2021 Plans: Conduct applied research in Advanced Rotary Wing Materials and Structures. Work executed by Army Futures Command.		
Congressional Add: Program increase: Adaptive flight control technology	-	4.000
FY 2021 Plans: Conduct applied research in Adaptive Flight Control Technology. Work executed by Army Futures Command.		
Congressional Add: Program increase: Lightweight hybrid composite medium caliber barrels	-	20.000
FY 2021 Plans: Conduct applied research in Lightweight Hybrid Composite Medium Caliber Barrels. Work executed by Army Futures Command.		
Congressional Add: Program increase: Technology transfer and innovation	-	5.000
FY 2021 Plans: Conduct applied research in Technology Transfer and Innovation. Work executed by Army Futures Command.		
Congressional Add: Program increase - self-sealing fuel tanks technology	-	6.000
FY 2021 Plans: Conduct applied research in Self-Sealing Fuel Tanks Technology. Work executed by Army Futures Command.		
Congressional Add: Program increase - high density eVTOL power source	-	15.000
FY 2021 Plans: Conduct applied research in High Density eVTOL Power Source.		

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** BP7 *I Future Vertical Lift Air Platform Tech (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed by Army Futures Command.		
Congressional Add: Program increase - individual blade and higher harmonic control	-	10.000
FY 2021 Plans: Conduct applied research in Individual Blade and Higher Harmonic Control. Work executed by Army Futures Command.		
Congressional Adds Subtotals	14.000	75.000

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 42 of 56

R-1 Line #15

Volume 1b - 375

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** BZ7 *I Future Vertical Lift Medical Technologies*		
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**
BZ7: *Future Vertical Lift Medical Technologies*	-	-	7.911	7.818	-	7.818	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project involves research to prevent injury and performance degradation in Aviators, Unmanned Arial System (UAS) Operators and other Warfighters in training and operations; refines risk assessment and performance models based on operational stressors, e.g., sleep deprivation, work load, fatigue; and delivers biomedical-based spinal injury criteria and assessment methodologies. This research provides medical information important to the design and operational use of future vertical lift aircraft, and when appropriate, ground vehicles.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Medical Standards to Support Future Vertical Lift	-	7.911	7.818
Description: This effort develops and delivers medical guidelines and strategies to assure optimal Soldier performance and protection on the future technologically-intensive battlefield. Key elements of the program include: 1) tailored medical selection and retention standards for FVL; 2) medical strategies to maintain and enhance human performance in Multi-domain operations (MDO); 3) human-centered technology design guidance to accommodate the range of aircrew; 4) improved protection standards to reduce FVL occupant injury; and 5) operator state monitoring tools to enable scalable autonomy in FVL aircraft. *FY 2021 Plans:* Develop advanced visual display guidelines to assist aviators in maintaining situational awareness during extreme degraded visual environment (DVE) conditions. Develop aviator composite risk assessment and performance model based on DVE and other operational stressors. Deliver to the Aviation and Missile Center (AvMC) for FVL, and when appropriate, to the Ground Vehicle Systems Center (GVSC) for the Next Generation Combat Vehicle (NGCV), provisional biomedical-based spinal injury criteria and assessment methodologies for two types of vertebral body fractures that seated occupants experience during vertical exposures. *FY 2022 Plans:* Will develop the holistic medical aspects of a Situational Awareness and Decision-Making (HAS-DM) Program. Will evaluate transcranial stimulation to enhance alertness and situational awareness in extended operations. Will determine medical optimal feedback modes to FVL operators for use in scalable autonomy. Will assess medical impacts of FVL scalable autonomy			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** BZ7 *I Future Vertical Lift Medical Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
at system level in degraded operator modes. Will evaluate composite workload for real time operator state monitoring. Will develop aircraft and human medical indicators of operator workload and state. Will develop helmet stability and dynamic retention standards for aviation helmets. Will evaluate aviation survivability development and tactics (ASDAT) in a retrospective study on combat-related injury.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding realigned to PE 0602787A Project MM4 (Cbt Casualty Care Applied Rsch Technology).			
Accomplishments/Planned Programs Subtotals	-	7.911	7.818

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 44 of 56

R-1 Line #15

Volume 1b - 377

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*					**Project (Number/Name)** CC3 *I FVL Radar Technologies*			
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**
CC3: *FVL Radar Technologies*	-	-	0.698	0.444	-	0.444	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops underlying technologies applicable to next generation radar apertures used for detection, tracking and precision targeting, navigation and fire control for multiple modalities.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Battlefield Surveillance & Targeting Radar Technology	-	0.698	0.444
Description: Advanced Reconnaissance, Surveillance and Target Acquisition Waveform Designs for advanced multi-beam Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR) systems. *FY 2021 Plans:* Investigate modeling and simulation of subsystem and component level designs for advanced GMTI and SAR systems. Investigate standards and interface requirements necessary to facilitate integration of scalable Radio Frequency (RF) components at the sub aperture level; conduct experiments to determine optimal techniques for waveform optimization to mitigate spectrum challenges. Investigate multi-function RF modes and waveforms external to traditional SAR and GMTI radar collection. *FY 2022 Plans:* Will conduct radar functionality study to investigate frequency, power/duty cycle, timing and aperture allocation requirements to inform and prioritize radar mode development strategy *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding decrease in FY22 reflects decrease in testing needs for more study of radar utilization.			
Accomplishments/Planned Programs Subtotals	-	0.698	0.444

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* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technol ogy*	**Project (Number/Name)** CC3 *I FVL Radar Technologies*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 46 of 56

R-1 Line #15

Volume 1b - 379

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*				**Project (Number/Name)** CG9 *I Adapt & Resilnt Tact Autnmy Cont & Struct Tech*			

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
CG9: *Adapt & Resilnt Tact Autnmy Cont & Struct Tech*	-	-	-	6.507	-	6.507	-	-	-	-	-	-

Note

 In Fiscal Year 2022 (FY22) this Project was administratively realigned from:
 Program Element (PE) 0602148A / Future Vertical Lift Technology
 * Project AJ4 "Digital Vehicle Management and Control Technology".

A. Mission Description and Budget Item Justification

This Project develops methodologies for advanced flight dynamics models, robust flight controls for superior handling qualities, and improved survivability, redundancy management with reduced structural loads on the aircraft. Designs algorithms for autonomy, optionally piloted operations and manned-unmanned teaming. This project directly supports FVL modernization priority capabilities by investigating, maturing, and harmonizing leap-ahead autonomy, structures, and controls technologies, concepts, and capabilities which enable combat mission success across the family of manned/unmanned FVL platforms.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Adaptive and Resilient Engineered Structures (ARES) Technologies	-	-	1.558
Description: Develop structures technologies providing performance, survivability, and sustainment benefits with broad applicability across platform scale and role, enabling mission success for manned/unmanned FVL platforms in the contested environment of multi-domain operations. *FY 2022 Plans:* Will develop weight-efficient unitized structural assembly concepts. Will develop innovative weight-efficient blast-tolerant structural concepts. Will apply advanced material systems to develop strong, resilient rotor blade spar designs. Will develop weight-efficient multifunctional structural concepts with integral electromagnetic shielding. *FY 2021 to FY 2022 Increase/Decrease Statement:*			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** CG9 *I Adapt & Resilnt Tact Autnmy Cont & Struct Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding realigned in FY22 from PE 0602148A, Project AJ4 ?Digital Vehicle Management and Control Technology?.			
Title: Adaptive Tactical Autonomy and Control (ATAC) Technologies	-	-	4.949
Description: Develop vehicle management, flight control, and autonomy technologies that enable FVL aircraft to achieve superior maneuverability and agility at all speeds, effectively exploit extreme/degraded environmental conditions as a force multiplier, fight and win in presence of failure or damage, and operate on a cognitive-loading-spectrum from piloted to fully autonomous. *FY 2022 Plans:* Will collaborate with Original Equipment Manufacturers (OEM) using flight data from extended Joint Multi-Role Technology Demonstrator (JMR-TD) flight tests to validate Army?s flight-dynamics modeling techniques for modern configurations. Will apply lessons learned to improve Army models of Future Attack Reconnaissance Aircraft (FARA) and Future Long Range Assault Aircraft (FLRAA) and help validate/improve OEM models. Will correlate JMR-TD flight and simulation data with new and existing handling qualities criteria to expand requirements to high speed. Will continue developing Damage Tolerant Control (DTC) technologies and state-of-the-art autonomy algorithms for advanced configurations and military Unmanned Aerial Vehicles (UAV) / Air-Launched Effects (ALE). *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding realigned in FY22 from PE 0602148A, Project AJ4 ?Digital Vehicle Management and Control Technology?.			
Accomplishments/Planned Programs Subtotals	-	-	6.507

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 2 | R-1 Program Element (Number/Name)
PE 0602148A I *Future Verticle Lift Technology* | Project (Number/Name)
CH2 I *Air Launched Effects 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
CH2: *Air Launched Effects Technology*	-	-	-	7.567	-	7.567	-	-	-	-	-	-

Note
Funding for this project is realigned in FY22 from PE 0602148A, Project AI5 Next Gen Tactical UAS TD Technology.

A. Mission Description and Budget Item Justification
This Project utilizes improved analytic modeling to investigate the effects that potential unmanned system capabilities could have on air vehicle design considerations and operational concepts. This project improves government capability to design and assess novel Unmanned Aircraft System (UAS) concepts. This Project develops and investigates the ability to launch a UAS from a manned or unmanned future vertical lift aircraft at tactical altitudes and to control the same after launch from nearby FVL aircraft, as well as development of the associated payloads (recon, BDA, targeting, comms, decoy). This Project will assess the enabled capabilities and determine their relevance to current Army Aviation engagement and survivability portfolios.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Systems Concepts Studies for Air Launched Effects *Description:* Investigate potential air vehicle configurations and capabilities to develop and refine the design trade space enabling Future Vertical Lift. Models air vehicle concepts to understand the effects that potential operational Air Launched Effects capabilities will have on air vehicle properties. *FY 2022 Plans:* Will conduct configuration trade and analysis studies to develop novel UAS concepts that will serve to inform Air Launched Effects system specification. Will investigate critical design attributes to inform UAS system performance, weight, and cost. Will develop analytic modeling capabilities to improve timeliness, accuracy, and detail of conceptual design for unmanned systems. *FY 2021 to FY 2022 Increase/Decrease Statement:*	-	-	7.567

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 49 of 56

R-1 Line #15

Volume 1b - 382

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** CH2 *I Air Launched Effects Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding increase due to this effort being realigned in FY22 from PE 0602148A, Project AI5 Next Gen Tactical UAS TD Technology.			
Accomplishments/Planned Programs Subtotals	-	-	7.567

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 50 of 56

R-1 Line #15

Volume 1b - 383

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*			**Project (Number/Name)** CH3 *I Holistic Team Survivability 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**
CH3: *Holistic Team Survivability Technology*	-	-	-	11.217	-	11.217	-	-	-	-	-	-

Note

In Fiscal Year 2022 (FY22) this Project was realigned from:
Program Element (PE) 0602148A / Future Vertical Lift Technology
* Project AK2 (Aviation Survivability Technology).

A. Mission Description and Budget Item Justification

This project will investigate and design advanced survivability technologies to develop a holistic team-based solution that delivers advanced sensing and EW effects across a family of aircraft to optimally penetrate and survive in the A2AD environment. This project will take an integrated team-based system of systems survivability approach through a purpose-driven mix of improved survivability situational awareness, signature management, vulnerability reduction, route and maneuver optimization, expendables, advanced sensors, and electro-optics (EO) & radio frequency (RF) jamming for existing and future air platforms. This project will also provide advanced teaming algorithms for survivability. This Project develops and evaluates multi layered survivability concepts and supporting technologies for increased survivability of Future Vertical Lift Family of Systems (FVL FoS) in an advanced and evolving integrated air defense systems environment.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advanced Survivability Concepts	-	-	4.189
Description: This effort will provide analysis of the rapidly evolving and emerging threat environment and impacts to Future Vertical Lift Family of Systems FVL FoS platforms, developing and evaluating full spectrum survivability concept, collaborative team based survivability algorithms and behaviors			
FY 2022 Plans:			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** CH3 *I Holistic Team Survivability Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will begin development of full spectrum susceptibility and vulnerability reduction component technologies that enhance holistic end-to-end survivability. Development of algorithms, behaviors, and human machine interface for team-based survivability. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds for this effort are realigned in FY22 from PE 0602148A (FVL Technology), Project AK2 (Aviation Survivability Technology).			
Title: Distributed Electronic Warefare Effects *Description:* This effort investigates and develops critical Electronic Warfare (EW) components and techniques to enable the FVL capability to operate and survive in Anti-Access/Area-Denied environments. It provides scalable low size, weight, power, and cost (SWaP-C) signal processing components and decision-making algorithms that adapt and counter the characteristics of advanced and emerging threats. ***FY 2022 Plans:*** Will develop novel algorithms to incorporate distributed sensor data into threat declaration algorithms; will develop methodology to optimize decision-making behaviors of sensor and countermeasure technologies to counter advanced threats; will investigate novel methods to adaptively update behavior of sensor and countermeasure technologies to react to changing threats and environmental conditions; will analyze impact of threat progression on measured performance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds for this effort are realigned in FY22 from PE 0602148A (FVL Technology), Project AK2 (Aviation Survivability Technology).	-	-	7.028
Accomplishments/Planned Programs Subtotals	-	-	11.217

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 52 of 56

R-1 Line #15

Volume 1b - 385

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*				**Project (Number/Name)** CH4 *I Power & Thermal Management for FVL Tech*		

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
CH4: *Power & Thermal Management for FVL Tech*	-	-	-	7.175	-	7.175	-	-	-	-	-	-

Note

 In Fiscal Year (FY) 2022 this Project was administratively realigned from:
 Program Element (PE) 0602148A Future Vertical Lift Technology
 * Project AM4 Opt Energy Stg & Therm Mgmt for FVL Survivability Tech

A. Mission Description and Budget Item Justification

This Project directly supports Future Vertical Lift (FVL) Modernization Priority capabilities by investigating and developing power and thermal management technologies to provide significantly higher electrical power capability to FVL aircraft while addressing consequential size, weight, and thermal issues. This effort provides power capability for advanced electric aeromechanical effectors, advanced mission systems algorithms for route planning and teaming, and advanced electronic warfare devices. This Project investigates emerging electrical power generation and distribution, energy storage, and thermal management technologies needed for future Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR) and survivability equipment for application to Future Vertical Lift (FVL) and other Army platforms. Enables significantly increased aircraft electrical power capability for advanced electric aeromechanical effectors, advanced mission systems to include algorithms for route planning and teaming, and for advanced electronic warfare devices while minimizing size and weight.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Optimized Energy for C5ISR Platforms	-	-	4.905
Description: This effort investigates electrical power and thermal management associated with high power C5ISR capabilities on ground and air platforms enabling enhanced mobility and mission flexibility. This effort funds research to improve FVL aircraft and other Army platforms power efficiency through the use of on-demand hybrid electrical power architectures, while also researching ways to eliminate platform thermal constraints. This effort will also investigate safer battery chemistries which enable very high density electrical power sources and energy storage to be flight certified for high rate pulsed power, electrical power management, and thermal management for dynamic high rate pulsed power.			

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 53 of 56

R-1 Line #15

Volume 1b - 386

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** CH4 *I Power & Thermal Management for FVL Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2022 Plans: Will apply models based on size, weight, and power requirements of air platforms to inform design and development of energy storage components needed to support high power, short duration bursts. Will design and develop phase change material and pumped two-phase based thermal management components to support rejection of waste heat due to inefficiencies in power conversion. Will conduct experiments on both energy storage and thermal management components to determine performance against advanced C5ISR devices such as advanced radars and sensors. Will conduct experiments to determine the effectiveness of power electronic components and power management strategies. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY22 this effort is administratively realigned from PE 0602148A (Future Vertical Lift Technology /AM4 (Opt Energy Stg & Therm Mgmt for FVL Surv Tech)			
Title: Power & Thermal Management Components *Description:* This effort develops electrical power and thermal management component technologies to meet the power and thermal demands of Future Vertical Lift aircraft while minimizing system size and weight. Technology will be validated through component level test. *FY 2022 Plans:* Will perform design and fabrication of efficient, distributed, and adaptable cooling systems enabling increased electrical power capability while reducing weight and cost to Future Vertical Lift aircraft electrical power and thermal management systems. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY22 this effort is administratively realigned from PE 0602148A (Future Vertical Lift Technology /AM4 (Opt Energy Stg & Therm Mgmt for FVL Surv Tech)	-	-	2.270
Accomplishments/Planned Programs Subtotals	-	-	7.175

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 54 of 56

R-1 Line #15

Volume 1b - 387

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602148A I *Future Verticle Lift Technology*				**Project (Number/Name)** CI5 I *High Speed Maneuverable Missile (HSMM) Tech*		
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**
CI5: *High Speed Maneuverable Missile (HSMM) Tech*	-	-	-	8.526	-	8.526	-	-	-	-	-	-

Note

This is a new start Project in Fiscal Year 2022, and was realigned from PE 0602148A Future Vertical Lift Technology/ Project AK4 Multi-Role Small Guided Missile Technology.

A. Mission Description and Budget Item Justification

The Project investigates, designs, and evaluates missile component technologies compatible with Future Vertical Lift (FVL) and Future Unmanned Aircraft Systems (FUAS) aviation platforms in a Multi-Domain Battle/Cross-domain Maneuver operational environment. Efforts provide technologies to support a smaller, faster, maneuverable missile capable of long range non-line-of-sight attack in contested/degraded environments. Technology development increases aviation lethality and platform survivability by increasing missile standoff range, speed, and maneuverability, a faster rate of fire, shorter times of flight, and multi-threat lethal effects. Enables cross domain applications for aviation and ground vehicle platforms, including handoff capability, to engage threats in dead zones, and to operate in contested environments.

Work in this Project is fully coordinated with PE 0603465A (Future Vertical Lift Advanced Technology Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: High Speed Maneuverable Missile (HSMM) Technology	-	-	8.526
Description: Efforts provide technology development to support a maneuverable missile capable of both short range direct attack and long range non-line-of-sight attack with reduced time to target; reduced size and weight for increased load-out; capable of air and ground launched missions in degraded/contested environments.			
FY 2022 Plans: Will continue component maturation based on PE 0602148A Future Vertical Lift Technology/ Project AK4 Multi-Role Small Guided Missile Technology efforts. Will investigate options for multi-mode propulsion to increase range and speed with desired trajectory for effectiveness and survivability. Will determine appropriate missile test bed. Will validate preliminary design accurately reflects			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602148A *I Future Verticle Lift Technology*	**Project (Number/Name)** CI5 *I High Speed Maneuverable Missile (HSMM) Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
platform interfaces and requirements to include maneuverability, long range precision strike capability in degraded/contested environments, and reduced time to target. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In Fiscal Year 2022, this Project was realigned from PE 0602148A Future Vertical Lift Technology/ Project AK4 Multi-Role Small Guided Missile Technology.			
Accomplishments/Planned Programs Subtotals	-	-	8.526

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

D. Acquisition Strategy
 N/A

PE 0602148A: *Future Verticle Lift Technology*
Army

UNCLASSIFIED
Page 56 of 56

R-1 Line #15

Volume 1b - 389

UNCLASSIFIED

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 2: *Applied Research*

R-1 Program Element (Number/Name)
PE 0602150A *I Air and Missile Defense 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
Total Program Element	-	93.937	107.584	19.316	-	19.316	-	-	-	-	-	-
AC9: *High Energy Laser Tactical Vehicle Demonstrator Te*	-	10.657	9.008	-	-	-	-	-	-	-	-	-
AD2: *High Energy Laser (HEL) Enabling and Support Techn*	-	7.635	9.744	5.991	-	5.991	-	-	-	-	-	-
AD3: *Maneuver Air Defense Technology*	-	4.027	12.744	7.893	-	7.893	-	-	-	-	-	-
AD5: *Next Generation Fires Radar Technology*	-	8.875	5.336	1.505	-	1.505	-	-	-	-	-	-
AD7: *Missile Fire Control Sensors Technology*	-	1.542	-	-	-	-	-	-	-	-	-	-
AD9: *Close Combat High Energy Laser Technology*	-	7.139	8.467	-	-	-	-	-	-	-	-	-
AE2: *Unconventional Countermeasures-Survivability Tech*	-	5.690	6.347	3.927	-	3.927	-	-	-	-	-	-
AE4: *Collaborative ISR Sensors Technology*	-	3.372	2.938	-	-	-	-	-	-	-	-	-
BN6: *Advanced Weapons Components (CA)*	-	45.000	53.000	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

Work in this PE investigates and develops Air and Missile Defense (AMD) technologies to enable defense of ground forces and selected geopolitical assets from aerial attack, missile attack, and surveillance. Major focus areas for AMD Science and Technology include: Missiles, Directed Energy, Gun-Based Air Defense Technologies, and Battlefield Sensors and Supporting AMD Technologies. Missiles Applied Research investigates and develops a broad range of Missile technologies to enhance Army integrated AMD capabilities at extended range. Directed Energy Applied Research investigates and develops critical High Energy Laser (HEL) technologies to explore performance against Air Defense threats and for other Directed Energy applications across Army Modernization Priorities. Gun-Based Air Defense Technologies Applied Research investigates and develops Combined Arms for Air Defense (CAFAD) technologies and components in a laboratory environment. Sensors and Supporting AMD Technologies Applied Research investigates and develops Battlefield Sensor and radar technologies required for detection, acquisition and tracking of air defense targets as well as supporting technologies that enhance AMD.

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 1 of 23

R-1 Line #16

Volume 1b - 390

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 2: Applied Research*	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*

Work in this PE complements PE 0603466A (Air and Missile Defense Advanced Technology).

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

Work is performed by the United States Army Futures Command (AFC), the United States Army Space and Missile Defense Command/Army Strategic Forces Command (SMDC/ARSTRAT), and the United States Army Rapid Capabilities and Critical Technologies Office (RCCTO).

B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	95.771	56.298	51.609	-	51.609
Current President's Budget	93.937	107.584	19.316	-	19.316
Total Adjustments	-1.834	51.286	-32.293	-	-32.293
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	53.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.834	-1.714			
• Adjustments to Budget Years	-	-	-32.293	-	-32.293

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Project: BN6: *Advanced Weapons Components (CA)*		
Congressional Add: *Sustainable Energy Materials and Manufacturing*	12.000	-
Congressional Add: *High-Energy Laser Hardware in the Loop*	20.000	-
Congressional Add: *COE in High-Energy Laser and Optical Technology*	3.000	-
Congressional Add: *Cybersecurity and Supply Chain Risk Management*	10.000	-
Congressional Add: *Program increase - beam control systems and industry grade optical fiber fabrication for energy laser*	-	12.000
Congressional Add: *Program increase - high energy laser enabling and support technology*	-	7.000
Congressional Add: *Program increase - Army missile supply chain risk management*	-	15.000
Congressional Add: *Program increase - close combat high energy laser technology*	-	8.500
Congressional Add: *Program increase - fires center of excellence*	-	1.500
Congressional Add: *Program increase - cyber resiliency in weapon systems*	-	1.500

PE 0602150A: *Air and Missile Defense Technology*
Army
UNCLASSIFIED
Page 2 of 23
R-1 Line #16
Volume 1b - 391

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Congressional Add: *Program increase - countermeasures based on artificial intelligence enabled material analysis and design*	-	6.000
Congressional Add: *Program increase - counter-UAS center of excellence*	-	1.500
Congressional Add Subtotals for Project: BN6	45.000	53.000
Congressional Add Totals for all Projects	45.000	53.000

Change Summary Explanation

FY2022 funding change due to partial administrative realignments of research to 0602141A (Lethality Technology), the transition of High Energy Laser Tactical Vehicle Demonstrator research to advanced research, and the conclusion of projects AE4 (Collaborative ISR Sensors Technology) and AD9 (Close Combat High Energy Laser Technology).

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*						**Project (Number/Name)** AC9 *I High Energy Laser Tactical Vehicle Demonstrator Te*		
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**
AC9: *High Energy Laser Tactical Vehicle Demonstrator Te*	-	10.657	9.008	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates component technologies for mobile high energy laser (HEL) weapon systems in solid state lasers (SSL) for use in protecting fixed and semi-fixed sites from Rocket, Artillery, and Mortars (RAM), Unmanned Aerial Systems (UAS) and advanced Air Defense threats. The Project researches advanced technologies for HEL weapon systems to enable more efficient laser systems with significantly greater power output for future HEL weapons to augment current kinetic Air Defense Artillery (ADA) systems and address additional missions with a low cost-per-kill exchange ratio. This includes technologies to support development of alternate laser sources, precision optical pointing and tracking components and adaptive optics to overcome laser degradation due to atmospheric effects to gain great lethality permitting expansion of threats set. Additionally development of compact and lighter weight energy generation and storage devices, and more efficient thermal management systems to remove excess heat will permit integrating laser weapons on additional combat platforms.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AD1 (High Energy Laser Tactical Vehicle Demonstrator Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy and supports the Army's future capability opportunities for leap-ahead technology for directed energy.

Work is performed by the United States (US) Army Rapid Capabilities and Critical Technologies Office (RCCTO).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: High Energy Laser Tactical Vehicle Demonstrator Technology *Description:* This effort develops technologies for robust beam control and SSL subsystems in the HEL Tactical Vehicle Demonstrator (TVD). Technologies developed under this effort will enable lighter, more agile beam control systems for tactical Army platform development and SSL technologies that enhance effectiveness against emerging air defense threats and increase efficiencies, enabling reductions in size, weight and power (SWaP) and improving the ability to integrate SSL systems into multiple Army weapon platforms. *FY 2021 Plans:* Conducts experimentation with prototype HEL TVD surrogate beam control system to characterize the performance of the base design: assess Adaptive Optics (AO) component demonstration and incorporate state-of-the-art optical focal planes to extend effectiveness of laser system in challenging environments to inform the HEL TVD beam control system design; Prepares beam control subsystem for integration with other subsystems in the system integration laboratory; Continues investigation, modeling &	10.657	9.008	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Te chnology*	**Project (Number/Name)** AC9 *I High Energy Laser Tactical Vehicle Demonstrator Te*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
simulation, assessment, and development of laser subsystems (e.g. laser sources, power and thermal subsystems) necessary for defeat of emerging and advanced air defense threats for the HEL TVD. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The beam control technologies and subsystems developed and demonstrated in FY2021 will transition to the HEL-TVD system integration and laboratory demonstration under PE 0603466A / Air and Missile Defense Advanced Technology Project AD1 High Energy Laser Tactical Vehicle Demo Advanced Technology.			
Accomplishments/Planned Programs Subtotals	10.657	9.008	-

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

D. Acquisition Strategy
 N/A

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 5 of 23

R-1 Line #16

Volume 1b - 394

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*						**Project (Number/Name)** AD2 *I High Energy Laser (HEL) Enabling and Support Techn*			

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
AD2: *High Energy Laser (HEL) Enabling and Support Techn*	-	7.635	9.744	5.991	-	5.991	-	-	-	-	-	-

Note

In FY 2022, a portion of this effort (High Energy Laser Enabling Technologies for Tactical Directed Energy Weapons) is administratively realigned to PE 0602141A Project CF7 Solid-state Laser Concepts and Architectures.

A. Mission Description and Budget Item Justification

This Project conducts static and dynamic High Energy Laser (HEL) vulnerability and lethality analyses and investigates advanced component technologies to enhance performance of future HEL weapons systems against advanced threats. In addition, this Project includes laboratory efforts for HEL applied research as well as concepts analysis for Army core competencies in Directed Energy (DE). This Project also investigates advanced laser technologies based on unconventional solid-state laser concepts, architectures, and thermal/power management schemes for the development of low size, weight, and power (SWaP) Army DE weapons and tactical laser developers.

Work in this effort compliments other Army Directed Energy efforts conducted under PE 0602150A (Air and Missile Defense Technology) and PE 0603466A (Air and Missile Defense Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Modernization Strategy, and supports the Army's future capability opportunities for leap-ahead technology for Directed Energy.

Work is performed by the United States Army Space and Missile Defense Command - Technical Center (USASMDC-TC) and the United States Army Combat Capabilities Development Command, Army Research Lab (CCDC-ARL).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: High Energy Laser Enabling and Support Technology *Description:* This effort provides the underlying data for future High Energy Laser weapons to effectively engage an array of threats. The data includes prioritized aim points on each threat as well as time to defeat the threats for each aim point. This activity includes the full spectrum of target lethality investigations and engagement of flying targets in relevant scenarios. This part of the activity is primarily executed at the Solid State Laser Testbed (SSLT) facility at White Sands Missile Range, New Mexico. This effort also focuses on developing core Army expertise through laser and beam control technology assessments, applied research, and other technical core competencies. This effort focuses on developing in-house expertise in Adaptive Optics (AO), Beam Control, laser diodes, target illuminators lasers and beacon illuminator lasers, laser diagnostics, and new tracking	6.446	7.739	5.991

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	**Project (Number/Name)** AD2 *I High Energy Laser (HEL) Enabling and Support Techn*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
algorithms. These technologies can be integrated into future laser systems to locate, identify, and engage critical targets. Results of this research may reduce the SWaP requirements, and the efficacy of laser weapons systems on Army platforms in the future. This part of the activity is primarily executed in Huntsville, Alabama. *FY 2021 Plans:* Conduct experiments to inform fixed wing threat assessment and develop defeat methodologies; will begin preliminary assessment of high energy laser effectiveness against Anti-Tank Guided Missile threats; will continue development of lethality database for RAM threats supporting the Maneuver - Short Range Air Defense (M-SHORAD) mission. Continue to evaluate and conduct experiments with advanced AO algorithms for deep turbulence atmospheric conditions. Integrate the Enhanced Tracking Sensor for Acquisition Tracking onto the MBC SIL for dynamic experiments. Complete Candidate Sensor Technology analysis for HEL Fine Tracking and Aimpoint designation in a pulsed illuminator and gated sensor configuration. *FY 2022 Plans:* Will conduct lethality studies and analysis of new/evolving threats and sustain core competency (SSLT and expertise) in HEL Lethality. Will advance AO studies and analysis to compensate for deep turbulence atmospheric conditions. Will fund research to show proof of concept of a tapered amplifier phased array laser system concept that compensate for atmospheric turbulence. *FY 2021 to FY 2022 Increase/Decrease Statement:* Decrease in funding from FY21 to FY22 shifts this effort into providing basic studies, analysis, assessments and retaining the Army core competency in Lethality, Lasers and Beam Control Technologies capability. Lethality testing will transition to a customer reimbursable mode. HEL Advanced Research will conduct in-house analysis of advanced HEL subsystem enhancements with no funding for hardware, field testing, or contracted subject matter expertise support. This impacts the ability to conduct S&T for future HEL System upgrades or improvements to meet future PoR Technology Transition Points.			
Title: High Energy Laser Enabling Technologies for Tactical Directed Energy Weapons *Description:* Research novel solid-state laser concepts, architectures, and components in support of the Army?s HEL weapons strategy; exploit breakthroughs in laser technology, develop and employ innovative laser gain material, and utilize photonics to meet the stringent weight/volume requirements for Army platforms, especially to enhance and improve the generation, transmission, and reception of lasers. *FY 2021 Plans:*	1.189	2.005	-

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 7 of 23

R-1 Line #16

Volume 1b - 396

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	**Project (Number/Name)** AD2 *I High Energy Laser (HEL) Enabling and Support Techn*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Investigate the potential of true-continuous wave fiber laser power scaling with crystalline core/crystalline cladding fibers; investigate power scaling potential of directly diode-cladding pumped Raman fiber laser. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort is administratively realigned to PE 0602141A Project CF7 Solid-state Laser Concepts and Architectures.			
Accomplishments/Planned Programs Subtotals	7.635	9.744	5.991

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 / 2				**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*					**Project (Number/Name)** AD3 / *Maneuver Air Defense 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
AD3: *Maneuver Air Defense Technology*	-	4.027	12.744	7.893	-	7.893	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Army Modernization Priority Air and Missile Defense capabilities by investigating and developing critical missile technologies and components necessary for an affordable short range air defense interceptor capability to defeat Cruise Missile (CM), Rotary Wing (RW), Tactical / Lethal Unmanned Aerial System (UAS), and Fixed Wing (FW) threats. This effort also designs and develops technologies to provide reduced size weight and power and cost for Maneuver Short Range Air Defense (MSHORAD), Short Range Air Defense (SHORAD), and Lower Tier essential to maintain overmatch against mid-/far-term threats.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AD4 (Maneuver Air Defense Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Maneuver Air Defense Technology **Description:** Investigates and develops critical missile technologies and components necessary for an affordable short range air defense interceptor capability to defeat RW, Tactical / Lethal UAS, and FW threats. **FY 2021 Plans:** Continue development of critical missile technologies for detection and tracking of hovering RW targets; develop and investigate an active radar seeker with integrated warhead fuzing capabilities through HWIL techniques for emulating hovering RW targets and other large Maneuver Short Range Air Defense (MSHORAD) targets in a laboratory environment. **FY 2022 Plans:** Will continue component maturation and software integration of seeker, guidance electronics, and control subsystems, then will integrate and validate performance of those subsystems in a dynamic HWIL environment; will conduct warhead lethality experiments to validate ability achieve an immediately observable kill against emulated threats. **FY 2021 to FY 2022 Increase/Decrease Statement:** Decrease in funding based on planned lifecycle events. Maturation and demonstration of technologies continue in PE 0603466A/AD4.	4.027	10.586	7.893
Title: Future Air Defense Missile Enabling Technology	-	2.158	-

PE 0602150A: *Air and Missile Defense Technology*
Army
UNCLASSIFIED
Page 9 of 23
R-1 Line #16
Volume 1b - 398

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	**Project (Number/Name)** AD3 *I Maneuver Air Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Designs and develops reduced cost advanced Air Defense missile critical components essential to maintain overmatch against Mid/Far term Maneuver-Short Range Air Defense threats. *FY 2021 Plans:* Perform component level trade studies and explore and develop new technologies to address emerging Maneuver-Short Range Air Defense (MSHORAD) threats and reduce space, weight, power and cost for future Air Defense missile guidance/ maneuverability/control, aerostructures, and propulsion technologies. *FY 2021 to FY 2022 Increase/Decrease Statement:* Efforts continue/realigned in FY 2022 to PE 0602141A/Project N49 (Future Air Defense Missile Enabling Technology)			
Accomplishments/Planned Programs Subtotals	4.027	12.744	7.893

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

D. Acquisition Strategy
 N/A

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 10 of 23

R-1 Line #16

Volume 1b - 399

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*					**Project (Number/Name)** AD5 *I Next Generation Fires Radar 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**
AD5: *Next Generation Fires Radar Technology*	-	8.875	5.336	1.505	-	1.505	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602303A Missile Technology:
* Project 214 Missile Technology
PE 0602120A Sensors and Electronic Survivability
* Project H16 S3I Technology
PE 0602705A Electronics and Electronic Devices
* Project H94 Elect & Electronic Devices

A. Mission Description and Budget Item Justification

This Project directly supports Army Modernization Priority Air and Missile Defense capabilities by investigating and developing advanced radar technologies for insertion into Multi-Mission Army Radar systems. This Project addresses challenges facing simultaneously achieving high linearity and efficiency at high frequencies, accuracy in the underlying high frequency device and circuit models, integration of new material into Silicon complementary metal-oxide-semiconductor (CMOS) processing flows, and electronics reliability that appear as new semiconductor materials are developed and feature sizes shrink.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AD6 (Next Generation Fires Radar Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advanced Fire Control Radar Technologies	3.619	-	-
Description: This effort develops advanced radar technologies for insertion into Multi- Mission Army Radar systems			
Title: Multi-Mode Air Defense Radar	1.510	1.522	1.505
Description: This research supports the technical challenges associated with air defense radar technology. In particular, this effort will analyze current and emerging radio frequency (RF) spoofing, RF jamming, and RF signature management technologies to determine their impact on the performance of air defense radars. Electromagnetic modeling, RF measurements, and experiments will be used to identify mitigation techniques for spoofing and jamming, and to identify useful signature			

PE 0602150A: *Air and Missile Defense Technology*
Army
UNCLASSIFIED
Page 11 of 23
R-1 Line #16
Volume 1b - 400

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	**Project (Number/Name)** AD5 *I Next Generation Fires Radar Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
management technologies. This will also include research in electronic devices, sub-assembly design, and laboratory experiments to advance the state-of-the-art of air defense radars operating in contested electronic environments. *FY 2021 Plans:* Develop algorithms for digital radar on laboratory hardware and assess compatibility with Army digital radar designs and testbeds; develop and model techniques and algorithms for survivable, cognitive, and distributed radar and quantify implications for radar device technology. *FY 2022 Plans:* Will leverage digital radar algorithms and modeling to evolve enhanced concepts for distributed and passive RF Sensing; validate and apply algorithms to distributed sub-array architectures and model system-level requirements for expanding battlefield sensing through distributed architectures. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change reflects planned lifecycle of this effort			
Title: Antennas and RF Device Components for Advanced Electronic Systems *Description:* This effort designs, characterizes, and validates high performance antennas, microwave components, and software for multifunction radar, RF sensing, and communication and position/timing systems. Research areas include scanning techniques, broadbanding, beamforming, polarization, platform integration, and affordability. For microwave components, research areas include software defined radios, analog-to-digital conversion rates, bandwidth resolution, bit accuracy, circuit design and affordability. *FY 2021 Plans:* Validate additively manufactured RF antenna arrays for scalability; validate efficient, multi-band, and survivable high power components and research ultra-wide bandgap semiconductor device technology for meeting power efficiency challenges. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, this effort has been realigned to a new Project titled Advanced Radar Concepts and Technologies in PE/Proj 0602141A CF7.	3.746	3.814	-
Accomplishments/Planned Programs Subtotals	8.875	5.336	1.505

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

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 12 of 23

R-1 Line #16

Volume 1b - 401

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	**Project (Number/Name)** AD5 *I Next Generation Fires Radar Technology*

D. Acquisition Strategy

  N/A

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 13 of 23

R-1 Line #16

Volume 1b - 402

UNCLASSIFIED

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

| Appropriation/Budget Activity
2040 I 2 | | | | | | R-1 Program Element (Number/Name)
PE 0602150A I Air and Missile Defense Technology | | | | | Project (Number/Name)
AD7 I Missile Fire Control Sensors 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
AD7: Missile Fire Control Sensors Technology	-	1.542	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Army Modernization Priority Air and Missile Defense capabilities by designing and developing technologies for advancements in next generation fire control sensor technology and target signature modeling.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AD6 (Next Generation Fires Radar Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Missile Fire Control Sensors Technology	1.542	-	-
Description: Design and develop technologies for advancements in next generation fire control sensor technology and target signature modeling.			
Accomplishments/Planned Programs Subtotals	1.542	-	-

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

Remarks

D. Acquisition Strategy
N/A

PE 0602150A: Air and Missile Defense Technology
Army

UNCLASSIFIED
Page 14 of 23

R-1 Line #16

Volume 1b - 403

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*				**Project (Number/Name)** AD9 *I Close Combat High Energy Laser 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**
AD9: *Close Combat High Energy Laser Technology*	-	7.139	8.467	-	-	-	-	-	-	-	-	-

Note

In Fiscal Year 2020 (FY20) this Project was realigned from:
Program Element (PE) 0062307A Advanced Weapons Technology
* Project 042 High Energy Laser Technology

A. Mission Description and Budget Item Justification

This Project investigates and develops technologies for compact, highly efficient lasers, and compact beam control for close-combat platforms. This project investigates and develops advanced technologies for High Energy Laser (HEL) weapon systems to enable more efficient laser systems with greater power output, which in-turn enables laser weapons on smaller vehicles for additional missions. This includes technologies to support development of alternate laser sources, precision optical pointing and tracking components, adaptive optics to overcome laser degradation due to atmospheric effects, more compact and lighter weight energy generation and storage devices, and more efficient thermal management systems to remove excess heat.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AE1 (Close Combat High Energy Laser Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, and the Army Modernization Strategy, and supports the Army's future capability opportunities for leap-ahead technology for directed energy.

Work is performed by the United States (US) Army Rapid Capabilities and Critical Technologies Office (RCCTO).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Close Combat High Energy Laser Technology	7.139	8.467	-
Description: This effort develops laser and beam control technologies with extremely low size, weight, and power (SWaP) requirements enabling high energy lasers in small, agile close combat platforms. Extremely low SWaP laser systems will expand the laser weapons mission set. Reduction in SWaP also provides for higher power systems on the large tactical vehicles that enable countering the current threat set at longer ranges as well as laser-hardened threats.			
FY 2021 Plans: Continue developing and validating laser and beam control technologies with extremely low SWaP to integrate on a risk reduction platform. Conducts modeling & simulation to inform experimentation and conduct experimentation with instrumented risk-reduction			

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 15 of 23

R-1 Line #16

Volume 1b - 404

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	**Project (Number/Name)** AD9 *I Close Combat High Energy Laser Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
platform for collecting and analyzing data for validation of technology and assessing its suitability for a Close Combat Platform risk reduction effort. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort has concluded.			
Accomplishments/Planned Programs Subtotals	7.139	8.467	-

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

D. Acquisition Strategy
 N/A

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 16 of 23

R-1 Line #16

Volume 1b - 405

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

Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602150A I *Air and Missile Defense Technology*						Project (Number/Name) AE2 I *Unconventional Countermeasures-Survivability Tech*	

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
AE2: *Unconventional Countermeasures-Survivability Tech*	-	5.690	6.347	3.927	-	3.927	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs and develops technologies to deter tactical surveillance and targeting by adversarial area denial systems and munitions. The Project investigates methods to increase survivability of critical assets against precision-guided near-peer advanced weapons threats, investigates and develops tonedown methods for signature management, and computationally develops novel countermeasures. This Project also develops a suite of high-fidelity, physics-based modeling and simulation tools for the design and development of unconventional countermeasures and survivability enhancers applicable to a wide range of operating environments.

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

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AE3 (Unconventional Countermeasures-Survivability ATech).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Development of Unconventional Countermeasures for Enhanced Survivability (DeUCES) ***Description:*** This effort designs and develops countermeasures to defeat near-peer advanced weapons through computational modeling and enhanced tonedown measures. ***FY 2021 Plans:*** Conduct experiments to investigate techniques and materials for hyperspectral and tone down response and validate their use on critical assets as either integrated systems or temporary coatings for various environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding decrease in FY22 reflects planned lifecycle for this effort, ending in in FY 2021.	3.171	4.075	-
Title: Model-Based Assessment of Sensors and Countermeasures ***Description:*** This effort develops a suite of high-fidelity, physics-based modeling and simulation tools for the design and development of unconventional countermeasures for a wide range of operating environments; develops tools for the evaluation of threat detection and object identification. ***FY 2021 Plans:***	2.519	2.272	2.492

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 17 of 23

R-1 Line #16

Volume 1b - 406

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	**Project (Number/Name)** AE2 *I Unconventional Countermeasures-Survivability Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Develop and investigate computational environments for sensor-algorithm performance in a range of simulated environments. These efforts couple large scale physics based sensor models with high resolution environmental test beds to develop medium-to short-range sensor performance models for guided weapons. *FY 2022 Plans:* Will integrate EO/IR sensor models and generated synthetic, physics based imagery into a computational testbed for the evaluation of unconventional countermeasure designs. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase in FY22 supports integration of sensor models into the computational testbed.			
Title: Advanced Integrated Unconventional Countermeasures Applications *Description:* This effort develops methods and materials to defeat peer advanced reconnaissance, surveillance, targeting methods through advancements in material science and computational prototyping to reduce targetable signatures and confuse targeting systems. *FY 2022 Plans:* Will conduct experiments to develop materials and techniques for hyperspectral camouflage and thermal tonedown utilizing novel waste heat rejection and recovery methods integrated into critical assets. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase in FY22 reflects planned lifecycle for this effort, beginning in in FY 2022.	-	-	1.435
Accomplishments/Planned Programs Subtotals	5.690	6.347	3.927

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

D. Acquisition Strategy
 N/A

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 18 of 23

R-1 Line #16

Volume 1b - 407

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*					**Project (Number/Name)** AE4 *I Collaborative ISR Sensors 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**
AE4: *Collaborative ISR Sensors Technology*	-	3.372	2.938	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project directly supports Army Modernization Priority Air and Missile Defense capabilities by designing and developing Intelligence, Surveillance, Reconnaissance (ISR) sensors with extended range threat detection and enhanced survivability by cooperative sensing while on-the-move.

Work in this Project complements PE 0603466A Air and Missile Defense Advanced Technology / Project AD6 Next Generation Fires Radar Advanced Technology.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Collaborative ISR Sensors Technology	3.372	2.938	-
Description: Design and develop ISR sensors with extended range threat detection and enhanced survivability by cooperative sensing while on-the-move. **FY 2021 Plans:** Continue to develop techniques and waveforms for clutter suppression and synchronization between platforms with non-traditional Radar sensing; develop algorithms to perform data collections to validate test cases; research non-traditional Radar sensing; continue to research best technology enablers for Multi-Domain Operations capability. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects the planned lifecycle completion of this effort.			
Accomplishments/Planned Programs Subtotals	3.372	2.938	-

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* 2				**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*					**Project (Number/Name)** BN6 *I Advanced Weapons Components (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
BN6: *Advanced Weapons Components (CA)*	-	45.000	53.000	-	-	-	-	-	-	-	-	-

Note

Congressional Interest Item funding provided for Advanced Weapons Components.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Advanced Weapon Components.

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: Sustainable Energy Materials and Manufacturing	12.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Sustainable Energy Materials and Manufacturing. Work executed under the direction of the Army Futures Command.		
Congressional Add: High-Energy Laser Hardware in the Loop	20.000	-
FY 2020 Accomplishments: Program Increase supported applied research on High-Energy Laser Hardware in the Loop. Work executed under the direction of the Army Futures Command.		
Congressional Add: COE in High-Energy Laser and Optical Technology	3.000	-
FY 2020 Accomplishments: Program Increase supported applied research on COE in High-Energy Laser and Optical Technology. Work executed under the direction of the Army Futures Command.		
Congressional Add: Cybersecurity and Supply Chain Risk Management	10.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Cybersecurity and Supply Chain Risk Management.		

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 20 of 23

R-1 Line #16

Volume 1b - 409

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	**Project (Number/Name)** BN6 *I Advanced Weapons Components (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
Work executed under the direction of the Army Futures Command.		
Congressional Add: Program increase - beam control systems and industry grade optical fiber fabrication for energy laser	-	12.000
FY 2021 Plans: Program increase supporting applied research in beam control systems and industry grade optical fiber fabrication for energy laser. This effort will develop Army capability to characterize and optimize a diverse set of fiber laser systems, optics, and photonics to support technology development and maturation for high energy laser weapon systems. Develop a Fiber Amplifier Laser Characterization and Optimization lab for evaluating kW class laser modules; the lab will be an open architecture design that will facilitate the capability to provide independent Army evaluation and verification of high energy laser source components. Conduct laboratory and field experiments to validate performance of the technologies. Work executed by the Rapid Capabilities and Critical Technologies Office under the direction of Army Futures Command.		
Congressional Add: Program increase - high energy laser enabling and support technology	-	7.000
FY 2021 Plans: Program increase supporting applied research in high energy laser enabling and support technology. This effort supports the design and development of agile and lightweight beam control system technology including gimbals and telescopes for High Energy Lasers (HEL). Researching innovative design solutions to revolutionize technology for improved size, weight, and power (SWaP), and cost in next generation HEL weapon systems. Researching and developing HEL platform Enhanced Tracking (ET) capabilities to improve current acquisition tracking and clutter, and fine tracking in deep turbulence in adverse weather conditions. Researching and developing improved HEL beam propagation techniques to achieve a higher laser power on target and improve the effectiveness of a HEL weapon system.		

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*	**Project (Number/Name)** BN6 *I Advanced Weapons Components (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Work executed by the Rapid Capabilities and Critical Technologies Office under the direction of Army Futures Command.		
Congressional Add: Program increase - Army missile supply chain risk management	-	15.000
FY 2021 Plans: Conduct applied research in Army Missile Supply Chain Risk Management. Work executed by Army Futures Command.		
Congressional Add: Program increase - close combat high energy laser technology	-	8.500
FY 2021 Plans: Program increase supporting applied research in close combat high energy laser technology. This effort will focus on integrating a 300 kW-class laser into a U.S. Army combat vehicle. This High Energy Laser platform will be capable of performing a wide variety of missions including air and missile defense as well as lethal engagement of enemy ground targets such as armored vehicles, artillery and rocket systems, logistics, and communications systems. Work executed by the Rapid Capabilities and Critical Technologies Office under the direction of Army Futures Command.		
Congressional Add: Program increase - fires center of excellence	-	1.500
FY 2021 Plans: Conduct applied research in Fires Center of Excellence. Work executed by Army Futures Command.		
Congressional Add: Program increase - cyber resiliency in weapon systems	-	1.500
FY 2021 Plans: Conduct applied research in Cyber Resiliency in Weapon Systems. Work executed by Army Futures Command.		
Congressional Add: Program increase - countermeasures based on artificial intelligence enabled material analysis and design	-	6.000
FY 2021 Plans: Conduct applied research in Countermeasures Based on Artificial Intelligence Enabled Material Analysis and Design.		

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 22 of 23

R-1 Line #16

Volume 1b - 411

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602150A I *Air and Missile Defense Technology*	Project (Number/Name) BN6 I *Advanced Weapons Components (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Work executed by Army Futures Command.		
Congressional Add: Program increase - counter-UAS center of excellence	-	1.500
FY 2021 Plans: Program increase supporting applied research in Counter-Unmanned Aerial Systems (C-UAS) Center of Excellence. This effort supports the development of enhancements for High Energy Laser modeling and simulation capabilities to improve current force-on-force models for Counter-small Unmanned Aerial Systems (C-sUAS). Enables C-sUAS force planning, experimentation, and Tactics, Techniques, and Procedures development. Work executed by the Rapid Capabilities and Critical Technologies Office under the direction of Army Futures Command.		
Congressional Adds Subtotals	45.000	53.000

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

D. Acquisition Strategy
 N/A

PE 0602150A: *Air and Missile Defense Technology*
Army

UNCLASSIFIED
Page 23 of 23

R-1 Line #16

Volume 1b - 412

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602180A *I Artificial Intelligence and Machine Learning Technologies*							
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	-	-	-	15.034	-	15.034	-	-	-	-	-	-
CL2: *AI Enhanced Intel Operations Technologies*	-	-	-	3.725	-	3.725	-	-	-	-	-	-
CL7: *ATR Using Multiple Cooperative Sensors App Tech*	-	-	-	7.645	-	7.645	-	-	-	-	-	-
CN7: *Predictive Maintenance Applied Research*	-	-	-	3.664	-	3.664	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this Program Element (PE) is created to focus on applied research efforts in the Army portfolio pertaining to Artificial Intelligence (AI) and Machine Learning (ML) coordinated by the Army's Artificial Intelligence Task Force (AITF); with funding realigned from:

PE 0602143A Soldier Lethality Technology
BD6 Soldier Sys Interfaces/Integration-Sensor Tech

PE 0602144A Ground Technology
CA9 Predictive Maintenance

PE 0602145A Next Generation Combat Vehicle Technology
BF6 Crew Augmentation and Optimization Tech
BF8 Artificial Intelligence & Machine Learning Tech
BF9 Sensors for Autonomous Operations and Surv Tech

0602146A (Network C3I Technology)
AN7 COE - Every Receiver is a Sensor Technology

PE 0603118A Soldier Lethality Advanced Technology
BD7 Soldier Sys Interfaces/Integration-Sensor AdvTech

PE 0603462A Next Generation Combat Vehicle Advanced Technology
BK1 Autonomous Mobility Adv Tech

PE 0602180A: *Artificial Intelligence and Machine Lear...*
Army

UNCLASSIFIED
Page 1 of 11

R-1 Line #17

Volume 1b - 413

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602180A *I Artificial Intelligence and Machine Learning Technologies*	

PE 0603465A Future Vertical Lift Advanced Technology
AL7 Full Spectrum Targeting Advanced Technology

This was a part of the Program Evaluation Groups (PEG) efficiency drill.

<u>**A. Mission Description and Budget Item Justification**</u>

This PE executes applied research in artificial intelligence (AI) and machine learning (ML) to support an AI-enabled Multi-Domain Operations (MDO) Force. This PE will investigate and further develop technologies in the use of artificial intelligence (AI) and machine learning (ML) to improve target recognition/detection using Multiple Cooperative Autonomous Sensors (MCAS), leader decision-making, replication of tactical behaviors to enable autonomous capabilities for maneuver, predictive maintenance, and Intel support for Operations (specifically in support of long range precision fires). The Army's Artificial Intelligence Task Force (AITF) will provide strategic guidance and coordination of these applied 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 0601601A Artificial Intelligence and Machine Learning Basic Research and PE 0603040A Artificial Intelligence Advanced Technologies.

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

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

<u>**B. Program Change Summary ($ in Millions)**</u>	**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	15.034	-	15.034
Total Adjustments	0.000	0.000	15.034	-	15.034
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	15.034	-	15.034

<u>**Change Summary Explanation**</u>

In FY2022, this is a new PE with three new FY22 Project funded by realignments from Program Element (PE) 0602143A Soldier Lethality Technology, 0602144A Ground Technology, 0602145A Next Generation Combat Vehicle Technology, 0602146A (Network C3I Technology), 0603118A Soldier Lethality Advanced

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602180A *I Artificial Intelligence and Machine Learning Technologies*	

Technology, PE 0603462A Next Generation Combat Vehicle Advanced Technology, and PE 0603465A Future Vertical Lift Advanced Technology as a part of the Program Evaluation Group (PEG) efficiency drill.

PE 0602180A: *Artificial Intelligence and Machine Lear...*
Army

UNCLASSIFIED
Page 3 of 11

R-1 Line #17

Volume 1b - 415

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602180A *I Artificial Intelligence and Machine Learning Technologies*				**Project (Number/Name)** CL2 *I AI Enhanced Intel Operations Technologies*		

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
CL2: *AI Enhanced Intel Operations Technologies*	-	-	-	3.725	-	3.725	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this project was realigned from the following:
0602145A (Next Generation Combat Vehicle Technology) Project BF9 (Sensors for Autonomous Operations and Surv Tech)
0602145A (Next Generation Combat Vehicle Technology) Project BF8 (Artificial Intelligence & Machine Learning Tech)
0602146A (Network C3I Technology) Project AN7 (COE - Every Receiver is a Sensor Technology)

A. Mission Description and Budget Item Justification

This project will develop various technologies to augment human analysts through AI-enabled decision support and recommendation tools to fundamentally change the way the Army fights and modernize how the Intelligence Warfighting Function supports Multi-Domain Operations and Joint All Domain Command and Control (JADC2). Ultimately, this project will help bridge the research and technology gap within intelligence support to operations and the sensor to shooter thread.

The Capstone Concept for Joint Operations: Joint Force 2020 and the Force 2025 and Beyond (F2025B) strategy calls for the integration of terrestrial sensing and exploitation capabilities to accelerate the data to decision cycle across the Range of Military Operations (ROMO). The Army Operating Concept and the Army Functional Concepts identifies the need for interoperable intelligence organizations capable of conducting synchronized proactive intelligence operations that optimize individual efficiencies and team performance. These concepts are driven by a threat that has studied US advancements during the Global War on Terror and taken notes.

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

This work is supported and coordinated with the Army Intel Community, Army Futures Command, and the Army ISR Task Force.

Work in this Project supports the Army Science and Technology Ground Portfolio and the Joint Artificial Intelligence Center (JAIC)

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Synthetics and Low Level Detection	-	-	0.850
Description: This effort will develop technology in low level object detection and recognition. Low level object detection and recognition is a key machine learning challenge because objects presented in such problems have a lot of variation and limited amounts of training data. This makes it difficult to build high performing AI models to address these challenges.			

PE 0602180A: *Artificial Intelligence and Machine Lear...*
Army
UNCLASSIFIED
Page 4 of 11
R-1 Line #17
| **Volume 1b - 416** |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602180A *I Artificial Intelligence and Machine Learning Technologies*	**Project (Number/Name)** CL2 *I AI Enhanced Intel Operations Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2022 Plans: This effort will leverage feature invariance from multi-class classification using data that is readily available to develop an AI network to predict class representatives from the samples themselves. Using such a model, we can then predict representation for novel object classes from very few novel class samples, improving AI algorithm learning and reducing the need for manual data input. In a separate approach to low level detection, we propose to enable the few-shot detector to learn novel objects from both the visual information and using semantic relations. This will promote knowledge propagation from base classes to novel classes, speeding up the time it takes to train AI algorithms. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In Fiscal Year (FY) 2022, this effort is a new start.			
Title: AI Enhancements for Prometheus ***Description:*** Prometheus is an umbrella of capabilities to support sensor to shooter automation for the strategic, operational, and tactical levels. This work will develop AI capabilities for support of Long Range Precision Fires, Mission Command, and Maneuver Commanders by leveraging Intelligence Community enterprise investments in sensing, data transport, and Machine Learning / AI frameworks. ***FY 2022 Plans:*** This effort will augment Military Intelligence and Operations (Intel/Ops) with computer vision and deep learning capabilities to automatically triage data collection and automate AI-driven indications and warning (I&W) to support targeting. This effort will also develop better AI collection management and tasking capability to allow Military Intelligence soldiers to automate AI workflows. Lastly, we will document repeatable process for deploying AI capabilities to meet Army needs. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In Fiscal Year (FY) 2022, this effort is a new start.	-	-	1.255
Title: AI-Enabled Intelligence Decision Support ***Description:*** This effort will augment Military Intelligence and Operations (Intel/Ops) with machine intelligence capabilities to leverage Mission, Enemy, Terrain and Weather, Troops, Time Available, and Civilian Considerations (METT-TC) information available to Commanders in support of Intelligence Preparation of the Battlefield (IPB) and the Military Decision Making Process (MDMP). The work will assist in visualizing and animating threat models to support automated AI-enabled enemy courses of action analysis. ***FY 2022 Plans:***	-	-	1.100

PE 0602180A: *Artificial Intelligence and Machine Lear...*
Army
UNCLASSIFIED
Page 5 of 11
R-1 Line #17
Volume 1b - 417

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602180A *I Artificial Intelligence and Machine Learning Technologies*	**Project (Number/Name)** CL2 *I AI Enhanced Intel Operations Technologies*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Develop AI agents to employ Mission, Enemy, Terrain and Weather, Troops, Time Available, and Civilian Considerations (METT-TC) information available to Commanders to generate courses of action for threat formations as well as conduct AI-war gaming in support of Intelligence Preparation of the Battlefield and the Military Decision Making Process. Smart ?agents? will enable automated, machine intelligence-enabled course of action analysis integrated with the broader mission command enterprise. Given these knowns about the operational environment, the effort will conduct automated real-time strategy war gaming between synthetic agents representing friendly and adversary forces at the Division echelon.			
FY 2021 to FY 2022 Increase/Decrease Statement: In Fiscal Year (FY) 2022, this effort is a new start.			
Title: Foundation for AI Intelligence Support to Operations (ARCANE SERIES) *Description:* Develop an AI infrastructure/pipeline for training, integrating, and sustaining computer vision algorithms into production grade systems enterprises and edge systems for the Army Military Intelligence and Operations (Intel/Ops) community. *FY 2022 Plans:* Will develop an algorithm development kit with standardized deep learning model architectures that simplify training and deploying computer vision-based AI models; will create a machine learning model library with registered models, training datasets, and near real-time diagnostics from deployed models, that can be used for monitoring, alerting, and accelerating transfer learning and recalibration; will develop containerized packaging for the algorithm development kit and machine learning model library, reducing the digital scope of these assets so they can more easily be deployed on edge applications and cloud-accessible servers; will deploy the development kit and library on various edge devices and cloud-accessible servers. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In Fiscal Year (FY) 2022, this effort is a new start.	-	-	0.520
Accomplishments/Planned Programs Subtotals	-	-	3.725

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

D. Acquisition Strategy
 N/A

PE 0602180A: *Artificial Intelligence and Machine Lear...*
Army

UNCLASSIFIED
Page 6 of 11

R-1 Line #17

Volume 1b - 418

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

| Appropriation/Budget Activity
2040 *I* 2 | | | | R-1 Program Element (Number/Name)
PE 0602180A *I Artificial Intelligence and Machine Learning Technologies* | | | | | Project (Number/Name)
CL7 *I ATR Using Multiple Cooperative Sensors App Tech* | | |

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
CL7: *ATR Using Multiple Cooperative Sensors App Tech*	-	-	-	7.645	-	7.645	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding was realigned from the following:
PE 0602143A (Soldier Lethality Technology) Project BD6 Soldier Sys Interfaces/Integration-Sensor Tech
PE 0602145A (Next Generation Combat Vehicle Technology) Project BF6 Crew Augmentation and Optimization Tech
PE 0602145A (Next Generation Combat Vehicle Technology) Project BF8 Artificial Intelligence & Machine Learning Tech
PE 0603118A (Soldier Lethality Advanced Technology) Project BD7 Soldier Sys Interfaces/Integration-Sensor AdvTech
PE 0603462A (Next Generation Combat Vehicle Advanced Technology) Project BK1 Autonomous Mobility Adv Tech
PE 0603465A (Future Vertical Lift Advanced Technology) Project AL7 Full Spectrum Targeting Advanced Technology

A. Mission Description and Budget Item Justification

This work will develop Artificial Intelligence (AI) and Machine Learning (ML) algorithms that leverage a team of air and ground sensors to autonomously navigate and collaborate through shared perception of the optical, thermal, and electromagnetic spectrums to find, identify, geo-locate, and track targets during reconnaissance missions.

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

Work in this Project supports the Army Science and Technology Lethality Portfolio and the Joint Artificial Intelligence Center (JAIC)

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Collaborative Target Detection and Tracking	-	-	5.645
Description: This effort will develop the ability to automatically detect and track targets using the electro-optical, thermal, and electromagnetic sensors and constrained computing hardware onboard the air and ground vehicles, which process the sensor data using AI/ML algorithms and share threat perception across the unmanned team. *FY 2022 Plans:*			

PE 0602180A: *Artificial Intelligence and Machine Lear...*
Army

UNCLASSIFIED
Page 7 of 11

R-1 Line #17

Volume 1b - 419

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602180A *I Artificial Intelligence and Machine Learning Technologies*	**Project (Number/Name)** CL7 *I ATR Using Multiple Cooperative Sensors App Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Develop the ability for unmanned vehicles to self-identify and geo-locate targets, share target data among the unmanned and manned team for verification, and then serve as autonomous forward observers to auto-correct indirect fire. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In Fiscal Year (FY) 2022, this effort is a new start.			
Title: Autonomous and Collaborative Mobility ***Description:*** This effort will develop mobility algorithms using AI/ML techniques to passively perceive the terrain so that air and ground vehicles can self-navigate without active and detectable sensing. Develop collaborative teaming techniques for autonomous air and ground vehicles to work together on reconnaissance missions. ***FY 2022 Plans:*** Develop AI algorithms that enable autonomous maneuver of air and ground platforms that collaboratively coordinate their movement within an assigned zone and passively sense the terrain and surroundings to avoid obstacles. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In Fiscal Year (FY) 2022, this effort is a new start.	-	-	1.000
Title: Intuitive Mission Command Interfaces ***Description:*** Develop ability for warfighters to quickly and intuitively convey reconnaissance guidance, confirm or deny detected targets, and take recommended action through common mission command tools, including Tactical Assault Kit (TAK) and Integrated Visual Augmentation System (IVAS). ***FY 2022 Plans:*** Develop the intuitive relay of reconnaissance intent to the autonomous team of air and ground vehicles. Develop the ability for rapid validation of targets and activation of recommended effects (e.g., indirect fire) using TAK and IVAS. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In Fiscal Year (FY) 2022, this effort is a new start.	-	-	1.000
Accomplishments/Planned Programs Subtotals	-	-	7.645

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

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 *I* 2	R-1 Program Element (Number/Name) PE 0602180A *I Artificial Intelligence and Ma chine Learning Technologies*	Project (Number/Name) CL7 *I ATR Using Multiple Cooperative Sensors App Tech*

D. Acquisition Strategy
 N/A

PE 0602180A: *Artificial Intelligence and Machine Lear...*
Army

UNCLASSIFIED
Page 9 of 11

R-1 Line #17

Volume 1b - 421

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2						**R-1 Program Element (Number/Name)** PE 0602180A *I Artificial Intelligence and Machine Learning Technologies*				**Project (Number/Name)** CN7 *I Predictive Maintenance Applied 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**
CN7: *Predictive Maintenance Applied Research*	-	-	-	3.664	-	3.664	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this project was realigned from:
PE 0602144A (Ground Technology) Project CA9 (Predictive Maintenance).

A. Mission Description and Budget Item Justification

This effort develops and characterizes artificial intelligence (AI) and machine learning (ML) tools and capabilities to intelligently predict and analyze maintenance status for emerging and legacy aviation and ground platforms; extracts maintenance data from databases, sensor data and inference of missing data via virtual simulations investigating maintenance concepts that employ AI data capture and integrate AI tools into enterprise resource planning for military aviation and ground vehicles. Platforms of focus are prioritized by cost and value to Army missions and potentially include the UH60, AH64, CH47, Stryker, and Abrams. Each platform will be sequentially evaluated both at the appropriate component (i.e. engine health) and fleet level. This research enables use of predictive maintenance to increase fleet operational readiness through reduced downtime by preventing critical failure during missions, maximizing availability to combatant commands. Findings will be used to construct a robust Army wide predicative maintenance platform that will accelerate the pace of innovation for this problem set. This platform includes data engineering, pipelines, AI development eco-system, and application delivery. All outcomes will be used to inform requirements and technical architectures for modernization efforts of next generation aviation and ground systems both manned and unmanned.

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

Work in this Project supports the Army Science and Technology Ground Portfolio and the Joint Artificial Intelligence Center (JAIC)

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Predictive Maintenance	-	-	3.664
Description: This effort performs research on AI, deep learning, and predictive analytics to forecast major issues on current and future platforms which enables the Army to respond to upcoming failures. Focus will be to identify component failure relationships to principal end items for prediction of critical failure prior to corrective maintenance and reactive supply chain requisitions. Research will increase efficiency, decrease fleet operating and sustainment costs for equipment platforms, and reduce the time and costs associated with repair part requisition, management and transportation.			
FY 2022 Plans:			

PE 0602180A: *Artificial Intelligence and Machine Lear...*
Army

UNCLASSIFIED
Page 10 of 11

R-1 Line #17

Volume 1b - 422

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602180A *I Artificial Intelligence and Machine Learning Technologies*	**Project (Number/Name)** CN7 *I Predictive Maintenance Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will investigate and develop new capabilities of a standardized end-to-end pipeline for gathering data from maintenance sensors in ground platforms (both manned and unmanned) and improve performance failure prediction models for critical components. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Work in this project was realigned from 0602144A (Ground Technology) Project CA9 (Predictive Maintenance).			
Accomplishments/Planned Programs Subtotals	-	-	3.664

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

D. Acquisition Strategy
 N/A

PE 0602180A: *Artificial Intelligence and Machine Lear...*
Army

UNCLASSIFIED
Page 11 of 11

R-1 Line #17

Volume 1b - 423

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 2: *Applied Research*						**R-1 Program Element (Number/Name)** PE 0602181A *I All Domain Convergence Applied 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	-	-	-	25.967	-	25.967	-	-	-	-	-	-
CM7: *Collaborative Convergence Applied Research*	-	-	-	25.967	-	25.967	-	-	-	-	-	-

Note

This is a new start in FY 2022.

This is a new start in Fiscal Year 2022 (FY22).

A. Mission Description and Budget Item Justification

The Program Element (PE) executes research as part of a campaign of learning to assess feasibility of technologies in an operational environment, learning from early failure and re-scope research to improve speed of response, scalability, interoperability and range of engagement. This program element will enable integration of technologies from sensor to shooter in near real-time, from tactical to strategic level, taking a system design approach. It will enable optimal lethal and non-lethal effects across all domains using artificial intelligence and machine learning to improve how we recognize threats, augment and enhance leader decision-making, replicate tactical behaviors to enable autonomous capabilities, and design system engineering architectures to validate interoperability of technologies.

Work in this PE complements PE 0602145A (Next Generation Combat Vehicle Technology).

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

Work is performed by the United States Army Futures Command.

PE 0602181A: *All Domain Convergence Applied Research*
Army
UNCLASSIFIED
Page 1 of 6
R-1 Line #18
Volume 1b - 424

UNCLASSIFIED

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 2: *Applied Research*			**R-1 Program Element (Number/Name)** PE 0602181A *I All Domain Convergence Applied Research*		

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	25.967	-	25.967
Total Adjustments	0.000	0.000	25.967	-	25.967
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	25.967	-	25.967

Change Summary Explanation

New Program Element in Fiscal Year (FY) 2022 established for applied research being advanced in support of Project Convergence, an effort to connect all sensors to all shooters to enable an all domain kill web.

PE 0602181A: *All Domain Convergence Applied Research*
Army

UNCLASSIFIED
Page 2 of 6

R-1 Line #18

Volume 1b - 425

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

Appropriation/Budget Activity 2040 *I* 2				R-1 Program Element (Number/Name) PE 0602181A *I All Domain Convergence Applied Research*					Project (Number/Name) CM7 *I Collaborative Convergence Applied 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
CM7: *Collaborative Convergence Applied Research*	-	-	-	25.967	-	25.967	-	-	-	-	-	-

Note

This is a new start in FY 2022.

In Fiscal Year 2022 (FY22). This is a new start Project.

A. Mission Description and Budget Item Justification

This Project supports research required to oppose adversary technologies in the threat based early operational environment. Focus is on those technologies that will aid in reducing the sensors to shooters timelines. This is accomplished using Artificial Intelligence (AI) algorithm decision agent design architectures, advanced methods for processing data, and improved AI performance. Additionally, this Project will research technologies and solutions necessary to enable mission command in multi-domain operations. The project will accelerate emerging research to achieve sensor to shooter dominance.

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 effort is performed by the United States (US) Army Futures Command.

Work in this Project supports Next Generation Combat Vehicle, Network, Future Vertical Lift, and Long Range Precision Fires Army Modernization Priorities.

This work is done in coordination with PE 0603041A (All Domain Convergence Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: AI-Enabled Decision Support in Distributed Networks	-	-	5.594
Description: This effort researches techniques to understand and model complex multi-platform tactical networks in Multi-Domain Operational environments to develop training data sets for AI-enabled tactical decision support capabilities. This effort leverages Army research informed by Army Doctrine on data value, consensus, uncertainty, human-agent teaming and network science to optimize decision support training data production. Supports AI-enabled decision support capabilities for Next Generation Combat Vehicle, Network, Future Vertical Lift, and Long Range Precision Fires Army Modernization Priorities. *FY 2022 Plans:*			

PE 0602181A: *All Domain Convergence Applied Research*
Army

UNCLASSIFIED
Page 3 of 6

R-1 Line #18

Volume 1b - 426

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602181A *I All Domain Convergence A pplied Research*	**Project (Number/Name)** CM7 *I Collaborative Convergence Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will collect Machine Learning (ML) training data such as imagery, quantitative confidence, speed, accuracy, and process data from sensor to shooter experimental tactical engagements for curation and distribution; develop tactical engagement models and training data sets for AI-enabled decision support tools in complex, multi-domain tactical networks. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this is a new start.			
Title: Synthetic Data for AI-Enabled Decision Support *Description:* This effort researches approaches to incorporate synthetic data to augment Army training data sets and optimize AI performance for uncommon Multi-Domain Operations (MDO) targets and environments. This effort investigates efficacy and optimal application of synthetic training data developed using multiple technical methods, including physics-based models and generative adversarial techniques. This effort will experiment with artificially augmented data sets to enable classification of rare targets and cost-effective enterprise-level training data generation. Supports AI-enabled decision support capabilities for Next Generation Combat Vehicle, Network, Future Vertical Lift, and Long Range Precision Fires Army Modernization Priorities. *FY 2022 Plans:* Will investigate techniques to develop and characterize state-of-the-art synthetic data sets; research methods to incorporate synthetic data into target classification algorithm training sets and understand its effects on target classification performance against uncommon high priority MDO targets; experiment with artificially augmented data sets to enable classification of rare targets and cost-effective enterprise-level data generation. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this is a new start.	-	-	6.295
Title: Data Characterization for AI-Enabled Decision Support *Description:* This effort will investigate techniques for data management, characterization, curation, labeling, and classification to enable repeatable, robust performance of trained AI-enabled decision support capabilities for complex, multi-platform tactical networks in varied tactical Multi-Domain Operations (MDO) environments. Supports AI-enabled decision support capabilities for Next Generation Combat Vehicle, Network, Future Vertical Lift, and Long Range Precision Fires Army Modernization Priorities. *FY 2022 Plans:* Will explore and assess methodologies for efficient, effective training data set development, characterization, and curation; develop and deploy Army?s curated training data sets on network-enabled development platforms for joint collaborative research on training methods for object classifiers, AI-enabled decision support tools, and autonomy. ***FY 2021 to FY 2022 Increase/Decrease Statement:***	-	-	5.390

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602181A *I All Domain Convergence Applied Research*	**Project (Number/Name)** CM7 *I Collaborative Convergence Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
In FY 2022, this is a new start.			
Title: Lethality Architecture ***Description:*** Designs networked lethality role-based architecture to support automated decision aids and target handoff capability for combined arms operations. Designs a hybrid distributed architecture that will ingest real-time, prioritized data for decision agents to support scalable operations with reduced processing time. ***FY 2022 Plans:*** Will develop an architecture to support time and space synchronization of fires and distributed lethality. Will determine required communications, data interfaces, and digital sensor to shooter planning for fires execution. Will also de-conflict between various sensors and weapon systems in combined arms maneuver to reduce sensor to shooter timelines. Will develop methods to use local distributed world model coordinates for input to decision aids when network is degraded and when network bandwidth is optimal. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY22, this is a New Start.	-	-	6.250
Title: Algorithms and Environment ***Description:*** Designs and develops a data model for commander decision aided algorithms to support integrated direct & indirect fires; defines the process and data structure to automate decision aids and target handoff for simultaneous engagements to air/ground platforms; and designs decentralized data structures and hybrid databases that can scale to echelons and user selectable input. ***FY 2022 Plans:*** Will investigate simulation requirements for tactical fires of multiple company formations, which will include coordinating decentralized operations in different terrain models. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY22, this is a New Start.	-	-	0.500
Title: Fires Coordination ***Description:*** Designs and develops integrated direct/indirect effects coordination and execution. Investigates autonomous cooperative engagement methods by modeling adversary behavior to determine the optimal shooter(s) for a large number of targets to achieve tactical overmatch. Design learning behaviors capable of incorporating commander?s guidance and based on enemy data and historic performance.	-	-	1.938

PE 0602181A: *All Domain Convergence Applied Research*
Army

UNCLASSIFIED
Page 5 of 6

R-1 Line #18

Volume 1b - 428

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602181A *I All Domain Convergence A pplied Research*	**Project (Number/Name)** CM7 *I Collaborative Convergence Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2022 Plans: Will investigate and validate AI based algorithms process design for Fires synchronization. Will design and validate courses of analysis integrated capability using AI based approaches. Will investigate algorithms for predicting adversary behaviors and investigate how these patterns can impact recommendations for optimal shooter scenarios.			
FY 2021 to FY 2022 Increase/Decrease Statement: IN FY22, this is a New Start.			
Accomplishments/Planned Programs Subtotals	-	-	25.967

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

D. Acquisition Strategy
 N/A

PE 0602181A: *All Domain Convergence Applied Research*
Army

UNCLASSIFIED
Page 6 of 6

R-1 Line #18

Volume 1b - 429

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 2: *Applied Research*						R-1 Program Element (Number/Name) PE 0602182A *I C3I Applied 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	-	-	-	12.406	-	12.406	-	-	-	-	-	-
CM9: *Convergent CEMA Deception*	-	-	-	5.626	-	5.626	-	-	-	-	-	-
CN4: *Network Enabling University Applied Research*	-	-	-	2.578	-	2.578	-	-	-	-	-	-
CN5: *Network Vuln/ Effectiveness Assess Methods (N-VEAM)*	-	-	-	4.202	-	4.202	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding is realigned from:
PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology)
PE 0602145A (Next Generation Combat Vehicle Technology) Project BF8 (Artificial Intelligence & Machine Learning Tech)

A. Mission Description and Budget Item Justification

This Program Element (PE) investigates, designs, validates, and conducts experimentation to establish technical solutions for creating integrated future equipment and systems that improve resiliency, survivability, operational effectiveness, mobility, sustainability, and readiness of ground forces. This PE provides mid-to-long term tactical Command, Control, Communications and Intelligence (C3I) capabilities (e.g. networking, cyber, electronic warfare, Positioning, Navigation and Timing (PNT), space, persistent surveillance) based upon promising technologies that address emerging and future threats, and includes research critical and unique to the Army and DoD (e.g., atmospheric modeling and meteorological technologies). Applied research investments focus on the design and investigation of materials, processes, technologies, methodologies, and models to establish architectures, systems, and interfaces that enhance and optimize performance on the future battlefield. The outputs of these efforts inform and transition to advanced research efforts that demonstrate improved C3I capabilities.

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 (US) Army Futures Command (AFC).

PE 0602182A: *C3I Applied Research*
Army

UNCLASSIFIED
Page 1 of 9

R-1 Line #19

Volume 1b - 430

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 2: *Applied Research*		**R-1 Program Element (Number/Name)** PE 0602182A *I C3I Applied Research*		

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	12.406	-	12.406
Total Adjustments	0.000	0.000	12.406	-	12.406
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	12.406	-	12.406

Change Summary Explanation

New Program Element in Fiscal Year (FY) 2022 established for enabling science and technology efforts that support applied network research

PE 0602182A: *C3I Applied Research*
Army

UNCLASSIFIED
Page 2 of 9

R-1 Line #19

Volume 1b - 431

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2				**R-1 Program Element (Number/Name)** PE 0602182A / *C3I Applied Research*					**Project (Number/Name)** CM9 / *Convergent CEMA Deception*		

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
CM9: *Convergent CEMA Deception*	-	-	-	5.626	-	5.626	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project is a realignment from:
PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology)

A. Mission Description and Budget Item Justification

This Project develops and characterizes hardware and software to enable cyber and radio frequency (RF) technical effects electronic spoofing and cyber deception along with inconspicuous Cyber Electromagnetic Activity (CEMA) and network operations of Army platforms and dismounts, while maintaining freedom to maneuver, communicate, and sense. This research is critical to counter near-peer ability to geo-locate and put indirect fires onto our positions.

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: Radio Frequency/Cyber Sensing and Effects *Description:* This effort develops technologies to avoid geolocation of blue force radio frequency (RF) emissions by peer/near-peer adversaries. Research will focus on developing low probability of detection (LPD) communications and RF transceivers to increase freedom of maneuver while maintaining effective communications. *FY 2022 Plans:* Will investigate synchronization techniques for a heterogeneous set of distributed transmitters; design and develop signals and waveforms for RF emissions on wideband reconfigurable transceivers; investigate interoperability for wideband reconfigurable RF transceiver hardware, including compact antennas, RF frontend hardware, and data converters; further develop materials, device designs, and components for non-RF communication techniques. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, this effort is realigned from PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology).	-	-	3.131
Title: Dynamic Intelligent Networks and Cyber Technical Effects for CEMA *Description:* This effort investigates techniques and develops methods for combining the physical (Radio Frequency) and network (cyber) layers for enhanced effects when coupled with electromagnetic technical effects.	-	-	2.495

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602182A / C3I Applied Research	**Project (Number/Name)** CM9 / Convergent CEMA Deception

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2022 Plans: Will explore methods for employing unconventional spectrum and communication modalities for enhanced robustness and reduced signature; investigate the combination of low signature networking methods with advanced technical effects; research and develop algorithms and methodologies in a rigorous approach to cyber security such as game theory; model attacker-defender interaction and scalable algorithms for cyber security application and verify algorithms by mathematical proofs, simulation, and experiment; develop and examine adaptive cyber approaches, involving network emulators and camouflaging systems, to bolster network security and resilience; using game theory and machine learning, develop and assess an adaptive honeynet to monitor and study unauthorized network users? exploits; introduce and examine dynamic honeynet processes to incorporate what is learned about the adversaries? network behaviors and intended network targets; investigate advanced methods to model approaches for the prediction of frequency and occurrence of network attacks by type for effectively implementing adaptive honeynets; research impact of Software Defined Networking (SDN) for mobile network architectures on implementation of adaptive honeynets for tactical networks.			
FY 2021 to FY 2022 Increase/Decrease Statement: In FY 2022, this effort is realigned from PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology).			
Accomplishments/Planned Programs Subtotals	-	-	5.626

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

D. Acquisition Strategy
 N/A

PE 0602182A: *C3I Applied Research*
Army

UNCLASSIFIED
Page 4 of 9

R-1 Line #19

Volume 1b - 433

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602182A I C3I Applied Research					**Project (Number/Name)** CN4 I Network Enabling University Applied 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
CN4: *Network Enabling University Applied Research*	-	-	-	2.578	-	2.578	-	-	-	-	-	-

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 Project leverages applied research from academia, in the focus areas of intelligent networks, self-sensing/self-healing networks, network security, air and ground vehicle teaming and alternatives to Global Positioning System (GPS). This new proposed project will perform mid-to-long term tactical Command, Control, Communications and Intelligence (C3I) capabilities (e.g. networking, cyber, electronic warfare, Positioning, Navigation and Timing (PNT), space, persistent surveillance) based while maintaining delivery of near-term technologies. This project focuses on research technologies originating from applied research in academia pertaining to intelligent networks, self-sensing/self-healing networks, and network security and artificial intelligence/machine learning as applied to C3I, and other innovative communication as well as alternatives to GPS, enabling applied research technologies that will accelerate the Army modernization in Network and Assured PNT (APNT). This effort conducts applied research and development leading to potential emerging technologies in areas of strategic importance to the Army in secure and intelligent communication and networking by bringing competitively selected Universities with research and development teams into Technical Alliances.

Work in this Project complements PE 0603042A (C3I Advanced Technology) Project CN3 (Network Enabling University Advanced Development).

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: Intelligent, Secure and Self-Sensing/Self-Healing Networks Applied Technology *Description:* Design fused networks and decision-making architecture into intelligent networks to provide the actionable autonomous intelligence while denying corruption, and/or attack and to execute operational missions securely and reliably. *FY 2022 Plans:* Will research artificial intelligence and machine learning (AI/ML) software, predictive analytics software, intelligent data integration software, edge computer processing platforms, edge sensing systems, and other technologies; investigate distributed AI and the communication between computing nodes and edge computing AI/ML solutions for network-driven intelligence; design	-	-	1.210

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602182A *I C3I Applied Research*	**Project (Number/Name)** CN4 *I Network Enabling University Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
intelligent multi-modal communication and more reliable, efficient, and effective use of available communication technologies; and investigate biometric and biosensor solutions for intelligent network credentialing and access. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort is a Fiscal Year (FY) 2022 New Start.			
Title: Real-Time Tactical Networks Applied Research *Description:* Investigate and design resilient and adaptable network communications to support intelligent systems in challenged environments with denied and constrained resources. *FY 2022 Plans:* Will construct a resilient information network to deliver reliable information pathways with caching, value-based prioritization, and information optimization; improve time and reliability of information/data over secure tactical networks; and investigate decentralized networks with knowledge bases, reasoning, planning, sensing, self-healing and control capabilities for advance teaming and collaborative operations. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort is a Fiscal Year (FY) 2022 New Start.	-	-	0.600
Title: Alternatives to GPS Applied Research *Description:* Research performance and assurance improvements against both electronic and kinetic attacks relative to current state of-the-art GPS, and that can provide PNT technology to users in disrupted, degraded or denied GPS environments. *FY 2022 Plans:* Will investigate direct use of signals from satellite constellations in low Earth orbit (LEO) for Assured Positioning, Navigation, and Timing (APNT); design dedicated navigation signal for a "hosted payload" alternative to direct use of signals from the satellites in LEO; investigate vision-based autonomous relative navigation solutions to address the critical need for reliable operability within GPS denied and contested environments; develop fusing vision, radar, inertial, and other sensors technologies to develop GPS alternatives; and research Global Navigation Satellite System (GNSS) independent navigation solution that is computationally lightweight enough to be implemented on low-cost, physically lightweight platforms. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort is a Fiscal Year (FY) 2022 New Start.	-	-	0.768
Accomplishments/Planned Programs Subtotals	-	-	2.578

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602182A *I C3I Applied Research*	**Project (Number/Name)** CN4 *I Network Enabling University Applied Research*

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602182A: *C3I Applied Research*
Army

UNCLASSIFIED
Page 7 of 9

R-1 Line #19

Volume 1b - 436

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2				**R-1 Program Element (Number/Name)** PE 0602182A / C3I Applied Research						**Project (Number/Name)** CN5 / Network Vuln/Effectiveness Assess Methods (N-VEAM)		
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**
CN5: Network Vuln/ Effectiveness Assess Methods (N-VEAM)	-	-	-	4.202	-	4.202	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project is an Administrative realignment from: PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology)

A. Mission Description and Budget Item Justification

This Project develops analytical methodology and capabilities to characterize hardware and software that enable Electromagnetic Warfare and Cyber capabilities to assess operations of Army Network and communication platforms and dismounts, while maintaining freedom to maneuver, communicate, and sense. This project develops a holistic cross-domain analysis and assessment methodology for network and communication technologies faced with advanced Cyber Electromagnetic Activity (CEMA). These investigations are critical to identifying vulnerabilities of United States systems and technologies so that network and network-enabled systems can be hardened as early in development as possible.

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: Understanding, Protecting, and Enabling CEMA Effects	-	-	2.142
Description: This effort develops and continually improves methodology and approaches for estimating and predicting Cyber Electromagnetic Activity (CEMA) effects on networks and network-enabled systems during complex multi-domain operations when significant cross-domain effects can be expected. Methods include drawing upon past research concerning the interaction of cyber and Electromagnetic Warfare threats on operational networks; laboratory operations, over-the-air anechoic chamber experimentation, and open-air field experimentation; and first principles Modeling and Simulation (M&S) and engineering analysis. Abstracting, generalizing, and automating multi-domain CEMA operations will enable the development of analysis and assessment capabilities to anticipate the impact of future threats. Live, virtual, and simulated environments will be developed to estimate the potential operational impact of threat CEMA technologies on friendly systems.			
FY 2022 Plans: Will apply combined Electromagnetic Electronic Warfare (EW) and cyber techniques for a converged assessment of CEMA effects on prototype network systems and components, to include technologies operation in the Integrated Tactical Network and Information Assurance and Network Resiliency technologies. Models for performance and behavior of Network technologies			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602182A *I C3I Applied Research*	**Project (Number/Name)** CN5 *I Network Vuln/Effectiveness Assess Methods (N-VEAM)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
and systems will be updated to reduce risks of Integrated Tactical Network failures in congested and contested electromagnetic environments.			
FY 2021 to FY 2022 Increase/Decrease Statement: In FY 2022, this effort is realigned from PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology).			
Title: Vulnerability Analysis Methodology for CEMA Threats *Description:* This effort investigates threat/target interactions to develop experimental and analytical methodology for separate and cross-domain cyber and electromagnetic threat attack so that assessed vulnerabilities in a multi-domain complex environment can be reduced or eliminated before fielding new networks and network-enabled systems. Experimental and analysis methodology will be developed to investigate vulnerabilities of specific configurations of complex future networks with multiple communications modalities, advanced deception techniques in the cyber and electromagnetic areas, and advanced Positioning, Navigation, and Timing (PNT) systems. *FY 2022 Plans:* Will continue to verify and validate assessment tools, methodologies and metrics (e.g., probability of detection, path loss, scattering in contested/congested electromagnetic environments) for novel Non-traditional waveforms communications such as millimeter wave, ultraviolet (UV)-based communication technologies and the vulnerabilities of beamforming techniques and network protocols; analyze automated software capabilities, refining methodology to increase speed of vulnerability detection and library of network protocols; update the contested/congested electromagnetic environment to reflect emerging threats; and provide threat environments to technology experimentation and technology exploration activities to inform vulnerability mitigations improving critical technologies to include Assured PNT (A-PNT) capabilities. *FY 2021 to FY 2022 Increase/Decrease Statement:* In FY 2022, this effort is realigned from PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology).	-	-	2.060
Accomplishments/Planned Programs Subtotals	-	-	4.202

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 2: *Applied Research*						**R-1 Program Element (Number/Name)** PE 0602183A *I Air Platform Applied 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	-	-	-	6.597	-	6.597	-	-	-	-	-	-
CL5: *Air Platform Enabling University Applied Research*	-	-	-	0.698	-	0.698	-	-	-	-	-	-
CL8: *Aviation Teaming Autonomy Concepts & Technologies*	-	-	-	3.945	-	3.945	-	-	-	-	-	-
CN1: *Disruptive Countermeasure Concepts for Aviation*	-	-	-	1.954	-	1.954	-	-	-	-	-	-

Note

 In Fiscal Year (FY) 2022, this Program Element (PE) is created to focus on longer-term, far-reaching applied research efforts in the Air portfolio.

A. Mission Description and Budget Item Justification

 This PE undertakes applied research efforts that support and enable the overall Army Aviation portfolio in general, and the Army's modernization priority for future vertical lift (FVL). Vital and enduring applied research is conducted in the air portfolio that supports mid-to-long term requirements in contested operational environments and technologies that have broad application to FVL modernization, as well as overall Army and specific DoD aviation needs.

 Work in this PE contributes to the Army Science and Technology (S&T) air systems portfolio and is fully coordinated with efforts in PE 0602148A (Future Vertical Lift Technology), PE 0603465A (Future Vertical Lift Advanced Technology) and PE 0603043A (Air Platform Advanced Technology).

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

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

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 2: *Applied Research*		**R-1 Program Element (Number/Name)** PE 0602183A *I Air Platform Applied Research*		

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	6.597	-	6.597
Total Adjustments	0.000	0.000	6.597	-	6.597
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	6.597	-	6.597

Change Summary Explanation

In FY2022, this is a new PE with two Projects realigned from PE 0602148A (Future Vertical Lift Technology) and one new FY22 Project.

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602183A *I Air Platform Applied Research*					**Project (Number/Name)** CL5 *I Air Platform Enabling University Applied 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**
CL5: *Air Platform Enabling University Applied Research*	-	-	-	0.698	-	0.698	-	-	-	-	-	-

Note

This is a new start in FY 2022.

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

A. Mission Description and Budget Item Justification

This Project focuses on applied research originating from extramural applied research in academia pertaining to navigation/routing, autonomous robotic vehicles, artificial intelligence and machine learning as applied to aerial mobility and maneuver, holistic survivability, teaming, integrated mission systems, air-launched effects, and other innovative air enabling applied research technologies that will accelerate the Army modernization in next generation aerial vehicles. This Project will perform discovery research efforts to focus more on mid to far-term Army modernization priorities while also maintaining delivery of near-term technologies fundamental to the modernization priorities. This effort conducts applied research and development leading to all the potential emerging technologies in areas of strategic importance to Army Aviation in AI/ML, autonomous systems, Advanced Teaming, Survivability, air-launched effects/payloads, coordinated air-ground maneuvering, etc., by bringing competitively selected Universities with research and development teams into Technical Alliances. The project will continuously experiment with methods to identify, demonstrate and transition novel technology from entities that might not otherwise collaborate with the DoD, with the end goal of accelerating the adoption of cutting-edge applied research technology for the warfighter in the Army aviation portfolio.

Work in this Project supports the Army Modernization Priority Future Vertical Lift and the overall aviation portfolio.

The cited work is consistent with 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 (US) Army Futures Command.

This work is done in coordination with and transitions to PE 0602148A (Future Vertical Lift Technology), PE 0603465A (Future Vertical Lift Advanced Technology Development) and PE 0603043A (Air Platform Advanced Technology) and is also coordinated with its sister project in PE 0602144A (Ground Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Advanced Teaming	-	-	0.333

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602183A *I Air Platform Applied Research*	**Project (Number/Name)** CL5 *I Air Platform Enabling University Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Develop capabilities to self-organize and coordinate large teams of unmanned vehicles participating in long-term reconnaissance operation using distributed command/control architectures despite communication delays and/or failures and showcasing resilience to wide-area jamming. *FY 2022 Plans:* Will investigate and develop decentralized self-organization AI/ML algorithms among large team of unmanned heterogeneous autonomous assets deployed inside contested environments that are robust to emerging threats, lost links, or change in mission priorities. Will develop decentralized interactions that will provide knowledge bases, reasoning, planning, sensing and control tools that reside inside the entire vehicle team and mobile computational resources. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding for this new effort is realigned from PE 0602145A / Project BF8 Artificial Intelligence & Machine Learning Tech			
Title: Coordinated Air-Ground Vehicle Maneuvering *Description:* Develop the technology for a fleet of ground and air vehicles to have the capabilities required to perform an autonomous reconnaissance mission in a relevant environment. *FY 2022 Plans:* Will investigate level coordinated landing/take off of unmanned aerial system from stationary platform near ground vehicle in simulations. Will develop software algorithms for air-ground coordination software support autonomous reconnaissance. Will perform applied research on developing coordination strategies for autonomous ground and air vehicles to perform tactical reconnaissance mission. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding for this new effort is realigned from PE 0602145A / Project BF8 Artificial Intelligence & Machine Learning Tech	-	-	0.365
Accomplishments/Planned Programs Subtotals	-	-	0.698

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 2				**R-1 Program Element (Number/Name)** PE 0602183A I *Air Platform Applied Research*					**Project (Number/Name)** CL8 I *Aviation Teaming Autonomy Concepts & Technologies*		
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**
CL8: *Aviation Teaming Autonomy Concepts & Technologies*	-	-	-	3.945	-	3.945	-	-	-	-	-	-

Note

This Project has been administratively realigned in Fiscal Year 2022 from Program Element (PE) 0602148A FVL Technology / Project AK9 Adv Teaming for Tactical Aviation Operations Tech

A. Mission Description and Budget Item Justification

This Project establishes multi-level simulations, physics-based models, and artificial intelligence/machine learning (AI/ML) algorithms and methods to inform and advance capabilities for heterogeneous advanced teaming concepts to support operations in complex and peer contested environments. Innovative solutions, knowledge, and understanding generated from this effort informs Project AK9 Advanced Teaming for Tactical Aviation Operations in PE 0602148A FVL Technology.

Work in this Project is fully coordinated with PE 0602148A (Future Vertical Lift Technology) and PE 0603465A (Future Vertical Lift Advanced Technology Development).

The cited work is consistent with the Under Secretary of Defense for 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: Intelligent Unmanned Aerial System Teaming Technologies	-	-	3.945
Description: Enables the establishment of component technologies to support resilient, multi-modal, survivable Unmanned Aircraft System (UAS) teams that can plan and act on time-scales beyond human capability and have a robust shared understanding of contested and dynamic environments to support effective tactical engagement. Specific topics include 1) novel artificial-intelligence algorithms and methods for adaptive team composition and control, 2) increased team knowledge base and understanding of local and global world models, 3) hierarchical, composable, and adaptive learning methods for increased mission resilience, and 4) understanding interaction and scalability between, amongst, and across heterogeneous team members and the environment. *FY 2022 Plans:* Will develop methods and technologies to provide heterogeneous unmanned teams increased endurance; enable unmanned air and ground vehicle teams to adapt energy usage in dynamic situations; develop algorithms to help predict energy demand			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602183A *I Air Platform Applied Research*	**Project (Number/Name)** CL8 *I Aviation Teaming Autonomy Concepts & Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
between unmanned teams; expand simulation hardware and software to client and server model to enable concurrent simulations; integrate simulation environments with established DoD terrain modeling data; investigate techniques to achieve robust unmanned aerial system homing performance in Global Positioning System (GPS)-denied environment; develop simulated agent-level behaviors that achieve coordinated multi-agent target homing through emergent multi-agent interactions; develop threat resilient autonomous tactical behaviors contextualized in perimeter defense and pursuit-evasion, accounting for team maneuver relative to defending agents and anticipated attrition.			
FY 2021 to FY 2022 Increase/Decrease Statement: Effort was administratively realigned in FY2022 from PE 0602148A Project AK9.			
Accomplishments/Planned Programs Subtotals	-	-	3.945

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

D. Acquisition Strategy
 N/A

PE 0602183A: *Air Platform Applied Research*
Army

UNCLASSIFIED
Page 6 of 8

R-1 Line #20

Volume 1b - 444

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

| Appropriation/Budget Activity
2040 I 2 | | | | R-1 Program Element (Number/Name)
PE 0602183A I *Air Platform Applied Research* | | | | | | Project (Number/Name)
CN1 I *Disruptive Countermeasure Concepts for Aviation* | |

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
CN1: *Disruptive Countermeasure Concepts for Aviation*	-	-	-	1.954	-	1.954	-	-	-	-	-	-

Note

This Project has been administratively realigned in Fiscal Year 2022 from Program Element (PE) 0602148A FVL Technology / Project AK2 Aviation Survivability Technology

A. Mission Description and Budget Item Justification

This Project investigates advanced technologies to reduce Future Vertical Lift (FVL) platform susceptibility and vulnerability to damage from guided and unguided threats, as well as technologies to defeat small arms, rocket, and missile threats. This project performs research and develops innovative detect and defeat technologies against next -generation threats to the FVL. Areas of research include new laser materials and designs for in-band, low size, weight, power, and cost (SWaP-C) precision laser soft-kill countermeasures operating in the mid- and long-wave infrared, lethality effects of ultrashort pulsed lasers, and sensitive radio frequency (SeRF) detection modality for use as aircraft survivability equipment (ASE).

Work in this Project is fully coordinated with PE 0602148A (Future Vertical Lift Technology) and PE 0603465A (Future Vertical Lift Advanced Technology Development).

The cited work is consistent with the Under Secretary of Defense for 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: Cognitive Countermeasures Technology Development *Description:* This effort investigates and matures novel materials, components, and techniques to counter legacy and emerging threats to Future Vertical Lift (FVL) platforms. Emphasis will be placed on technologies and approaches to enable a robust, holistic countermeasure capability for target defeat, regardless of threat characteristics or guidance mode. *FY 2022 Plans:* Will investigate dual-wavelength pumping, enabling beyond quantum defect limit efficiency, towards a diode pumped, in-band Midwave Infrared (MWIR) laser source for infrared countermeasures; conduct experiments exploring Ultra-Short Pulse Laser (USPL) out-of-band optical and electro-optical lethality effects; identify necessary USPL power/intensity/wavelength requirements	-	-	1.954

PE 0602183A: *Air Platform Applied Research*
Army

UNCLASSIFIED
Page 7 of 8

R-1 Line #20

Volume 1b - 445

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602183A *I Air Platform Applied Research*	**Project (Number/Name)** CN1 *I Disruptive Countermeasure Concepts for Aviation*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
for effective counter-threat lethality capability; design and develop research sensor for detection of specific targets and validate models against select targets. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Effort has been administratively realigned from PE 0602148A Project AK2 Aviation Survivability Technology in FY 2022.			
Accomplishments/Planned Programs Subtotals	-	-	1.954

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

D. Acquisition Strategy
 N/A

PE 0602183A: *Air Platform Applied Research*
Army

UNCLASSIFIED
Page 8 of 8

R-1 Line #20

Volume 1b - 446

UNCLASSIFIED

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

Appropriation/Budget Activity
2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*

R-1 Program Element (Number/Name)
PE 0602184A / *Soldier Applied 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	-	-	-	11.064	-	11.064	-	-	-	-	-	-
CK9: *Advancing Concepts and Technology Forecasting Tech*	-	-	-	2.289	-	2.289	-	-	-	-	-	-
CN2: *Intelligent Weapons Concepts and Technologies*	-	-	-	2.178	-	2.178	-	-	-	-	-	-
CN9: *Soldier Enabling University Applied Research*	-	-	-	0.939	-	0.939	-	-	-	-	-	-
CO1: *Soldier Power And Energy Concepts and Technologies*	-	-	-	1.241	-	1.241	-	-	-	-	-	-
CO2: *Soldier-Intelligent Technology Research*	-	-	-	4.417	-	4.417	-	-	-	-	-	-

Note
This is a new start in FY 2022.

This is a new Program Element in FY 2022.

A. Mission Description and Budget Item Justification
This PE investigates, designs, and performs research focused on technologies necessary for capability enhancements for the Soldier and Squad over the long-term well beyond those technologies planned within the Soldier Lethality Cross- Functional Team. Applied research projects investigate nascent and enduring science and technology areas that are applicable to the individual Soldier and Squads of Soldiers needs with emphasis on maximizing Soldier and Squad performance, lethality, mobility and survivability. This PE designs and validates technologies that are necessary and foundational for future capabilities with far-reaching impact on mission success. The outputs of these efforts transition to advanced research efforts that mature and demonstrate potential opportunities to realize improved Soldier performance and inform technical requirements for future Soldier systems.
The PE will fund civilian salaries for in-house researchers/scientists and program managers collaborating with external subject matter experts in academia and industry who are leaders in these technology research areas.

In FY20 the Army restructured Science and Technology resources to align to the Secretary of the Army's six modernization priorities and allow transparent accountability of these priorities. Creation of this PE will facilitate the Soldier Lethality priority identification of technologies that enable multiple Soldier systems and are enduring (e.g. power generation, storage and distribution; protective materials; network integration; human systems integration, personnel research). This PE creation completes the FY20 restructuring process and ensures consistency across the six priority areas PE structures, with each priority area having two PEs per Budget Activity: one aligned to Soldier efforts that support priority systems (e.g. Next Generation Squad Weapons, Integrated Virtual Augmentation System) and the other aligned to enduring

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 1 of 12

R-1 Line #21

Volume 1b - 447

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*	

enabling technologies projects for future capabilities and/or technology upgrades. The enabling projects will be moved from the Soldier Technologies PE 622143A to this new PE, improving visibility of Army research efforts that enable the future operating environment.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy. Work in this Project is performed by the United States (US) 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	11.064	-	11.064
Total Adjustments	0.000	0.000	11.064	-	11.064
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	11.064	-	11.064

Change Summary Explanation
New Program Element in Fiscal Year (FY) 2022 established for enabling science and technology efforts that support applied soldier research.

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*						**Project (Number/Name)** CK9 *I Advancing Concepts and Technology Forecasting Tech*		

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
CK9: *Advancing Concepts and Technology Forecasting Tech*	-	-	-	2.289	-	2.289	-	-	-	-	-	-

Note

This is a new start in FY 2022.

In Fiscal Year 2022 (FY22) this is a New Project.

A. Mission Description and Budget Item Justification

This Project works across the Army Futures Command Combat Capabilities Development Command (AFC CCDC) and with the Futures & Concepts Center (FCC) to explore current and future emerging and disruptive applied scientific research in order to translate, integrate, and ingrain applied research outcomes with Army Warfighting Concepts to describe how the Army will fight in the mid and far-term future. Applied research outcomes describe the projected future operational effects of science in the context of Army concepts to mitigate risk for future Army capabilities and enable informed decision making across the Army Modernization Enterprise. This Project ensures Army Concepts are grounded by recent discoveries in applied scientific research, Army applied research is capability use-inspired to deliver the right future capability identified in the Army Concepts, and learning opportunities are created to advance Army Concepts and operationalize science for transformational overmatch.

This Project also performs long-range technology forecasts and trend analysis, informed by the threat and the predicted future state of technology, of Army-relevant applied research topics to enable informed decision making for the near-, mid-, and far-terms.

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	-	-	2.289
Description: Advancing Concepts and Technology Forecasting identifies and translates emerging and disruptive applied scientific research current and future outcomes in order to integrate and ingrain applied scientific data and knowledge with Army Warfighting Concepts which describe how the Army will fight in the mid- and far-term future. This effort also provides long-range, scientifically grounded technology forecasts and trend analysis, informed by the threat and future predicted state of technology, of applied research topics to enable informed decision-making for the near-, mid-, and far-terms. **FY 2022 Plans:**			

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 3 of 12

R-1 Line #21

Volume 1b - 449

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*	**Project (Number/Name)** CK9 *I Advancing Concepts and Technology Forecasting Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will integrate knowledge of applied scientific research outcomes with warfighting concepts with a focus on mid- and far-term Maneuver, Fires, and Mission Command Army Warfighting Concepts; perform long-range technology forecasts and near/mid-term horizon scanning of the Army Priority Research Areas; provide reports, briefings, and information papers to the Army Modernization Enterprise to influence personnel and funding decisions. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding increase reflects realignment of funding to create this New Project for enabling informed decision making across the Army Modernization Enterprise and ensure Army Concepts are grounded by recent discoveries in applied scientific research.			
Accomplishments/Planned Programs Subtotals	-	-	2.289

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 4 of 12

R-1 Line #21

Volume 1b - 450

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*					**Project (Number/Name)** CN2 *I Intelligent Weapons Concepts and Technologies*		

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**
CN2: *Intelligent Weapons Concepts and Technologies*	-	-	-	2.178	-	2.178	-	-	-	-	-	-

Note

In FY 2022, Project is realigned form PE 0602143A (Soldier Lethality Technology) / Project AY6 (Soldier Squad Small Arms Armaments Technology).

A. Mission Description and Budget Item Justification

This effort focuses on far-term, overarching lethality technologies by investigating techniques for Soldiers to guide the in-field adaptation of intelligent small arm technologies to respond to changing mission requirements, novel environments, and adversarial actions. Research areas include cognition-centric displays to ensure Soldiers maintain appropriate situational awareness in augmented reality environments, opportunistic shooter sensing, and interactive machine learning techniques to ensure small arm technologies can adapt to changing situations quickly and with reduced data requirements as compared to non-human guided machine learning and Artificial Intelligence (AI). The results of this Project will enhance operational performance of individuals and teams of Soldiers in the future operational environment through novel weapon and human-agent interaction technologies.

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: Human-Agent Interactions for Intelligent Squad Weapons	-	-	2.178
Description: This effort investigates enhanced target acquisition, situational awareness, and shooting performance through Soldier-centered integration of intelligent technologies and distributed information in augmented squad weapons. Enhances operational performance of individuals and teams of Soldiers through novel weapon and human-agent interaction technologies. **FY 2022 Plans:** Will investigate methods to label relevant data from Soldier-systems interactions through opportunistic sensing and drive the adaptation of intelligent small-arms technology; design initial approaches for human-computer vision teamed augmented reality. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funding change reflects realignment of funding from PE 0602143A (Soldier Lethality Technology) / Project AY6 (Soldier Squad Small Arms Armaments Technology) in FY 2022.			
Accomplishments/Planned Programs Subtotals	-	-	2.178

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 5 of 12

R-1 Line #21

Volume 1b - 451

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*	**Project (Number/Name)** CN2 *I Intelligent Weapons Concepts and Technologies*

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

Remarks

D. Acquisition Strategy
  N/A

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 6 of 12

R-1 Line #21

Volume 1b - 452

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*						**Project (Number/Name)** CN9 *I Soldier Enabling University Applied 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**
CN9: *Soldier Enabling University Applied Research*	-	-	-	0.939	-	0.939	-	-	-	-	-	-

Note

This is a new start in FY 2022.

In Fiscal Year 2022 (FY22), this is a New Project.

A. Mission Description and Budget Item Justification

This Project investigates technologies from academia that will improve capabilities and systems to advance Soldier and Squad lethality-overmatch and Soldier performance. This Project funds collaborative, enduring applied extramural university-based research and brings together competitively selected universities with Army research teams into Technical Alliances. This Project will determine discovery solutions and inform capabilities development for mid- to far-term Army modernization priorities while also maintaining delivery of near-term technologies fundamental to the modernization priorities. The technical scope of this Project includes the investigation and design of overarching Soldier-centric technologies including, human systems integration, robotics, synthetic environments for training, advanced materials, power management, energy, Warfighter endurance, and computational technologies. This effort conducts applied research for potential emerging technologies in areas of strategic importance to the Army in Soldier capabilities related to increased protection, performance, agility, situational awareness, and lethality. This Project will continuously strive to engage and collaborate with entities that might not otherwise collaborate with the DoD to identify and determine novel Soldier-centric technologies for accelerating the adoption of emerging technologies for the Warfighter in the Army Soldier portfolio.

Work in this Project supports the Army Modernization Priority Synthetic Training Environment, and Soldier Lethality and the overall Soldier portfolio.

The cited work is consistent with 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 (US) Army Futures Command.

Work in this Project complements and transitions to Soldier Enabling University Advanced Development in PE 0603044A (Soldier Advanced Technology).

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Soldier Training and Performance	-	-	0.639
Description: Collaboratively investigate technologies for Soldier capabilities related to increased protection, performance, agility, situational awareness, training, and lethality.			
FY 2022 Plans:			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*	**Project (Number/Name)** CN9 *I Soldier Enabling University Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Investigate automated testing framework to guarantee that synthetic training environments are highly trustworthy, reliable, and usable, to ensure that Soldiers are efficiently trained; Optimize intelligent real time edge processing of streams for wide area persistent surveillance, signature event detection and tracking towards the Army's next generation active protection and situational awareness systems; investigate timely and reliable monitoring and assessment technologies for the health and readiness of Warfighters through digital biomarkers and biosensors. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase reflects realignment of funding to create this New task to support collaborative, enduring research with competitively selected universities that investigates Soldier-centric technologies to promote the adoption of emerging technologies for the Soldier.			
Title: Soldier Electronics for the Integrated Combat Platform *Description:* Design and determine advanced materials and electronics that are standardized to the Soldier and their equipment through integrated combat platform. *FY 2022 Plans:* Funds research to design and investigate Soldier electronics and standardize data, and power interfaces and connection points across the Soldier and Squad combat platform. Investigate and develop energy storage and other materials such as self-healing and super materials for increased protection, flexible electronics, and power generation. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding increase reflects realignment of funding to create this New task to support university-driven, enduring research that investigates Soldier-centric electronics technologies for integration with the combat platform to support adoption of emerging technologies for the Soldier that reduce burden and promote mobility.	-	-	0.300
Accomplishments/Planned Programs Subtotals	-	-	0.939

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

D. Acquisition Strategy
 N/A

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 8 of 12

R-1 Line #21

| **Volume 1b - 454** |

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2				**R-1 Program Element (Number/Name)** PE 0602184A I *Soldier Applied Research*						**Project (Number/Name)** CO1 I *Soldier Power And Energy Concepts and Technologies*		
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**
CO1: *Soldier Power And Energy Concepts and Technologies*	-	-	-	1.241	-	1.241	-	-	-	-	-	-

Note

 In FY 2022, this new Project is realigned from PE 0602143A (Soldier Lethality Technology) / Project BD8 (Soldier & Sm Unit Tactical Energy Tech).

A. Mission Description and Budget Item Justification

 This Project conducts applied research to improve safe, compact, efficient, rugged, lightweight, and energy dense power sources for increased capabilities for the mounted and dismounted force. This Project also investigates materials, processes, and component level energy storage and conversion technologies that enable tactical overmatch and reduce the physical and cognitive burden on Soldiers. Research will focus on safe electrochemical energy storage, high specific energy storage and conversion, novel materials and processing for energy and power, and new cell designs that address the power needs of future capabilities including the Next Generation Squad Weapons (NGSW), Integrated Visual Augmentation System (IVAS), and other advanced sensors, communications systems, and electronic Warfighting capabilities. Enabling and emerging technologies are supported in this Project to address future Soldier power needs necessary for increased lethality, increased mobility, and longer mission durations at reduced physical burden to the Soldier in the future operating environment.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Tactical Energy Sources and Energy Materials	-	-	1.241
Description: This effort conducts overarching power and energy research to determine and design alternative energy capabilities to replace current energy systems. Research focuses on new materials and processing techniques as well as energy storage technologies that support advanced sensors, communications systems, and electronic Warfighting capabilities. *FY 2022 Plans:* Will investigate improved anodes and cathode materials and electrode structures for aqueous electrolyte batteries including silicon based anode materials for high energy, safe, non-flammable aqueous batteries; extend aqueous electrolytes to other multivalent cations including zinc rechargeable systems; investigate zinc metal reversibility for high energy rechargeable safe batteries; explore the solvation, interface, and transport of highly concentrated electrolytes and the effects on electrode/electrolyte interfaces; assess energy conversion materials and technologies for FY 2023 inclusion. *FY 2021 to FY 2022 Increase/Decrease Statement:*			

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 9 of 12

R-1 Line #21

| **Volume 1b - 455** |

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*	**Project (Number/Name)** CO1 *I Soldier Power And Energy Concepts and Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding change in FY 2022 reflects realignment of funding from PE 0602143A (Soldier Lethality Technology) / BD8 (Soldier & Sm Unit Tactical Energy Tech).			
Accomplishments/Planned Programs Subtotals	-	-	1.241

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 10 of 12

R-1 Line #21

Volume 1b - 456

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*					**Project (Number/Name)** CO2 *I Soldier-Intelligent Technology 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
CO2: *Soldier-Intelligent Technology Research*	-	-	-	4.417	-	4.417	-	-	-	-	-	-

Note

In FY 2022 this new project is realigned from PE 0602143A (Soldier Lethality Technology) / Project BC3 (Soldier Decision Making & Comms Performance Tech).

A. Mission Description and Budget Item Justification

This Project investigates research gaps related to human and intelligent systems to enhance decision making in response to changing conditions. Applied research is conducted on novel and emerging visualization technologies as well as methodologies for intelligent systems and Soldier to co-adapt for the real-time quantification, prediction, and enhancement of squad-level shared situational awareness (SA) and situational understanding (SU) across dynamic, complex, and uncertain operating environments, leading to demonstrated increases in mission effectiveness. The result of this effort will inform various efforts that rely on human and intelligent system interactions including systems that adapt the behavior of autonomous assets and intelligent Soldier tools, based on dynamic needs of the Soldier/squad, using real-time opportunistic measures of Soldier SA and changing mission environment. In addition, this Project will design novel approaches to represent uncertain and dynamically changing information, to increase Soldier comprehension and enhanced mission effectiveness, with reduced Soldier/squad burden and training requirements.

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: Soldier Performance in Sociotechnical Environments	-	-	2.981
Description: Technologies for squad-level situational awareness assessment (information visualization) that provide command-level decision support with communication and intervention capabilities. Research focuses on algorithms for the quantification and visualization of collective uncertainty at the squad level for mission command decision making. This effort also supports the monitoring and assessing of Soldier tactical readiness and effectiveness through technologies and approaches for opportunistic human sensing. *FY 2022 Plans:* Will explore methods for how autonomous systems can leverage real-time measures of squad-level situational awareness to improve mission outcomes; design initial capability to opportunistically assess group performance in dismounted virtual environments; validate group performance measures in augmented reality systems. *FY 2021 to FY 2022 Increase/Decrease Statement:*			

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 11 of 12

R-1 Line #21

Volume 1b - 457

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602184A *I Soldier Applied Research*	**Project (Number/Name)** CO2 *I Soldier-Intelligent Technology Research*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Funding change in FY 2022 reflects realignment of funding from PE 0602143A (Soldier Lethality Technology) / BC3 (Soldier Decision Making & Comms Performance Tech).			
Title: Algorithms for Sensing Soldiers in Mission Context *Description:* This effort investigates novel and emerging visualization technologies representing complex, time-sensitive information in the dynamic operating environment as well as technologies for human and artificial intelligence (AI) situational understanding for enhanced operational performance and decision making under conditions of time sensitive and dynamically changing information. *FY 2022 Plans:* Will design techniques for tailoring the representation of uncertain battlespace information in time-sensitive environments for increased Soldier situation awareness and improved mission relevant decision making. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding change in FY 2022 reflects realignment of funding from PE 0602143A (Soldier Lethality Technology) / BC3 (Soldier Decision Making & Comms Performance Tech).	-	-	1.436
Accomplishments/Planned Programs Subtotals	-	-	4.417

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

D. Acquisition Strategy
 N/A

PE 0602184A: *Soldier Applied Research*
Army

UNCLASSIFIED
Page 12 of 12

R-1 Line #21

Volume 1b - 458

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 2: *Applied Research*						**R-1 Program Element (Number/Name)** PE 0602213A *I C3I Applied Cyber*						

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	-	17.351	18.816	12.123	-	12.123	-	-	-	-	-	-
2CY: *Information Trust Technology*	-	1.222	1.220	0.601	-	0.601	-	-	-	-	-	-
3CY: *Network Access and Effects Technology*	-	3.945	4.191	6.479	-	6.479	-	-	-	-	-	-
5CY: *Offensive Cyber Operations (OCO) Mirror Technology*	-	1.000	0.999	0.987	-	0.987	-	-	-	-	-	-
CY1: *Information Assurance and Network Resiliency Tech*	-	3.357	3.488	3.397	-	3.397	-	-	-	-	-	-
CY6: *Autonomous Cyber Technology*	-	3.733	6.133	0.659	-	0.659	-	-	-	-	-	-
CY8: *Cyber Security App Research and Exper Partner Tech*	-	2.733	2.785	-	-	-	-	-	-	-	-	-
CY9: *Decoy and Deterrence Technology*	-	1.361	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This PE designs cyber architectures, software, tools, and techniques to enable Cyber Electromagnetic Activities (CEMA) to counter adversary communications and harden the Army's tactical communications networks against cyber attacks. For offensive cyber effort against adversary communications, efforts investigate capabilities to identify and capture data traversing targeted networks for detection, identification, exploitation, direction finding, geolocation, and denial of service. For defensive cyber efforts hardening the Army's tactical network, efforts also investigates and applies robust cyber security technologies and techniques to advance software, algorithms and protocols utilized within tactical networks to protect against nation state level cyber attacks and maintain Warfighter confidence in network information by hardening the blue force attack surface.

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

PE 0602213A: *C3I Applied Cyber*
Army
UNCLASSIFIED
Page 1 of 15
R-1 Line #22
Volume 1b - 459

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 2: *Applied Research*		**R-1 Program Element (Number/Name)** PE 0602213A *I C3I Applied Cyber*		
B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	18.947	18.816	15.351	-	15.351
Current President's Budget	17.351	18.816	12.123	-	12.123
Total Adjustments	-1.596	0.000	-3.228	-	-3.228
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-1.596	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	-3.228	-	-3.228

Change Summary Explanation

FY22 decrease related to completion of Project CY8 (Cyber Security App Research and Exper Partner Tech) and transition of funding from Project CY6 (Autonomous Cyber Technology) to the follow on work in 0603457A (C3I Cyber Advanced Development) Project 6CY (Autonomous Cyber Advanced Technology).

PE 0602213A: *C3I Applied Cyber*
Army

UNCLASSIFIED
Page 2 of 15

R-1 Line #22

Volume 1b - 460

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602213A *I C3I Applied Cyber*					**Project (Number/Name)** 2CY *I Information Trust 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**
2CY: *Information Trust Technology*	-	1.222	1.220	0.601	-	0.601	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops defensive cyber technology to ensure that data traversing the network remains verified and has not been modified through unauthorized means.

Work in this Project complements PE 0603457A (C3I Cyber Advanced Development) Project 8CY (Information Trust Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Information Trust Technology	1.222	1.220	0.601
Description: This effort develops defensive cyber technology to ensure that data traversing the network remains verified and has not been modified through unauthorized means. *FY 2021 Plans:* Design and conduct experiments with specification based fixed format message checking and machine learning based integrity services that ensure the integrity of a message?s data, origin, and chain of custody as it traverses the network; mature the trust score architecture that can provide real time analytics of the data through distributed processing and minimization of network traffic; and design suitable de-centralized lightweight block chain algorithms that can be leveraged to ensure a secure distributed ledger of messages and associated risk with automated analysis of attempted malicious modification. *FY 2022 Plans:* Will mature and validate the trust score architecture that provides real time analytics of the data through distributed processing and minimization of network traffic. *FY 2021 to FY 2022 Increase/Decrease Statement:* This effort concludes in FY22, reduction in funding reflects deceleration of effort towards completion.			
Accomplishments/Planned Programs Subtotals	1.222	1.220	0.601

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* 2	**R-1 Program Element (Number/Name)** PE 0602213A *I* C3I Applied Cyber	**Project (Number/Name)** 2CY *I* Information Trust Technology

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy
 N/A

PE 0602213A: *C3I Applied Cyber*
Army

UNCLASSIFIED
Page 4 of 15

R-1 Line #22

Volume 1b - 462

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2				**R-1 Program Element (Number/Name)** PE 0602213A / C3I Applied Cyber					**Project (Number/Name)** 3CY / Network Access and Effects 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**
3CY: *Network Access and Effects Technology*	-	3.945	4.191	6.479	-	6.479	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates the application of machine learning technologies to assist in capability development and mission execution processes with respect to Offensive Cyber Operations (OCO)/Radio Frequency (RF) Enabled capabilities.

Work in this Project complements PE 0603457A (C3I Cyber Advanced Development) Project 9CY (Network Access and Effects Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Applied OCO Techniques and Analytics	3.945	3.945	6.479
Description: This effort investigates the application of machine learning technologies to assist in capability development and mission execution processes with respect to OCO/RF Enabled capabilities. *FY 2021 Plans:* Research techniques to expedite protocol-based vulnerability discovery against emerging targets; and investigated OCO capabilities that focus on commonalities between targets of interest in support of non-kinetic OCO effects against emerging hybrid commercial/military technologies in Adversary Command, Control, Communication, Computers, and Intelligence (AC4I) systems. *FY 2022 Plans:* Will conduct experiments of OCO/RF Enabled access and effects vectors against emerging AC4I targets of interest. Shall investigate software approaches to support vulnerability discovery against emerging targets of interest and conduct experiments to determine development time reduction. Will conduct experiments with decision aids leveraging machine learning to reduce cognitive burden on OCO/RF operators. *FY 2021 to FY 2022 Increase/Decrease Statement:* FY22 funding increased to conduct experiments to determine development time reduction of vulnerability discovery.			
Title: Command, Control and Communications Attack	-	0.246	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602213A *I C3I Applied Cyber*	**Project (Number/Name)** 3CY *I Network Access and Effects Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort investigates RF Enabled access and effects against adversary Command, Control, Communication, Computers, and Intelligence (C4I) systems executed from agile OCO/RF Enabled firing platforms. *FY 2021 Plans:* Research target design commonalities in support of non-kinetic Radio Frequency-enabled access and effects against emerging hybrid commercial/military technologies used within AC4I systems. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding was realigned towards task Applied OCO Techniques and Analytics in this project.			
Accomplishments/Planned Programs Subtotals	3.945	4.191	6.479

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

D. Acquisition Strategy
 N/A

PE 0602213A: *C3I Applied Cyber*
Army
UNCLASSIFIED
Page 6 of 15
R-1 Line #22
Volume 1b - 464

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

Appropriation/Budget Activity 2040 *I* 2	R-1 Program Element (Number/Name) PE 0602213A *I* C3I Applied Cyber	Project (Number/Name) 5CY *I* Offensive Cyber Operations (OCO) Mirror 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
5CY: *Offensive Cyber Operations (OCO) Mirror Technology*	-	1.000	0.999	0.987	-	0.987	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs, creates, evaluates, and applies emerging cyber techniques and cyber situational awareness technologies to enhance Army capabilities. This Project leverages behavioral Modeling and Simulation to mitigate risks and investigates cyber collection and mapping technologies to offer real time cyber situational awareness to enable interpretation of current threats and predict future enemy activities. This allows commanders to develop operational courses of action in time to act decisively and in a pre-emptive manner. This work complements PE 0603457A (C3I Cyber Advanced Development) Project CB4 (Offensive Cyber Operations (OCO) Mirror Adv Tech).

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: Offensive Cyber Operations Mirror Technology *Description:* Designs and develops emerging internet technologies that enable Offensive Cyber operations infrastructure maneuver within neutral (gray) cyberspace environment; conduct experiments within a modeling and simulation environment (to include behavioral components) to enhance rapid offensive cyber developed capabilities, cyber mission rehearsal, and training. *FY 2021 Plans:* Investigate novel methods for an enhanced discrete event simulator required for future modeling and simulation environments, at scale with advanced behavioral models; and experiment on the traffic shaping mirror capability components. *FY 2022 Plans:* Will determine methodologies for assisted Offensive Cyber Operations (OCO) maneuver and conduct experiments to enable fidelity driven Development Security Operations (DevSecOps) leveraging foundational modeling and simulation environments *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding reflects planned lifecycle of project.	1.000	0.999	0.987
Accomplishments/Planned Programs Subtotals	1.000	0.999	0.987

PE 0602213A: *C3I Applied Cyber*
Army

UNCLASSIFIED
Page 7 of 15

R-1 Line #22

Volume 1b - 465

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602213A *I C3I Applied Cyber*	**Project (Number/Name)** 5CY *I Offensive Cyber Operations (OCO) Mirror Technology*

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602213A: *C3I Applied Cyber*
Army

UNCLASSIFIED
Page 8 of 15

R-1 Line #22

Volume 1b - 466

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602213A I C3I Applied Cyber					Project (Number/Name) CY1 I Information Assurance and Network Resiliency Tech		

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
CY1: *Information Assurance and Network Resiliency Tech*	-	3.357	3.488	3.397	-	3.397	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project develops and characterizes techniques for detecting, disrupting, understanding and predicting complex adversarial activities and their impacts for developing agile, adaptive maneuvers in defense of information and networks (Agile Cyber Maneuver and Resilience). This Project develops hardware, algorithms, and methods that jointly adapt to support uninterrupted communications (Autonomous Tactical Networking). This work complements PE 0603457A (C3I Cyber Advanced Development) Project 8CY (Information Trust Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Information Assurance and Network Resiliency Technology *Description:* This effort designs and characterizes software for the protection of information and networks in wireless tactical environments. The goal is to develop software algorithms that detect and defeat malicious activities of adversaries in bandwidth-constrained tactical networks. *FY 2021 Plans:* Develop and implement novel methods for network control that include joint optimization of the layers of the protocol stack, the adaptation of multiple diverse communication and networking modalities, and the optimization with respect to generalized mission-centric objectives; develop, implement, and experimentally validate protocols that feature improvements in energy usage, jamming resistance, and security; utilize machine learning methods to detect, predict, and disrupt adversarial activities; and develop techniques to defend against adversarial influence of machine learning (ML) based Intrusion Detection Systems (IDS) methods. *FY 2022 Plans:* Will develop, characterize, and conduct experiments on networking methods for unconventional communications modalities; design and develop adaptive networking protocols for the simultaneous operation of multiple communications modalities; implement and conduct experiments on multilayer network control algorithms for mission-centric network operation in complex environments including jamming; develop example of adversarial machine learning (AML) methods within a laboratory environment against existing cyber security classifiers, enhance network intelligence gathering, machine learning applications, and decoding tool capabilities; increase network forensics capabilities to adapt to more complex networks and protocols,	3.357	3.488	3.397

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602213A *I C3I Applied Cyber*	**Project (Number/Name)** CY1 *I Information Assurance and Network Resiliency Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
investigating methods which may utilize Machine Learning and autonomous analysis; increase network situational awareness, enable sophisticated analysis and reverse engineering of current and emerging network protocols, and apply and assess foundational network security research algorithms. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funding change reflects planned lifecycle of this effort.			
Accomplishments/Planned Programs Subtotals	3.357	3.488	3.397

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* 2					**R-1 Program Element (Number/Name)** PE 0602213A *I C3I Applied Cyber*					**Project (Number/Name)** CY6 *I Autonomous Cyber 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**
CY6: *Autonomous Cyber Technology*	-	3.733	6.133	0.659	-	0.659	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project investigates and applies robust cyber security techniques and applications to advanced communications and networking devices, software, algorithms and protocols utilized within wireless tactical networks to protect against nation state level cyber effects and maintain Warfighter confidence in network information, resources, identities and mission partners by hardening the blue force attack surface. This work complements PE 0603457A (C3I Cyber Advanced Development) Project 6CY (Autonomous Cyber Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Autonomous Cyber Technology	3.733	6.133	0.659
Description: This effort develops defensive cyber technology to secure the automated network decisions (e.g., Primary, Alternate, Contingency, and Emergency (PACE)) and defend against adaptive, autonomous cyber-attacks at machine speed.			
FY 2021 Plans: Mature technology and validate the interoperable AI/ML based cyber defense decision aid architecture supporting warfighter planning; and mature and validate generative network algorithms and neural network software to simulate adversarial attacks on AI/ML algorithms that can be utilized to ensure trustworthiness of autonomous network configuration decisions and mitigate any vulnerable decisions.			
FY 2022 Plans: Will mature and demonstrate proof-of-concept generative network algorithms and neural network software to simulate adversarial attacks on AI/ML algorithms that can be utilized to ensure trustworthiness of autonomous network configuration decisions and mitigate any vulnerable decisions.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort as it transitions to follow on work in PE 0603457A Project 6CY (Autonomous Cyber Advanced Technology).			
Accomplishments/Planned Programs Subtotals	3.733	6.133	0.659

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602213A *I* C3I Applied Cyber	**Project (Number/Name)** CY6 *I* Autonomous Cyber Technology

C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

D. Acquisition Strategy

 N/A

PE 0602213A: *C3I Applied Cyber*
Army

UNCLASSIFIED
Page 12 of 15

R-1 Line #22

Volume 1b - 470

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602213A *I C3I Applied Cyber*						**Project (Number/Name)** CY8 *I Cyber Security App Research and Exper Partner Tech*		
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**
CY8: *Cyber Security App Research and Exper Partner Tech*	-	2.733	2.785	-	-	-	-	-	-	-	-	-

Note

In FY (Fiscal Year) 2022, the project was realigned towards the following projects:
PE 0603457 (C3I Cyber Advanced Development) Project 6CY (Autonomous Cyber Advanced Technology)
PE 0602146A (Network C3I Technology) Project CI3 Mobile and Survivable Command Post (MASCP) Tech
PE 0603463A (Network C3I Advanced Technology) Project CI7 (Mobile and Survivable Command Post (MASCP) Adv Tech)

A. Mission Description and Budget Item Justification

This Project investigates cyber electromagnetic activities (CEMA), cyber security devices, software and techniques to harden wireless communications networks against cyber-attacks and new mobile networking protocols that afford resilience within our networks to automatically 'fight through' and/or evade hostile cyber effects.

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: Cyber Security Applied Research & Experimentation Partner (AREP) Technology	2.733	2.785	-
Description: This effort will take innovative basic research theories from the Cyber Collaborative Research Alliance (CRA) and experimentally validate the hypothesis and create proof-of-concept defensive cyber software implementations. Work being accomplished under PE 0602782A (Command, Control, Communications Technology) / Project H92 (Communications Technology) complements this effort, and this effort is fully coordinated with the Army Research Lab Cyber Security Collaborative Research Alliance, PE 0601121A (Cyber Collaborative Research Alliance) / Project CB5 (Cyber Collaborative Research Alliance).			
FY 2021 Plans: Conduct experiments with efficient machine learning techniques and multi-user behavior modeling to enhance fidelity of cyber decoys and enable pre-predicting of adversarial action; conduct experiments with artificial intelligence (AI) techniques that can reason on adversarial tactic techniques and procedures (TTP's) to detect and counter adversarial machine learning; and conduct			

PE 0602213A: *C3I Applied Cyber*
Army

UNCLASSIFIED
Page 13 of 15

R-1 Line #22

Volume 1b - 471

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602213A *I C3I Applied Cyber*	**Project (Number/Name)** CY8 *I Cyber Security App Research and Exper Partner Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
experiments with AI and game theoretical techniques that can operate on limited or 'dirty' data sets (data set that contains errors such as redundant, duplicate or incomplete data) to enable agility of tactical network assets to counter threat. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY (Fiscal Year) 2022, the project was realigned towards the following projects: PE 0603457 (C3I Cyber Advanced Development) Project 6CY (Autonomous Cyber Advanced Technology) PE 0602146A (Network C3I Technology) Project CI3 Mobile and Survivable Command Post (MASCP) Tech PE 0603463A (Network C3I Advanced Technology) Project CI7 (Mobile and Survivable Command Post (MASCP) Adv Tech)			
Accomplishments/Planned Programs Subtotals	2.733	2.785	-

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602213A: *C3I Applied Cyber*
Army

UNCLASSIFIED
Page 14 of 15

R-1 Line #22

Volume 1b - 472

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2					**R-1 Program Element (Number/Name)** PE 0602213A / C3I Applied Cyber				**Project (Number/Name)** CY9 / Decoy and Deterrence 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**
CY9: *Decoy and Deterrence Technology*	-	1.361	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project designs technologies to counter enemy cyber threats by delaying, disrupting, and deterring their ability to successfully attack tactical systems, applications, and critical data.

Work in this Project complements PE 0603457A (C3I Cyber Advanced Development) Project 7CY (Decoy and Deterrence Advanced Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Decoy and Deterrence Technology	1.361	-	-
Description: This effort designs technologies to counter enemy cyber threats by delaying, disrupting, and deterring their ability to successfully attack tactical systems, applications, and critical data.			
Accomplishments/Planned Programs Subtotals	1.361	-	-

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

D. Acquisition Strategy
N/A

PE 0602213A: *C3I Applied Cyber*
Army

UNCLASSIFIED
Page 15 of 15

R-1 Line #22

Volume 1b - 473

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 2: *Applied Research*						**R-1 Program Element (Number/Name)** PE 0602386A *I Biotechnology for Materials - Applied 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	-	-	-	20.643	-	20.643	-	-	-	-	-	-
CP6: *Foundational Biotechnology Design and Dev*	-	-	-	20.643	-	20.643	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, this Program Element (PE) is created to focus on broad biotechnology efforts in collaboration with Joint Service partners supporting Tri-Service Biotechnology for a Resilient Supply Chain efforts.

A. Mission Description and Budget Item Justification

This PE investigates, designs, and performs research focused on novel biotechnological methods, techniques, and materials to increase the resiliency of the military supply chain. The Army is responsible for centrally managing funding for Tri-Service Biotechnology for a Resilient Supply Chain (T-BRSC) efforts. T-BRSC leverages bio-industrial manufacturing to ensure critical domestic supply chain resilience for defense needs through domestic production of raw materials and critical products. Efforts under this PE collaborate with sister Services and select allied partners to create a cohesive biotechnology architecture to enable defense needs. Applied research projects investigate and design bio-engineered materials to ensure domestic sourcing for critical supply chain resiliency. This PE designs and validates technologies to enable rapid prototyping and evaluating of bio-engineered and bio-manufactured materials. Also under this PE, efforts determine and validate a digital architecture to secure biotech data and create computer aided design software to support the safe design and enhanced biosecurity of biotechnology products and applications.

Creation of this PE facilitates the Army's central management of the Joint Service T-BRSC effort and ensures traceability of funding. The foundational efforts of T-BRSC support a robust pipeline for biotechnology related manufacturing for defense needs. The Army recognizes emerging biotechnologies as a critical technology that will provide innovative solutions to address the Army's capability gaps for decades to come. This PE creation is necessary for the broad planned initiatives under this effort as no existing Army S&T Project has the requisite programmatic scope of T-BRSC.

Work in this PE is coordinated with PE 0603386A (Biotechnology for Materials - Advanced 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 PE is performed by the United States (US) Army Futures Command (AFC).

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 2: *Applied Research*		**R-1 Program Element (Number/Name)** PE 0602386A *I Biotechnology for Materials - Applied Research*		

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	20.643	-	20.643
Total Adjustments	0.000	0.000	20.643	-	20.643
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	20.643	-	20.643

PE 0602386A: *Biotechnology for Materials - Applied Re...*
Army

UNCLASSIFIED
Page 2 of 4

R-1 Line #23

Volume 1b - 475

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army										Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602386A I Biotechnology for Materials - Applied Research						Project (Number/Name) CP6 I Foundational Biotechnology Design and Dev	
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
CP6: *Foundational Biotechnology Design and Dev*	-	-	-	20.643	-	20.643	-	-	-	-	-	-

Note

This is a new start in FY 2022.

In Fiscal Year (FY) 2022, this new Project is created to support the Army's central management of Tri-Service Biotechnology for a Resilient Supply Chain (T-BRSC) efforts.

A. Mission Description and Budget Item Justification

This Project works collaboratively with Joint Service partners to investigate and determine novel biotechnology methods and processes to establish a domestic resilient supply chain for defense needs. Applied research designs and conducts experiments on bio-derived, bio-functionalized, and bio-manufactured materials and biosynthetic precursors. Efforts under this Project investigate and validate models for design of defense applications. Areas of focus may include reclamation or sequestration of rare Earth/critical elements in the defense supply chain and drop-in replacements for currently employed military materials.

This Project is coordinated with PE 0603386A (Biotechnology for Materials - Advanced Research) / CP7 (Biotechnology Demonstration and Evaluation).

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 (US) Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Biotechnology Safety by Design for Defense *Description:* This task designs and investigates novel and emerging biotechnologies related to bio-engineered or bio-manufactured materials and their precursors to address vulnerabilities in the critical material supply chain for military needs. *FY 2022 Plans:* ? Investigate biotechnology capabilities to determine more rapid, innovative, and diverse applications of biotechnology solutions than is currently realized. Design computational models and computer aided design software to enable virtual tests of biotechnology solutions for defense needs. ? Investigate safety-by-design measures and other biosecurity methods to protect biotechnology capabilities and products from misuse to ensure their safe and effective use in an operational environment.	-	-	20.643

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602386A *I Biotechnology for Materials* *- Applied Research*	**Project (Number/Name)** CP6 *I Foundational Biotechnology Design* *and Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
? Determine a Joint digital architecture to consolidate and secure DoD biotechnology data to promote and streamline information exchange and collaboration toward accelerating the development of innovative applications of biotechnologies for defense needs. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This project is a new start in FY 2022.			
Accomplishments/Planned Programs Subtotals	-	-	20.643

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

D. Acquisition Strategy
 N/A

PE 0602386A: *Biotechnology for Materials - Applied Re...*
Army

UNCLASSIFIED
Page 4 of 4

R-1 Line #23

Volume 1b - 477

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 2: *Applied Research*						**R-1 Program Element (Number/Name)** PE 0602785A *I Manpower/Personnel/Training 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**
Total Program Element	-	20.406	20.399	18.701	-	18.701	-	-	-	-	-	-
790: *Personnel Performance & Training Technology*	-	20.406	20.399	18.701	-	18.701	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) designs and validates applied behavioral and social science research to enhance the Soldier Lifecycle (e.g., selection, assignment, training, and leader development) and human relations (e.g., unit cohesion). This PE develops new personnel measures and methods that more fully assess potential and predict performance, behavior, attitudes, and resilience. These technologies also provide innovative and effective Talent Management methods to optimize individual and team performance to ensure the Army can meet mission requirements in uncertain and complex environments. This PE develops new performance measures and metrics for individuals and units, designs innovative training methods, and conducts scientific assessments to inform Human Capital policy and programs. Research in this PE will result in effective non-materiel solutions to help the Army adjust to changes in force size and structure, a variety of mission demands and contexts, challenges in human relations, and budgetary constraints.

Work in this PE complements PE 0603007A (Manpower, Personnel and Training Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Vision, the Army's Talent Management Strategy, and the Army Modernization Strategy.

Work is performed by the Army Research Institute (ARI) for the Behavioral and Social Sciences at Fort Belvoir, VA.

B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	20.873	20.766	19.039	-	19.039
Current President's Budget	20.406	20.399	18.701	-	18.701
Total Adjustments	-0.467	-0.367	-0.338	-	-0.338
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.467	-0.367			
• Adjustments to Budget Years	-	-	-0.338	-	-0.338

PE 0602785A: *Manpower/Personnel/Training Technology*
Army

UNCLASSIFIED
Page 1 of 4

R-1 Line #24

Volume 1b - 478

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602785A *I Manpower/Personnel/Training Technology*	

Change Summary Explanation

Funding was decrease by $0.683 million due to the Army Artificial Intelligence Task Force (AITF) planned on doing talent management research in 6.2 and 6.3. As part of the EE PEG 2.5 Trade space Assessment, the Army Research Institute (ARI) was used as a bill payer for this talent management work. The funding from the trade space assessment was left in the original APEs with the intention of creating a new task specific to AI in talent management. G-1 does not want any funding for the AITF to be mixed with their APEs. The subject of AITF involvement in talent management beyond basic research will be addressed in POM23.

$0.683 million of FY22-23 will be realigned into Program Element 0603040 (Artificial Intelligence and Machine Learning Advanced Technologies), Project CL1 (AI Enhanced Intel Operations Advanced Technologies).

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602785A I Manpower/Personnel/Train ing Technology					Project (Number/Name) 790 I Personnel Performance & Training 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
790: Personnel Performance & Training Technology	-	20.406	20.399	18.701	-	18.701	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project conducts applied behavioral and social science research to enhance the Soldier Lifecycle (e.g., selection, assignment, training, leader development) and human relations (e.g., unit cohesion). This Project develops new personnel measures and methods that more fully assess potential and predict performance, behavior, attitudes, and resilience. These technologies also provide innovative and effective Talent Management methods to optimize individual and team performance to ensure the Army can meet mission requirements in uncertain and complex environments. This Project develops new performance measures and metrics for individuals and units, designs innovative training methods, and conducts scientific assessments to inform Human Capital policy and programs. Research in this Project will result in effective non-materiel solutions to help the Army adjust to changes in force size and structure, a variety of mission demands and contexts, challenges in human relations, and budgetary constraints.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Vision, the Army People Strategy, the Army's Talent Management Strategy, Army Human Capital Strategy, and the Army Modernization Strategy.

This Project is renamed from Personnel Performance and Training Technology to reflect the change in work that supports Army priorities.

Work is performed by the United States Army Research Institute (ARI) for the Behavioral and Social Sciences in Fort Belvoir, VA.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Talent Assessment and Development	20.406	20.399	18.701
Description: This effort conducts applied research that provides the Army with innovative approaches to personnel assessment, improved prediction and modeling of personnel outcomes (e.g., attrition, retention) and an improved capability to improve prediction and modeling (e.g., potential performance, behaviors, attitudes, and resilience of Soldiers). Conducts applied research to provide the Army with effective leader assessment and development methods to measure, develop, and sustain individual/ leader competencies and performance across the Soldier life cycle. Conducts research to create scientifically valid models, tools and techniques for team assignment and development to optimize team effectiveness in-garrison and future operational environments.			
FY 2021 Plans: Conducting research to develop new proof of concept measures to improve integrated personnel assessments that holistically capture the individual attributes that predict job performance, job satisfaction, resilience, attrition, and continuance; Conducting			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602785A *I Manpower/Personnel/Training Technology*	**Project (Number/Name)** 790 *I Personnel Performance & Training Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
research to develop evidence-based methods to improve assessments of teams-based assignments, leader competencies, collective performance, and team process enablers. *FY 2022 Plans:* Will design assessment materials for computerized adaptive testing applications in the investigation of new proof of concept measures to improve integrated personnel assessments for both Enlisted/Officer Selection and Assignment; will continue to investigate innovative job analytic techniques by determining psychometrically valid talent constructs for the branch assignment process. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funding was partially realigned to Program Element 0603040 (Artificial Intelligence and Machine Learning Advanced Technologies), Project CL1 (AI Enhanced Intel Operations Advanced Technologies) for work in Artificial Intelligence informed Talent Management.			
Accomplishments/Planned Programs Subtotals	20.406	20.399	18.701

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

D. Acquisition Strategy
 N/A

PE 0602785A: *Manpower/Personnel/Training Technology*
Army

UNCLASSIFIED
Page 4 of 4

R-1 Line #24

Volume 1b - 481

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 2: *Applied Research*					**R-1 Program Element (Number/Name)** PE 0602787A *I Medical 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
Total Program Element	-	110.928	101.341	91.720	-	91.720	-	-	-	-	-	-
874: *Cbt Casualty Care Tech*	-	0.834	-	-	-	-	-	-	-	-	-	-
BS7: *Medical Technology (CA)*	-	13.800	7.000	-	-	-	-	-	-	-	-	-
MK4: *Warfigher Health Applied Rsch Technology*	-	37.652	29.726	28.664	-	28.664	-	-	-	-	-	-
MM4: *Cbt Casualty Care Applied Rsch Technology*	-	17.708	19.301	23.437	-	23.437	-	-	-	-	-	-
MM6: *Medical Technologies to Support Dispersed Ops Tech*	-	11.780	14.052	10.724	-	10.724	-	-	-	-	-	-
MM8: *Infectious Diseases and Applied Rsch Technology*	-	21.277	24.542	28.895	-	28.895	-	-	-	-	-	-
MN1: *Applied Sensory Systems Trauma Technology*	-	7.302	6.720	-	-	-	-	-	-	-	-	-
VB4: *System Biology And Network Science Technology*	-	0.575	-	-	-	-	-	-	-	-	-	-

Note
.

A. Mission Description and Budget Item Justification
This Program Element (PE) supports application of knowledge gained through basic research to refine drugs, vaccines, medical devices, diagnostics, medical practices/procedures, and other preventive measures essential to the protection and sustainment of Warfighter health. Research is conducted in six principal areas: Combat Casualty Care, Military Operational Medicine, Military Relevant Infectious Diseases, Clinical and Rehabilitative Medicine, Medical Capabilities to Support Dispersed Operations, and Systems Biology/Network Sciences. Projects are coordinated with the Defense Health Agency.

Project 874: Cbt Casualty Care Tech
Description: Identifies and evaluates drugs, biologics (medical products derived from living organisms), medical devices, and associated clinical practices for field trauma care systems, resuscitation, and life support, with emphasis on provision of prolonged field care when medical evacuation and access to definitive surgical care are delayed. Focus is identification of more effective critical care technologies and clinical practices to treat severe bleeding, traumatic brain injury, burns and other combat related injuries. This Project is coordinated with the Defense Health Agency.

PE 0602787A: *Medical Technology*
Army
UNCLASSIFIED
Page 1 of 40
R-1 Line #25
Volume 1b - 482

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*

Project MK4: Warfighter Health Applied Rsch Technology

Description: Refines knowledge and technologies on screening tools and preventive measures for PTSD, behavioral health problems, and mild traumatic brain injuries, physiological monitors, and interventions to protect Warfighters from injuries resulting from operational stress and exposure to hazardous environments and materials. Also conducts research on medically valid testing devices and predictive models used for the refinement of Warfighter protective equipment.

Project MM4 Cbt Casualty Care Applied Rsch Technology

Description: Identifies and evaluates drugs, biologics (medical products derived from living organisms), medical devices and associated clinical practices for field trauma care, resuscitation, and life support with emphasis on provision of prolonged field care when medical evacuation and access to definitive surgical care is delayed. Focus is identification of more effective critical care technologies and clinical practices to treat severe bleeding, traumatic brain injury, burns and other combat related injuries.

Project MM6: Medical Technologies to Support Dispersed Ops Technology

Description: Medical Robotic and Autonomous Systems (Med-RAS) - Research to develop the ability to deliver emergency resupply of Medical material including repair parts peculiar to medical equipment by ground or air, such as blood products, and, utilization of autonomous platforms to perform medical treatment and medical evacuations in dispersed and multi-domain battle environments.

Project MM8: Infectious Diseases Applied Rsch Technology

Description: Applied research to design and refine drugs, vaccines, and other medical countermeasures against naturally occurring infectious diseases as identified by worldwide medical surveillance and capability needs assessments.

Project MN1: Applied Sensory Systems Trauma Technology

Description: Research to understand the influence of stress on the effectiveness of pain relief drugs (analgesics). This Project conducts laboratory and animal studies for the purpose of developing novel, non-opioid drugs to treat pain in the austere battlefield environment with minimal side effects.

Project VB4: System Biology and Network Science Technology

Description: Includes strategic oversight, direction and management of applied research in integrative systems biology of military relevant conditions, and the Systems Biology Collaboration Center (SBCC). The Sys Bio Cube (a biomedical research data integration and analysis system), managed by the SBCC, provides the ability for multi-site collaborative efforts to integrate, visualize and evaluate complex data using innovative technologies. Post-Traumatic Stress Disorder and coagulopathy (a disorder that impairs the blood's ability to form clots) projects have utilized the systems biology analytical tools and visualization within the Sys Bio Cube to inform the development of prognostic indicators, objective diagnostics, and improved and personalized therapeutic strategies more quickly than non-systems approaches. The SBCC also serves as a US Army Medical Research and Development Command (USAMRDC) resource for data sharing and data management for maximizing the value of all research efforts across the Command.

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

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	

Work in this PE is performed by the United States Army Medical Research and Development Command (USAMRDC), Fort Detrick, MD.

All medical applied research is conducted in compliance with Food and Drug Administration (FDA) or Environmental Protection Agency (EPA) regulations. The FDA requires thorough testing in animals (preclinical testing) to ensure safety and, where possible, effectiveness prior to evaluation in controlled human clinical trials (upon transition to Advanced Technology Development). This PE focuses on research and refinement of technologies such as product formulation and purification and laboratory test refinement with the aim of identifying candidate solutions. This work often involves testing in animal models. The EPA also requires thorough testing of products, such as sterilants, disinfectants, repellents, and insecticides to ensure the environment is adequately protected before these products are licensed for use. Program refinement and execution is externally peer-reviewed and fully coordinated with all Services as well as other agencies through the Joint Technology Coordinating Groups of the Armed Services Biomedical Research Evaluation and Management (ASBREM) Community of Interest (COI). The ASBREM COI, formed under the authority of the Assistant Secretary of Defense for Research and Engineering, serves to facilitate coordination and prevent unnecessary duplication of effort within the Department of Defenses (DoD) biomedical research community, as well as their associated enabling research areas.

B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	112.955	95.496	95.558	-	95.558
Current President's Budget	110.928	101.341	91.720	-	91.720
Total Adjustments	-2.027	5.845	-3.838	-	-3.838
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	7.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.027	-1.155			
• Adjustments to Budget Years	-	-	-3.838	-	-3.838

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Project: BS7: *Medical Technology (CA)*		
Congressional Add: *Military Force Vector Borne Health Protection*	5.000	-
Congressional Add: *Heat Stress on Female Soldiers*	2.000	-
Congressional Add: *Burn Patient Transfer System*	2.000	-
Congressional Add: *Musculoskeletal Injury and Bone and Muscle Adaption for Military Physical Training*	4.800	-
Congressional Add: *Program increase - safety and performance of female warfighters in extreme heat*	-	2.000
Congressional Add: *Program increase - military force vector borne health protection*	-	5.000

UNCLASSIFIED

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 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2020**	**FY 2021**
Congressional Add Subtotals for Project: BS7	13.800	7.000
Congressional Add Totals for all Projects	13.800	7.000

Change Summary Explanation

$7.000 million of FY22 will be realigned to APE 622787MM4 (Cbt Casualty Care Applied Rsch Technology) and $18.200 million of FY22-26 will be realigned to APE 622787MM8 (Infectious Diseases Applied Rsch Technology) from PE 0603002A (Medical Advanced Technology), APE 633002MM9((Tech Base/Enabling Research for Infect Dis Adv Tech)

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 4 of 40

R-1 Line #25

Volume 1b - 485

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 / 2				R-1 Program Element (Number/Name) PE 0602787A / Medical Technology						Project (Number/Name) 874 / Cbt Casualty Care Tech		
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
874: *Cbt Casualty Care Tech*	-	0.834	-	-	-	-	-	-	-	-	-	-

Note

In Fiscal Year 2021 (FY21) this Project is being realigned to:
Program Element (PE) 0602787A Medical Technology
* Project MM4 Cbt Casualty Care Applied Rsch Technology

A. Mission Description and Budget Item Justification

Applied technology development of burn recovery optimization technologies: applied technologies for acute burn treatment that remove dead tissue, prevent infection, and protect the wound from further damage until definitive burn care is available; diagnostic technologies to predict skin graft success or failure, identify patients at heightened risk for scarring, and monitor effectiveness of treatment.

Research conducted in this Project focuses on the following five areas:

(1) Damage Control Resuscitation
(2) Combat Trauma Therapies
(3) Combat Critical Care Engineering
(4) Traumatic Brain Injury (TBI)
(5) Prolonged Field Care

All drugs, biological products, and medical devices are refined in accordance with US Food and Drug Administration (FDA) regulations, which govern testing in animals to assess safety, toxicity, and effectiveness and subsequent human subject clinical trials.

Promising efforts identified in this Project are further matured under PE 0603002A (Medical Advanced Technology) / Project 840 (Combat Injury Mgmt).

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

Work in this Project is performed by the US Army Medical Research and Development Command (USAMRDC), Fort Detrick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Combat Trauma Therapies	0.834	-	-

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 5 of 40

R-1 Line #25

Volume 1b - 486

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** 874 *I Cbt Casualty Care Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort conducts research to enhance the ability to diagnose, stabilize, and accelerate wound healing and repair of damaged tissue for casualties with severe wounds to the face, mouth and extremities.			
Accomplishments/Planned Programs Subtotals	0.834	-	-

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

D. Acquisition Strategy
 N/A

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 6 of 40

R-1 Line #25

Volume 1b - 487

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army											**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*				**Project (Number/Name)** BS7 *I Medical Technology (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**
BS7: *Medical Technology (CA)*	-	13.800	7.000	-	-	-	-	-	-	-	-	-

Note
 Congressional Interest Item funding provided for Medical Technology.

A. Mission Description and Budget Item Justification
 Congressional Interest Item funding provided for Medical 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**
Congressional Add: Military Force Vector Borne Health Protection	5.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Military Force Vector Borne Health Protection. Work executed under the direction of the Army Futures Command.		
Congressional Add: Heat Stress on Female Soldiers	2.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Heat Stress on Female Soldiers. Work executed under the direction of the Army Futures Command.		
Congressional Add: Burn Patient Transfer System	2.000	-
FY 2020 Accomplishments: Program Increase supported applied research on Burn Patient Transfer System. Work executed under the direction of the Army Futures Command.		
Congressional Add: Musculoskeletal Injury and Bone and Muscle Adaption for Military Physical Training	4.800	-
FY 2020 Accomplishments: Program Increase supported applied research on Musculoskeletal Injury and Bone and Muscle Adaption for Military Physical Training. Work executed under the direction of the Army Futures Command.		
Congressional Add: Program increase - safety and performance of female warfighters in extreme heat	-	2.000

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 7 of 40

R-1 Line #25

Volume 1b - 488

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** BS7 *I Medical Technology (CA)*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**
FY 2021 Plans: Program Increase supported applied research on Safety and Performance of Female Warfighters in Extreme Heat. Work executed under the direction of the Army Futures Command.		
Congressional Add: Program increase - military force vector borne health protection *FY 2021 Plans:* Program Increase supported applied research on Military Force Vector Borne Health Protection. Work executed under the direction of the Army Futures Command.	-	5.000
Congressional Adds Subtotals	13.800	7.000

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

D. Acquisition Strategy
 N/A

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 8 of 40

R-1 Line #25

Volume 1b - 489

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 I 2					**R-1 Program Element (Number/Name)** PE 0602787A I *Medical Technology*				**Project (Number/Name)** MK4 I *Warfigher Health Applied Rsch 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**
MK4: *Warfigher Health Applied Rsch Technology*	-	37.652	29.726	28.664	-	28.664	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project conducts research to prevent and protect Warfighters from training and operational injuries; refine mechanisms for detection of physiological (human physical and biochemical function) and psychological (mental) health problems; reduce the effects of trauma and promote rapid recovery from acute stress in far forward operational environments; evaluate hazards to head, neck, spine, eyes, and ears; set the standards for rapid return to duty; and determine new methods to sustain and enhance performance and readiness across the operational spectrum. This research provides medical information important to the design and operational use of military systems, and this work forms the basis for behavioral, training, and nutritional interventions.

The four main areas of study are:
(1) Physiological Health and Performance
(2) Environmental Health and Protection
(3) Injury Prevention and Reduction
(4) Psychological Health and Resilience

This effort is coordinated with and complimentary to work done in PE 0602143A Soldier Lethality Technology and PE 0603118A Soldier Lethality Advanced Technology.

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

Work in this Project is performed by the United States Army Medical Research and Development Command (USAMRDC), Fort Detrick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Physiological Health and Performance	21.488	14.272	-
Description: This effort evaluates methods for managing and controlling the effects of fatigue on Soldier operational performance and the impact of nutritional strategies to optimize operational performance. Efforts will also contribute to new high-priority medical investments in human biomedical performance enhancement and medical aspects of manned-unmanned machine teaming (MUM-T). ***FY 2021 Plans:*** Expeditionary Force Nutrition to Improve Performance ? Evaluate the effects of nutritional energy balance on inflammatory response.			

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MK4 *I Warfigher Health Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
? Refine understanding of the environmental influences on eating behavior, to include extreme environmental influences such as heat, cold and altitude. ? Evaluate the effects of protein source in protein kinetics and muscle growth and strength. Medical Interventions to Reduce Impact of Fatigue on Performance ? Develop a demonstration of the effectiveness of electrical stimulation of the brain for enhancing learning through the consolidation of emotional memories. ? Evaluate the effectiveness of SWS augmentation via AS for enhancing tactical performance and reducing sleepiness during a subsequent period of sustained wakefulness. Biomedical Performance Enhancement ? Evaluate drug-delivered testosterone for maintenance of physiological and psychological performance under conditions of medically relevant hypogonadism (a failure of the gonads, testes in men and ovaries in women, to function properly) induced by high operational tempo military activity. ? Provide medical and Soldier integration criteria for single-joint exoskeleton to enhance Soldier physical performance in military operations. ? Evaluate pharmacological strategies for improving Soldier endurance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project MK4 (Biomedical Performance Enhancement, Expeditionary Force Nutrition to Improve Performance, and Medical Interventions to Reduce Impact of Fatigue on Performance).			
Title: Environmental Health and Protection ***Description:*** This effort involves applied research addressing the 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 Soldier performance in austere environments. This effort also supports and matures non-invasive technologies, decision-aid tools, and models to enhance Soldier protection and sustainment across the operational spectrum. This effort provides the scientific basis for developing focused heating and cooling solutions to maintain fine motor dexterity, core temperature, and optimize physical and cognitive performance during cold- weather and hot-humid operations. This effort will develop knowledge and materiel solutions that enable Soldier individualized metabolic assessments and optimization during training and operations. ***FY 2021 Plans:*** Operational Risk Planning Tools for Battlefield Environmental Threats	5.688	7.431	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602787A / *Medical Technology*	Project (Number/Name) MK4 / *Warfigher Health Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
? Predict, protect, and enhance performance of the Soldier operating in dense urban and subterranean environments, with a focus on respiratory threats, mental and physical performance, and survivability. ? Develop studies exposing zebrafish to low oxygen conditions, altered temperatures, and psychological stressors (e.g., predator exposure) to evaluate the potential effectiveness of pharmaceutical interventions to optimize performance. ? Develop an immersive screening task that, in combination with select measures, will be utilized as screening tool for predicting individuals likely to experience impairment. ? Develop tools to assess medical effects for using personal protective equipment in dense urban and subterranean environments to prevent degraded physical and cognitive performance. Prevention of Soldier Performance Degradation in Extreme Environments ? Evaluate human performance in heat, cold and altitude studies which provide physiological monitoring data for algorithms for an integrated Soldier sensor system to sustain lethality, optimize performance, and improve health and readiness. ? Evaluate strategies to improve Soldier health, readiness and mission performance through interventions designed to prevent injuries that result from multi-environmental stressors. ? Evaluate interventions to reduce environmental injuries in the heat and cold weather operations. ? Refine and develop tools that sustain lethality, improve health, and optimize performance to reduce injuries following exposures to heat, cold, terrestrial altitude for squad leaders and mission planners. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project MK4 (Operational Risk Planning Tools for Battlefield Environmental Threats and Prevention of Soldier Performance Degradation in Extreme Environments).			
Title: Injury Prevention and Reduction ***Description:*** This effort addresses the Army's number one priority of readiness by improving musculoskeletal injury prevention efforts as well as contributing to preparing Soldiers for potential threats (e.g., directed energy) in and developing capabilities for the multi domain operations environment. It evaluates and assesses the effects of repetitive motion during military operations and training on the human body; provides mathematical models to predict the likelihood of physical injuries following continuous operations and muscle fatigue; evaluates current standards for return-to-duty; and establishes improved medical test methods with the goal of rapid return to duty of Soldiers following injury. This effort also develops prevention-based strategies and medically-based injury criteria for hearing, vestibular (sensory system supporting movement and sense of balance, located in the inner ear), and ocular/facial protection devices; develops and evaluates neurosensory operational risk factors; develops medically based guidelines to assess neurosensory performance and models the effects of acoustic and impact trauma as stressors on vision and hearing. Efforts will investigate the medical aspects of manned unmanned teaming (MUM-T) and medical aspects of and protection against directed energy.	6.556	4.379	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602787A / *Medical Technology*	**Project (Number/Name)** MK4 / *Warfigher Health Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2021 Plans: Physical Fitness Standards to Prevent Musculoskeletal Injuries ? Administer field expedient physical performance tests (PPTs) known to be predictive of performance of common Soldier tasks to Soldiers following lower extremity musculoskeletal injuries. ? Compare PPT data to known reference values to assess readiness for return to duty (RTD). ? Use data to assess the prognostic accuracy of PPTs in determining Soldier progression from initial injury to readiness for RTD. Leader Tools to Reduce Musculoskeletal Injury in all Settings ? Establish and publish modifiable and non-modifiable factors that impart resilience or contribute to risk for stress fracture and other musculoskeletal injury development during Basic Combat Training (BCT). Leader Decision Aids to Manage Blast Head Injury in All Settings ? Determine an objective blood-based biomarker of cognitive status from field studies of blast overpressure and head impact exposures in various heavy weapons military training environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project MK4 (Physical Fitness Standards to Prevent Musculoskeletal Injuries, Leader Tools to Reduce Musculoskeletal Injury in all Settings and Leader Decision Aids to Manage Blast Head Injury in All Settings).			
Title: Psychological Health and Resilience ***Description:*** This effort refines and evaluates tools and early interventions to prevent and reduce the impact of military stressors and combat-related exposures on behavioral health problems, including symptoms of post-traumatic stress disorder (PTSD), depression, anger problems, anxiety, substance abuse, suicide, and other health risk behaviors. This effort assesses and refines tools and interventions to enhance and sustain psychological resilience throughout Soldiers' careers. Efforts also address the health and well-being of families. ***FY 2021 Plans:*** Optimal Delivery of Far Forward Psychological Health Care ? Develop content and products to deliver behavioral health services oriented to far forward operational settings for the promotion of rapid recovery from acute stress and other behavioral health issues. ? Develop readiness tools and recommendations to assist in behavioral health readiness decisions made by unit leaders and medics. ? Develop clinical practice guidelines medics will follow to address the core behavioral health problems encountered in far-forward settings.	3.920	3.644	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602787A I *Medical Technology*	Project (Number/Name) MK4 I *Warfigher Health Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
? Develop neurocognitive optimization and enhancement tools to mitigate health and performance decrements during and following stress exposure (i.e., point of psychological injury). Unit-Level Psychological Interventions to Enhance Performance ? Develop and evaluate next-generation bystander intervention training to increase unit member response to high-risk behaviors. ? Determine how transition points place Soldiers at risk. ? Conduct assessment of Security Forces Assistance Brigades. ? Develop a method for assessing military-relevant moral injury concerns. ? Establish components for enhancing behavioral health leadership skills and develop new training. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other priorities within Project MK4 (Tasks Optimal Delivery of Far Forward Psychological Health Care and Unit-Level Psychological Interventions to Enhance Performance).			
Title: Operational Risk Planning Tools for Battlefield Environmental Threats ***Description:*** This effort investigates and incorporates mechanisms for health risks of heat, cold, and altitude injuries to develop guidelines and advise countermeasure development for operations in extreme environments. Investigates health risks from industrial chemicals and pollutants found in dense urban and subterranean (SubT) environments in which Soldiers operate. ***FY 2022 Plans:*** Will develop risk profiles for exposures in extreme environments including cold water; develop and validate models for high-throughput screening for novel or repurposed drugs to counter performance decrements encountered in SubT operational environments; validate heat injury biomarkers to inform return to duty guidance. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MK4 (Environmental Health & Protection).	-	-	2.282
Title: Prevention of Soldier Performance Degradation in Extreme Environments ***Description:*** This effort develops and matures non-invasive technologies, decision-aid tools, and other countermeasure to prevent and enhance Soldier performance in extreme environments of heat, cold, altitude, dense urban and subterranean (SubT) environments. This effort includes validation of approved pharmaceuticals as well as provides improved sensors and predictive algorithms models. ***FY 2022 Plans:*** Will validate performance of pharmaceuticals to reduce acute mountain sickness, heat injuries and other environmental exposures; assess the feasibility of dietary supplements as a mitigation for increased carbon dioxide blood levels and potential	-	-	4.198

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602787A / Medical Technology	Project (Number/Name) MK4 / Warfigher Health Applied Rsch Technology

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
respiratory failure recurrent in SubT environments; evaluate cold habituation as an intervention to augment peripheral blood flow in cold exposure; investigate models for the effect of wet clothing on heat loss; determine advanced decision aids for pacing and load carriage optimization; design physiological modes to predict human state during complex military scenarios; develop and/or assess various countermeasures for improved performance in extreme environments.			
FY 2021 to FY 2022 Increase/Decrease Statement: Funds realigned from other efforts within Project MK4 (Environmental Health & Protection).			
Title: Leader Decision Aid to Manage Blast Head Injury in All Settings	-	-	0.255
Description: Develop injury risk assessment/guidance/criteria that will inform the development of technologies (i.e., personal protection equipment, vehicles) and strategies (i.e., health hazard assessments) to protect the Soldier against current and emerging operational threats (i.e., blast, blunt, ballistic, and accelerative). Improve the prevention of and reduce the severity of spinal injuries experienced by military vehicle occupants and dismounted Warfighters during non-underbody blast operational exposures (aircrew crash, vibration, head-supported mass) through the development of improved, biomedically valid spinal injury criteria and health hazard assessments. **FY 2022 Plans:** Will conduct experiments to build upon performance based weight limit criteria for loads added to the head (head protection systems, night vision goggles) to include acute injury based criteria for mounted and dismounted environments. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funds realigned from other efforts within Project MK4 (Injury Prevention & Reduction).			
Title: Physical Fitness Standards to Prevent Musculoskeletal Injuries	-	-	1.625
Description: Develops validated standards and strategies to optimize Soldier readiness and performance related to musculoskeletal injury (MSKI) in order to provide military leadership with strategies and standards to mitigate musculoskeletal injuries, facilitate quick return to combat effectiveness after MSKI, and decrease risk of re-injury once been cleared to return after injury to increase the probability of mission success. **FY 2022 Plans:** Will quantify relative contributions of modifiable and non-modifiable risk factors for MSKI; examine relationship between Holistic Health and Fitness (H2F) metrics and Soldier fitness and operational readiness to inform updates to H2F program; determine incidence of degraded performance metrics in combat units with and without embedded specialty providers and develop strategies to enhance performance and reduce injury and re-injury rates. **FY 2021 to FY 2022 Increase/Decrease Statement:**			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602787A / *Medical Technology*	**Project (Number/Name)** MK4 / *Warfigher Health Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Funds realigned from other efforts within Project MK4 (Injury Prevention & Reduction).			
Title: Leader Tools to Reduce Musculoskeletal Injury In All Settings **Description:** Enhances the Army's understanding of the physiological mechanisms underlying musculoskeletal injuries and identifies countermeasures to mitigate injury risk in order to reduce musculoskeletal injuries in new recruits, thereby directly impacting force readiness and improving lethality. **FY 2022 Plans:** Will define factors that contribute to risk for stress fracture and other MSKI development during Basic Combat Training (BCT); develop evidence-based, actionable recommendations to Army leadership (TRADOC-Center for Initial Military Training) to reduce MSKI in recruits without reducing training standards; determine trends/rates of negative health outcomes incurred by Soldiers to include risk and protective factors. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funds realigned from other efforts within Project MK4 (Injury Prevention & Reduction).	-	-	3.626
Title: Forward Neuro-Muscular Skeletal Injury Assessment **Description:** Focus on developing portable imaging technologies to identify soft tissue musculoskeletal injury severity in the field and generate capabilities to guide musculoskeletal injury management to inform appropriate evacuation vs. return to duty (RTD) decisions. **FY 2022 Plans:** Design and conduct experiments for an ultrasound-based bone injury screening device and investigate its translation to a soft tissue imaging based capability for diagnosing and screening of musculoskeletal injury. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funds realigned from other efforts in Project MN1 (Forward Neuro-Muscular Skeletal Injury Assessment).	-	-	0.391
Title: Biomedical Performance Enhancement **Description:** This effort evaluates strategies and technologies that enhance Soldier physical and mental performance in Multi-Domain operations. Additional efforts concentrate on characterization of physiological and genetic factors that contribute to physiological resilience to military stressors. **FY 2022 Plans:** Will complete evaluation of drug-delivered testosterone for maintenance of physiological and psychological performance under conditions of medically relevant hypogonadism (a failure of the gonads, testes in men and ovaries in women, to function properly)	-	-	6.511

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			**Date:** May 2021		
Appropriation/Budget Activity 2040 I 2		**R-1 Program Element (Number/Name)** PE 0602787A I *Medical Technology*	**Project (Number/Name)** MK4 I *Warfigher Health Applied Rsch Technology*		

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
induced by high operational tempo military activity; investigate pharmacological strategies for improving Soldier vigilance & endurance; refine electrical stimulation technologies to augment military performance and mitigate high OPTEMPO performance degradation. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Fund realigned from other efforts within Project MK4 (Physiological Health and Performance).			
Title: Expeditionary Force Nutrition to Improve Performance ***Description:*** Characterizes and refines field fueling and garrison practices to sustain Medical readiness, military performance and recovery from military operations. Evaluates combat ration components to sustain Medical Readiness and performance in deployed, disaggregated and dispersed operations. ***FY 2022 Plans:*** Will conduct experiments to improve understanding of environmental influences (heat, cold, altitude) on eating behavior; investigate the effects of protein source on muscle mass growth, strength and maintenance; evaluate nutritional requirements for maintenance of cognitive, physical and immune function during arduous military training. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MK4 (Physiological Health and Performance).	-	-	1.793
Title: Medical Interventions to Reduce Impact of Fatigue on Performance ***Description:*** Investigates and determines strategies and technologies that prevent or mitigate fatigue-related performance decrements and injuries during training and operations. Refines interventions that prevent or mitigate clinical sleep disorders in Soldiers. Evaluates technologies to non-intrusively & non-invasively monitor vigilance and performance in real-time. ***FY 2022 Plans:*** Will determine the effectiveness of electrical stimulation of the brain for enhancing learning through the consolidation of emotional memories; investigate the effectiveness of slow-wave sleep augmentation via auditory and electrical stimulation for enhancing tactical performance and reducing sleepiness during a subsequent period of sustained wakefulness. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MK4 (Physiological Health and Performance).	-	-	2.349
Title: Optimal Delivery of Far Forward Behavioral Health Care ***Description:*** This effort will develop a Far Forward Behavioral Health (BH) delivery system of care for rapid recovery in austere environments, and guidelines for use of pharmacologic and non-pharmacologic solutions for BH issues in MDO without dedicated	-	-	2.752

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602787A I *Medical Technology*	**Project (Number/Name)** MK4 I *Warfigher Health Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
BH assets, tailored to needs and training of medics, that will reduce the development of deployment-related psychological health issues. *FY 2022 Plans:* Will investigate pharmacotherapies in preclinical models for their efficacy in speeding recovery and restoring behavioral and physiological function after traumatic stress, to inform clinical trials in humans; design guidelines for medics to use existing Role 1 pharmacologic solutions to prevent and reduce the development of behavioral health issues in Soldiers; investigate the safety and efficacy of pharmacologic candidate compounds to speed recovery after traumatic stress exposure, to be tested in humans; investigate delivery of far-forward, non-pharmacological behavioral health services intervention package, and report on feasibility and effectiveness; determine a neurocognitive optimization, sustainment and recovery platform that mitigates responses to and expedites recovery from stress/trauma at or near point of psychological injury (Role 1); determine a blood-based biomarker screening panel to characterize objective signatures of Acute Stress Disorder that indicate risk of unresolved symptoms. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned from other efforts within Project MK4 (Psychological Health & Resilience).			
Title: Unit-Level Psychological Interventions to Enhance Performance *Description:* This effort will deliver evidence-based strategies and inform policies to optimize, enhance and sustain Service member and Unit psychological health, well-being, resilience and readiness. *FY 2022 Plans:* Determine recommendations for leaders to address behavioral health threats and profiles identified by the rapid feedback mechanism; design and investigate measures of morally-challenging combat events, moral reactions, and moral leadership; design and conduct experiments on a framework that assists in identifying profiles of cognition and behavior to assist in matching individuals to appropriate resilience interventions; design and investigate candidate tools to improve small-team culture, performance and resilience; determine neurocognitive mechanisms of performance, particularly under high stress conditions. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned from other efforts within Project MK4 (Psychological Health & Resilience).	-	-	2.882
Accomplishments/Planned Programs Subtotals	37.652	29.726	28.664

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

PE 0602787A: *Medical Technology*
Army
UNCLASSIFIED
Page 17 of 40
R-1 Line #25
Volume 1b - 498

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MK4 *I Warfigher Health Applied Rsch Technology*

D. Acquisition Strategy
 N/A

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 18 of 40

R-1 Line #25

Volume 1b - 499

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

Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602787A I *Medical Technology*	**Project (Number/Name)** MM4 I *Cbt Casualty Care Applied Rsch 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**
MM4: *Cbt Casualty Care Applied Rsch Technology*	-	17.708	19.301	23.437	-	23.437	-	-	-	-	-	-

Note
In FY 2022 funding for this Project was realigned from:

PE 0602148A (Future Vertical Lift Technology)
*Project BZ7 (Future Vertical Lift Medical Technologies)

PE 0602787A (Medical Technology)
*Project MM6 (Medical Technologies to Support Dispersed Ops Tech)
*Project MK4 (Warfigher Health Applied Rsch Technology)

PE 0603002A (Medical Advanced Technology)
*Project MN3 (Immediate Cardiopulmonary Stabilization Adv Tech)
*Project MO2 (Traumatic Brain Injury (TBI) Treatment Adv Tech)
*Project MO4 (Burn Recovery Optimization Advanced Technology)

A. Mission Description and Budget Item Justification
This Project refines and assesses concepts, techniques, and materiel that improve survivability and treatment outcomes for Warfighters wounded during combat operations and treated under austere field conditions, including prolonged field care, and during medical evacuation, and maintains laboratory capability to perform these functions. Combat casualty care research addresses control of severe bleeding; resuscitation and stabilization; advanced automated life support systems suitable for use in forward areas, treatment of severe orthopedic injuries, treatment of severe burns, and combat-related brain injury.

Promising efforts identified in this Project are further matured under PE 0603002A (Medical Advanced Technology).

The cited work is consistent with the Under 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 Medical Research and Development Command (USAMRDC), Fort Detrick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Damage Control Resuscitation	4.216	-	-

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 19 of 40

R-1 Line #25

Volume 1b - 500

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602787A I *Medical Technology*	**Project (Number/Name)** MM4 I *Cbt Casualty Care Applied Rsch Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: This effort develops and refines knowledge products (such as clinical practice guidelines, manuals, protocols, studies, and media), materials, and systems for control of internal bleeding; minimizing the effects of traumatic blood loss; preserving, storing, and transporting blood and blood products; and resuscitation following trauma.			
Title: Combat Trauma Therapies *Description:* This effort conducts research to enhance the ability to diagnose, stabilize, and accelerate wound healing and repair of damaged tissue for casualties with severe burn, facial or extremity wounds.	4.125	-	-
Title: Pre-Hospital Tactical Combat Casualty Care *Description:* This effort refines diagnostic and therapeutic medical devices, drugs, and new clinical practices for resuscitation, stabilization, and preservation of vital organ function that can be applied by combat medical personnel in the pre-hospital combat setting.	0.864	-	-
Title: Traumatic Brain Injury (TBI) *Description:* This effort supports refinement of drug (includes mature drug technologies and those that are Food and Drug Administration [FDA] approved for other indications) and therapeutic (i.e., novel use of stem cells or selective brain cooling) strategies to manage TBI resulting from battlefield trauma.	1.622	-	-
Title: Prolonged Care *Description:* This effort performs applied research to study the physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties. *FY 2021 Plans:* Battlefield sustainment of critical organ function cap set 1 ? Perform large animal studies of stem cell products to treat acute respiratory distress syndrome. Future en Route Casualty Care Sustainment System Cap Set ? Assess biological effects and safety of new extracorporeal life support technologies (medical devices situated external to the body that provide prolonged organ support in casualties whose vital organs are, due to illness or injury, unable to sustain life). Modular and Automated Battlefield Sustainment of Critical Organ Function Cap Set 2 ? Develop sepsis prediction and prolonged field care decision support system.	6.881	7.299	-

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM4 *I Cbt Casualty Care Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Limb Function Repair and Return to Combat Duty ? Evaluate technologies to preserve injured limb tissues and function under prolonged field care conditions. Field Stabilization of Preparation of Evac ? Evaluate drug and biological compounds to improve extremity wound healing. ? Begin evaluation of litter carriage performance and post-carry fatigue effects in prolonged field care environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other priorities within Project MM4 (Candidate Capabilities for Battlefield Sustainment of Critical Organ Function, Modular and Automated Battlefield Sustainment of Critical Organ Function Cap Set 2, Future En Route Casualty Care Sustainment System Cap Set).			
Title: Blood and Blood Products ***Description:*** This effort develops and refines knowledge products (such as clinical practice guidelines, manuals, protocols, studies, and media), materials, and systems for control of internal bleeding and mitigation of shock; minimizing the effects of traumatic blood loss; preserving, storing, and transporting blood and blood products. ***FY 2021 Plans:*** Synthetic Blood Replacement ($0.987M) ? Study use of whole blood as treatment for acute traumatic coagulopathy (blood clotting disorder). Next Generation Human-Derived Blood Replacement ($3.949M) ? Identify new efficacious preservative solutions for platelets and whole blood. ? Begin study of cellular therapies for treatment of acute radiation sickness combined with traumatic injury. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project MM4 (Next Generation Human-Derived Blood Replacement, Bioengineered Blood Surrogate).	-	4.906	-
Title: Severe Burns ***Description:*** This effort conducts research to enhance the ability to treat acute severe burns at or near the point of injury; protect burn wounds from further injury, infection and inflammation, especially when definitive surgical burn wound care is delayed or unavailable; and accelerate wound healing and return to combat duty. ***FY 2021 Plans:*** Rapid Burn Injury Treatment and Return to Duty Cap Set 1 ($2.272M)	-	2.822	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021		
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM4 *I Cbt Casualty Care Applied Rsch Technology*		

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
? Assess novel technologies to prevent burn progression in casualties treated in far forward environments. ? Develop new severe burn animal models in which to assess new burn treatments along with technologies that quantify burn wound healing rate and measure effectiveness of treatment. Next Generation Rapid Burn Injury Treatment and Return to Duty Cap Set 2 ($0.568M) ? Develop new treatment approaches to protect burn wounds, prevent infection and inflammation, accelerate healing and restore function. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project MM4 (Candidate Capabilities for Rapid Burn Treatment, Next Generation Rapid Burn Injury Treatment and Return to Duty Cap Set 2).			
Title: Tactical Combat Casualty Care *Description:* This effort refines diagnostic and therapeutic medical devices, drugs, and new clinical practices for hemorrhage control, resuscitation, stabilization, and preservation of vital organ function that can be immediately applied by combat medical personnel in the pre-hospital combat setting. *FY 2021 Plans:* Advanced Tactical Combat Casualty Stabilization System Cap Set 2 ($0.423M) ? Examine therapeutic approaches to preserving kidney function following crush injuries. Tactical Combat Casualty Stabilization System Cap Set 1 ($1.690M) ? Evaluate catheter-based techniques to control non-compressible hemorrhage. ? Characterize new animal pain models. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project MM4 (Tactical Combat Casualty Care Candidate Pharmaceuticals and Devices, Autonomous Cardiopulmonary Resuscitation).	-	2.099	-
Title: Brain Trauma *Description:* This effort supports refinement of drug (includes mature drug technologies and those that are FDA approved for other indications) and therapeutic strategies to manage brain injury resulting from battlefield trauma. *FY 2021 Plans:* Drugs to Prevent and Treat Brain Injury ($1.751M) ? Perform applied research on nanoparticles to evaluate their use as a drug delivery vehicle.	-	2.175	-

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 22 of 40

R-1 Line #25

| Volume 1b - 503 |

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM4 *I Cbt Casualty Care Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
? Study therapies that enhance inherent brain healing abilities. ? Evaluate nicotine as a potential neuroprotective drug. Advanced Medic Brain Injury Diagnostic and Treatment System ($0.438M) ? Study correlative relationships between brain injury-induced non-convulsive seizures, brain injury-specific biomarkers, and clinical outcomes. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project MM4 (Prevention and Treatment of Brain Injury, Automated Management of TBI & Concussion in Prolonged MDO (Multi-Domain Operations)).			
Title: Modular and Automated Battlefield Sustainment of Critical Organ Function Cap Set 2 **Description:** This effort performs applied research to support development of novel, disruptive technologies to improve survival of the most severely injured casualties when medical evacuation is delayed and access to definitive surgical care is limited. *FY 2022 Plans:* Will conduct experiments on technologies designed to mitigate detrimental effects that would otherwise occur in critically wounded casualties receiving prolonged care in forward operating areas when medical evacuation is either delayed or not possible, or definitive surgical care is unavailable; design tools that will enable medics to continuously monitor vital organ function in severely injured casualties, who for tactical reasons must be provided prolonged critical care in forward operating areas pending availability of medical evacuation and/or definitive surgical care; investigate the effects of reducing inflammation on vital organ function following severe injury; initiate investigation of drugs and other medical products that will protect blood deprived tissues from further damage after blood flow is restored. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned from other efforts within Project MM4 (Prolonged Care, Modular and Automated Battlefield Sustainment of Critical Organ Function Cap Set 2).	-	-	1.257
Title: Battlefield Pain Control without Physiological Impairment **Description:** This effort performs applied research in laboratory and animal studies to determine novel, non-opioid drugs to treat pain in the austere battlefield environment with minimal side effects. *FY 2022 Plans:*	-	-	2.351

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM4 *I Cbt Casualty Care Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will conduct preclinical evaluation of promising non-opioid, side effect-free pain relieving drugs that act on non-opiod targets in the nervous system to inhibit pain signaling without affecting cognitive ability in treating post-traumatic, moderate-to severe pain in order for the wounded casualty to be able to remain in the fight. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts in Project MN1 (Battlefield Pain Control without Physiological Impairment).			
Title: Candidate Capabilities for Rapid Burn Treatment ***Description:*** This effort conducts research to enhance the ability to treat acute severe burns at or near the point of injury, protect burn wounds from further injury, infection and inflammation, especially when definitive surgical burn wound care is delayed or unavailable, and accelerate wound healing and return to combat duty. ***FY 2022 Plans:*** Will conduct experiments to evaluate new technologies and clinical practices for improving treatment of acute burns at the point of injury with aim to accelerate wound healing, reduce complications, and increase rate of return to duty; determine a dual treatment targeting both ischemia (poor blood & oxygen supply) and inflammation to prevent burn progression on the battlefield using a large animal model; investigate the effect of enzymatic debridement (removal of damaged tissue) on wound healing of full thickness burns in a preclinical pig large animal model; evaluate extracellular vesicle (particles that are naturally released from a cell)-releasing plasma-alginate wound dressing to reduce inflammation and improve healing of acute wounds; investigate optimal off-the-shelf therapies to accelerate wound healing in a large, 20% total body surface area, and deep partial thickness burn wound model. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Severe Burns).	-	-	1.695
Title: Autonomous Cardiopulmonary Resuscitation ***Description:*** Currently, definitive surgical repair is required to stop non-compressible bleeding (bleeding that cannot be stopped with application of direct pressure or tourniquet) in the chest or abdomen. This effort investigates new technologies addressing major causes of battlefield mortality, including non-compressible hemorrhage, safe mitigation of hemorrhagic shock, and airway obstruction and ventilation. ***FY 2022 Plans:***	-	-	0.528

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 24 of 40

R-1 Line #25

Volume 1b - 505

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602787A I *Medical Technology*	**Project (Number/Name)** MM4 I *Cbt Casualty Care Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will investigate new technologies that may be deployed by medics in the far-forward, prehospital environment to temporarily stop lethal non-compressible bleeding until definitive surgical repair is available; will design and determine efficacy and safety of emerging foams that stop bleeding in animal models of non-compressible truncal hemorrhage. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Tactical Combat Casualty Care).			
Title: Unconventionally-acquired Brain Injury (UBI) ***Description:*** This effort performs applied research aimed at determining the physiological effects of unconventionally-acquired threat technologies to support development of future diagnostic and treatment tools. ***FY 2022 Plans:*** Will determine and investigate treatment for unconventionally-acquired brain injury threat technologies; conduct Unconventionally-acquired Brain Injury human-like animal experiments; validate Unconventional-acquired Brain Injury threat source symptomology and determine injury mechanisms; validate understanding of injury mechanisms to enable direct medical diagnosis, treatment and clinical management. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds reprogrammed from Project MN1 (Battlefield Pain Control without Physiological Impairment).	-	-	8.897
Title: Automated Management of TBI & Concussion in Prolonged MDO ***Description:*** This effort performs applied research to support development of therapies to treat and clinically manage brain injury under prolonged care conditions. ***FY 2022 Plans:*** Will investigate efficacy of an immunomodulation agent (stimulates or suppresses the immune system) to mitigate both intracerebral bleeding (bleeding within the brain tissue), as well as neurological, motor impairment and cognitive deficits following TBI. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Brain Trauma).	-	-	1.266
Title: Prevention and Treatment of Brain Injury ***Description:*** This effort supports refinement of drug (includes mature drug technologies and those that are FDA approved for other indications) and therapeutic strategies to manage brain injury resulting from battlefield trauma. ***FY 2022 Plans:***	-	-	1.497

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021	
Appropriation/Budget Activity 2040 I 2	**R-1 Program Element (Number/Name)** PE 0602787A I *Medical Technology*	**Project (Number/Name)** MM4 I *Cbt Casualty Care Applied Rsch Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Will determine the efficacy of a novel anti-oxidant and anti-inflammatory peptide, currently undergoing FDA evaluation, against blast-induced TBI, and will perform dosing studies to determine the optimum effective dose. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Brain Trauma).			
Title: Next Generation Rapid Burn Injury Treatment and Return to Duty Cap Set 2 ***Description:*** This effort conducts research to support development of novel, disruptive technologies that will significantly enhance the ability to treat acute severe burns at or near the point of injury, protect burn wounds from further injury, infection and inflammation, especially when definitive surgical burn wound care is delayed or unavailable, and accelerate wound healing and return to combat duty. ***FY 2022 Plans:*** Will determine effectiveness of a thin film containing antimicrobial and anti-inflammatory drugs applied to deep partial thickness- and full thickness-burn wounds early after injury to reduce bacterial burden, inflammation, and injury progression. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Severe Burns).	-	-	0.726
Title: Bioengineered Blood Surrogate ***Description:*** This effort performs applied research focused on development of modified whole blood or blood products, and synthetic blood products that will stop life threatening bleeding, stabilize tissue metabolism, mitigate shock and restore normal blood clotting, and will improve prompt hemorrhage control and minimize sustainment requirements. ***FY 2022 Plans:*** Will comparatively investigate ability of promising cold-stored whole blood additives to extend shelf life and maintain normal blood function. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Blood and Blood Products).	-	-	0.361
Title: Next Generation Human-Derived Blood Replacement ***Description:*** This effort performs applied research focused on development of improved blood products and biopharmaceutical technologies that stop life threatening bleeding, stabilize tissue metabolism, mitigate shock and restore normal blood clotting, and will improve prompt hemorrhage control and minimize sustainment requirements. ***FY 2022 Plans:***	-	-	0.772

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM4 *I Cbt Casualty Care Applied Rsch Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will investigate single drugs and multiple drugs in combination to determine their efficacy in prolonging survival and improving outcomes in animal models of hemorrhagic shock. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Blood and Blood Products).			
Title: Future En Route Casualty Care Sustainment System Cap Set *Description:* This effort performs applied research to support development of technologies that will increase capability and capacity to provide combat casualty care from point of injury to final point of care. ***FY 2022 Plans:*** Will determine and validate a post mortem human subject model for use in patient in transport research- all use of post-mortem human subjects will be done in an ethical and respectful manner in accordance with the 05-November-2019 Army Policy for Use of Human Cadavers for RDTE, Education and Training. Will conduct engineering evaluation of the Interim Medevac Mission Support System to support future studies aimed at improving patient and medical attendant survivability in potentially survivable mishaps. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Prolonged Care).	-	-	1.843
Title: Candidate Capabilities for Field Stabilization of Bone in Preparation for Evacuation *Description:* This effort focuses on multiple disruptive technologies for early treatment of extremity fractures to accelerate healing and mitigate complications, while maintaining soldier mobility. ***FY 2022 Plans:*** Will investigate pharmaceuticals and biologics that reduce cellular metabolism in injured limbs and protects injured tissues from the effects of prolonged lack of blood and oxygen followed by period of blood and oxygen re-supply. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Prolonged Care).	-	-	0.542
Title: Candidate Capabilities for Limb Function Repair and Return to Combat Duty *Description:* This effort focuses on multiple disruptive technologies directed toward early treatment of extremity fractures to accelerate healing and mitigate complications and includes compartment syndrome (Increased pressure within a closed body space, especially of the leg or forearm. May require surgery and loss tissue or extremity). ***FY 2022 Plans:***	-	-	0.596

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 27 of 40

R-1 Line #25

Volume 1b - 508

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM4 *I Cbt Casualty Care Applied Rsch Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Will determine efficacy of two drugs in preserving skeletal muscle function following extended tourniquet application. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Prolonged Care).			
Title: Candidate Capabilities for Battlefield Sustainment of Critical Organ Function ***Description:*** This effort performs applied research to study the physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties. ***FY 2022 Plans:*** Will investigate field-deployable pharmacological treatments using a previously developed combat-relevant small animal model that reliably produces acute kidney injury; investigate drugs that increase renal oxygen delivery and improve energy utilization; determine the efficacy of targeting key immunomodulatory (affecting the immune system) players on progression of smoke inhalation injury in a small animal lung injury model. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM4 (Prolonged Care).	-	-	1.106
Accomplishments/Planned Programs Subtotals	17.708	19.301	23.437

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

D. Acquisition Strategy
 N/A

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 28 of 40

R-1 Line #25

Volume 1b - 509

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040 *I* 2					**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*				**Project (Number/Name)** MM6 *I Medical Technologies to Support Dispersed Ops Tech*			

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
MM6: *Medical Technologies to Support Dispersed Ops Tech*	-	11.780	14.052	10.724	-	10.724	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project supports applied research in two task areas: 1) Medical Robotic and Autonomous Systems (Med-RAS) - will a) leverage emerging technologies in biomedical engineering, robotics, autonomy, unmanned systems, and assured position navigation and timing, to improve capabilities and expand capacity to deliver prolonged care, perform evacuation, delivery emergency resupply of CLVIII, such as blood products, by ground or air, in dispersed and Multi-Domain Operations and b) establish medical performance criteria to ensure Soldiers are able to effectively perform manned-unmanned teaming tasks; and, 2) Virtual Health - will leverage emerging technologies in information science, artificial intelligence, telecommunications network engineering, and cyber security to enable prolonged care, remote telemonitoring, automated decision support, and telementoring between providers in Role of Care 3 and 4 to patients in Role of Care 1 and 2. Promising work in this Project will be further matured in PE 0603002A (Medical Advanced Technology) / Project MM7 (Enabling Med Cap to Support Dispersed OPS Adv Tech).

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 Medical Research and Development Command (USAMRDC), Fort Detrick, MD.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2020	FY 2021	FY 2022
Title: Medical Robotic and Autonomous Systems (Med-RAS)	7.886	9.726	7.377

Description: Research, design, and validate autonomous and unmanned capabilities to deliver high quality combat casualty care in dispersed operations with limited or absent medical care personnel, and future medical robotic systems capable of providing autonomous combat casualty care while optimizing the medical logistic footprint in far-forward and dispersed geographic environments in support of the Army Multi-Domain Operations concept and the Army Force 2025 and Beyond vision documents.

FY 2021 Plans:
Medical Robotic and Autonomous Systems (Med-RAS)
? Design medical robotic systems, including physical interfaces and hardware configurations, for procedures driven by AI and Machine Learning (ML) by: 1) refining polytrauma protocols for animals, 2) conducting human stress testing in a Lower Body Negative Pressure (LBNP) chamber, and 3) performing lab testing of ?soft? robotic noninvasive sensing, force feedback control, needle insertion, patient immobilization, and airway access and insertion.
? Expand methods for integrating medical systems with unmanned aerial system (UAS) platforms that address patient transport safety concerns, reliability of medical systems in flight, and low-bandwidth and cyber-secure transmission of medical data by 1) testing the patient simulator system on board a unmanned aerial vehicle (UAV) research platform and 2) prototyping and flight testing various communication architectures for closed-loop and tele-operated patient support systems.

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM6 *I Medical Technologies to Support Dispersed Ops Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
? Refine and further develop Prolonged Field Care guidelines for a prototype AI assisted Decision Support System (DSS). Based on previous year?s research, develop strategies to implement 1) predictive patient state algorithms, 2) ML capabilities to continually improve recommendations, and 3) automated patient encounter and medic interventions through speech to text technologies. ? Expand research and design of autonomy-based countermeasures to signal latency and constrained bandwidth capabilities for conducting tele-robotic tasks by: 1) integrating force/torque sensing capabilities with the robotic vision system, and 2) designing semi-autonomous surgical protocols. ? Design layout of a ?CASEVAC kit? subsystem of the Combat Medical Mission Module (CEMM) based on new en route care technologies to include: 1) remotely operated, or semi-autonomous/closed-loop intervention and patient management systems, and 2) enabling medical communications systems and telehealth/Virtual Health and 3) creating computer-aided design (CAD) models and constructing mock-up models. *FY 2022 Plans:* Will conduct in-flight experimentation of emerging semi-autonomous and autonomous en route care technologies and capabilities that are candidates for providing patient management during UAS Casualty Evacuation (CASEVAC) missions; investigate comparisons of performance of medical devices and support systems on board UAS to performance in a controlled environment; funds research of in-flight testing of at least two technologies for low-band width, cyber- secure, communications networking with potential for overcoming limitations in bandwidth, range, beyond line-of-sight transmissions, cyber security, and security domain restrictions which limit medical use of current tactical networks; initiate investigation of methods to modify communications protocols for transmitting telemetry data from the UAS in order to mitigate UAS flight induced communications effects determine and investigate a method for interfacing with the unmanned vehicle?s flight controller to adapt the vehicles route planning and flight performance parameters based on patient conditions and injury type to ensure a safe ride profile is attainable; determine method for visual and audio data capture for hands free documentation, requiring a data collection system that is worn by the end user; investigate low size, weight, and power (SWaP) body worn data collection system to ensure solutions function within Army established performance parameters; investigate baseline, rule based, Medic Computer Decision Support System (CDSS) prototype for an end user study of CDSS effectiveness. *FY 2021 to FY 2022 Increase/Decrease Statement:* Decrease reflects the technical maturation of Med-RAS and Automated Unmanned Medical Capabilities (AUMC) knowledge, devices and methods toward inclusion in, and development of, subsystems and components. Funding realigned to PE 0602787A Project MM4 (Cbt Casualty Care Applied Rsch Technology) and PE 0603002A Project MO2 (Traumatic Brain Injury (TBI) Treatment Adv Tech).			
Title: Virtual Health	3.894	4.326	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021	
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM6 *I Medical Technologies to Support Dispersed Ops Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Develop future Virtual Health enterprise process architectures and integrated physical solutions capable of supporting prolonged field care in conditions with limited or lacking traditional field communications. *FY 2021 Plans:* Virtual Health Applications For Multi Domain Operational Environments ? Research and validate enterprise architectures for the Virtual Health support and integration with autonomous (real time) and/or semi-autonomous patient care capabilities. ? Expand research and validate means to leverage contemporary VH data components to drive future semi-autonomous and autonomous VH system support tools. ? Explore strategies for VH solutions that align with best practices to counteract threats from electronic warfare (EW). ? Expand mechanisms to streamline the engagement with VH solutions by clinical end users in the operational environment. ? Expand research mechanisms to provide VH solutions when an established synchronous VH consultation is disrupted due to communication failure/outages to include, but not limited to, closed loop systems and machine learning techniques. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project MM6 (Virtual Health Applications for Multi Domain Operational Environments).			
Title: Virtual Health Applications for Multi Domain Operational Environments *Description:* Investigate future Virtual Health enterprise process architectures and integrated physical solutions capable of supporting prolonged field care in conditions with limited or lacking traditional field communications. Deliver sustainable high-quality medical care using advanced technology approaches to export medical expertise to ill/injured soldiers where and when it is needed regardless of geographic location of medical providers, enabling the MDO tenet of maximizing human potential." *FY 2022 Plans:* Will conduct research and validation of models for the Virtual Health (VH) support and integration with autonomous (real time) and/or semiautonomous patient care capabilities; investigate methods and determine means to leverage contemporary VH data components to drive future semi-autonomous and autonomous VH system support tools; conduct research and design strategies and mechanisms to provide VH solutions when an established synchronous VH consultation is disrupted due to communication failure/outages to include, but not limited to closed loop systems and machine learning techniques; funds research on vocal patterning data analysis to link vocal capture to stress-related changes in risk mechanisms; investigate the link between vocal behavioral markers sleep loss and stress-related changes in health risk mechanisms for more accurate interpretation of commands and recognize changes in environment to determine risk, for improved recommended/best medical courses of action; conduct a systematic retrospective review and case analysis of virtual/telehealth encounters across the Military Health System to quantify and categorize the types of casualty information data required to deliver care and methods of data communication	-	-	3.347

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 31 of 40

R-1 Line #25

Volume 1b - 512

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM6 *I Medical Technologies to Support Dispersed Ops Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
using a mixed method (qualitative and quantitative) approach; determine virtual/telehealth health information data elements and prioritization guide and roadmap for future casualty care information data optimization for virtual/telehealth application in the Role 1&2 environment. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned from other efforts within Project MM6 (Virtual Health).			
Accomplishments/Planned Programs Subtotals	11.780	14.052	10.724

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 32 of 40

R-1 Line #25

Volume 1b - 513

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

Appropriation/Budget Activity 2040 I 2				R-1 Program Element (Number/Name) PE 0602787A I Medical Technology					Project (Number/Name) MM8 I Infectious Diseases and Applied Rsch 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
MM8: *Infectious Diseases and Applied Rsch Technology*	-	21.277	24.542	28.895	-	28.895	-	-	-	-	-	-

Note

In FY22 funding for this Project was realigned from:

PE 0603002A Medical Advanced Technology
* Project CJ3 (Prophylactic for Endemic Diarrheal Diseases)
* Project MP3 (Physiological Chemical Toxicity Assessment System)
* Project MN3 (Immediate Cardiopulmonary Stabilization Adv Tech)

PE 0602787A (Medical Technology)
*Project MK4 (Warfigher Health Applied Rsch Technology)

A. Mission Description and Budget Item Justification

This Project conducts applied (pre-clinical) research for medical countermeasures to prevent naturally occurring infectious diseases that impact operational readiness and maintains laboratory capability to perform these functions. The Project builds on basic research to optimize lead countermeasures and determines their safety and efficacy in animal models of infection. Effective preventive countermeasures protect the Warfighter from disease and sustain readiness and operations. Infectious disease threats from parasitic diseases, bacterial diseases, and viral diseases are high priorities for military operations.

Research conducted in this project focuses on the following three areas:

(1) Parasitic Diseases
(2) Bacterial Diseases
(3) Viral Diseases

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

Work is managed by the United States Army Medical Research and Development Command (USAMRDC) in coordination with the Naval Medical Research Center (NMRC). The Army is responsible for programming and funding all Department of Defense (DoD) naturally occurring infectious disease research requirements, thereby precluding duplication of effort within the Military Departments.

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 33 of 40

R-1 Line #25

Volume 1b - 514

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM8 *I Infectious Diseases and Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Title: Applied research on drugs and vaccines against parasitic diseases	10.252	13.451	-
Description: Develop and validate malaria preclinical animal models. Demonstrate and optimize prophylactic safety and efficacy in validated malaria preclinical animal models. Down-select lead malaria prophylactic candidates for use in human clinical trials. **FY 2021 Plans:** Prevention and Treatment of Parasitic Diseases ? Perform test tube and/or cell-based studies to optimize and select the next lead prophylactic and/or treatment candidate for prevention and treatment of malaria. ? Develop, assess and validate performance parameters of a mouse and/or non-human primate malaria efficacy models. ? Evaluate the safety and efficacy of lead candidates in validated malaria animal models. ? Assess technologies for extended release that provides long-term prophylaxis. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funds realigned to other efforts within Project MM8 (Prevention & Treatment of Combat Wound Infections during Prolonged Care, Prevention and Treatment of Endemic Diseases).			
Title: Applied Research to Prevent Viral Diseases	5.401	6.039	-
Description: Develop and validate viral disease preclinical animal models. Demonstrate and optimize prophylactic safety and effectiveness in validated viral disease preclinical animal models. Down-select lead viral disease prophylactic candidates for use in human clinical trials. **FY 2021 Plans:** Prevention and Treatment of Viral Diseases ? Perform test tube and/or cell-based studies to optimize and select the next lead prophylactic and/or treatment candidate for prevention and treatment of viral diseases. ? Develop, assess and validate performance parameters of animal efficacy models of viral diseases. ? Evaluate the safety and efficacy of lead candidates in validated viral diseases animal models. ? Assess technologies for extended release that provides long-term prophylaxis. **FY 2021 to FY 2022 Increase/Decrease Statement:** Funds realigned to other efforts within Project MM8 (Prevention and Treatment of Endemic Diseases) and Project CJ3 (Prophylactic for Endemic Diarrheal Diseases).			
Title: Applied Research to Prevent Bacterial Diseases	5.624	5.052	-

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM8 *I Infectious Diseases and Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Optimize antigens and platforms for use in animal studies. Evaluate bacterial diarrheal vaccine candidates for safety, effectveness, and immunogenicity in animal models to advance to human clinical trials (ETEC, Shigella and Campylobacter). Examine host/pathogen/vector interactions for scrub typhus and other Rickettsial diseases. *FY 2021 Plans:* Prevention and Treatment of Bacterial Diseases ? Perform test tube and/or cell-based studies to optimize and select the next lead prophylactic and/or treatment candidate for prevention and treatment of bacterial diarrheal disease. ? Develop, assess and validate performance parameters of animal efficacy models of bacterial diarrheal and rickettsial diseases. ? Evaluate the safety and efficacy of lead candidates in validated diarrheal disease animal models. ? Assess technologies for extended release that provides long-term prophylaxis. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned to other efforts within Project MM8 (Prevention & Treatment of Combat Wound Infections during Prolonged Care).			
Title: Prevention & Treatment of Combat Wound Infections during Prolonged Care *Description:* Determine and validate combat wound infection preclinical animal models. Investigate and validate prophylactic and treatment safety and effectiveness in validated combat wound infection preclinical animal models. Fund research to down-select lead combat wound infection prophylactic and treatment candidates for use in human clinical trials. *FY 2022 Plans:* Will perform test tube and/or cell-based studies to determine the next lead prophylactic and/or treatment candidate for prevention and treatment of combat wound infections; design, assess and validate performance parameters of animal efficacy models of combat wound infections; evaluate the safety and efficacy of lead candidates in validated combat wound infection animal models; investigate technologies for extended release that provides long-term prophylaxis in order to reduce disease and non-battle injury (DNBI) through prevention of wound infections and reduce unit loss rate for effective wound infection prevention to sustain unit readiness, operational effectiveness, Warfighter performance, and quicker return to duty. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned from other efforts within Project MM8 (Prevention and Treatment of Bacterial Diseases (Prevention and Treatment of Parasitic Diseases).	-	-	11.704
Title: Prevention and Treatment of Endemic Diseases	-	-	17.191

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MM8 *I Infectious Diseases and Applied Rsch Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Description: Determine and validate endemic bacterial and viral disease preclinical animal models. Investigate and validate prophylactic and treatment safety and effectiveness in validated bacterial and viral disease preclinical animal models. Down-select lead bacterial and viral infection prophylactic and treatment candidates for use in human clinical trials. *FY 2022 Plans:* Will perform test tube and/or cell-based studies to investigate and determine the next lead prophylactic and/or treatment candidate for prevention and treatment of endemic bacterial and viral infections; determine, assess and validate performance parameters of animal efficacy models of endemic bacterial and viral infections; investigate the safety and efficacy of lead candidates in validated bacterial and viral infection animal models; assess technologies for extended release that provide long-term prophylaxis. *FY 2021 to FY 2022 Increase/Decrease Statement:* Funds realigned from other efforts within Project MM8 (Prevention and Treatment of Parasitic Diseases, Prevention and Treatment of Viral Diseases).			
Accomplishments/Planned Programs Subtotals	21.277	24.542	28.895

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

Remarks

D. Acquisition Strategy
 N/A

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 36 of 40

R-1 Line #25

Volume 1b - 517

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

Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602787A I Medical Technology	Project (Number/Name) MN1 I Applied Sensory Systems Trauma 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
MN1: Applied Sensory Systems Trauma Technology	-	7.302	6.720	-	-	-	-	-	-	-	-	-

Note
 In FY22, this Project is being realigned to:

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

PE 0603002A - Medical Advanced Technology
* Project MN7 Musculoskeletal Injury Screening Tool Adv Tech

A. Mission Description and Budget Item Justification
This Project conducts laboratory and animal studies for the purpose of developing novel, non-opioid drugs to treat pain in the austere battlefield environment with minimal side effects. Research to understand the influence of stress on the effectiveness of pain relief drugs (analgesics). All drugs, biological products, and medical devices are refined in accordance with Food and Drug Administration (FDA) regulations, which govern testing in animals to assess safety, toxicity, and effectiveness and subsequent human subject clinical trials.

Promising efforts identified in this Project are further matured under PE 0603002A (Medical Advanced Technology) / Project MN7 (Musculoskeletal Injury Screening Tool Advanced Technology).

The cited work is consistent with the Under 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 Medical Research and Development Command (USAMRDC), Fort Detrick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Applied Sensory Systems Trauma Technology	7.302	6.720	-
Description: This effort performs applied research in laboratory and animal studies to develop novel, non-opioid drugs to treat pain in the austere battlefield environment with minimal side effects.			
FY 2021 Plans:			

PE 0602787A: Medical Technology
Army
UNCLASSIFIED
Page 37 of 40
R-1 Line #25
Volume 1b - 518

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** MN1 *I Applied Sensory Systems Trauma Technology*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022**
Applied Sensory Systems Trauma Technology ? Conduct preclinical evaluation of promising non-opioid, side effect-free analgesics in treating post-traumatic, moderate-to-severe pain. These drugs act on non-opioid targets in the nervous system that inhibit pain signaling without affecting cognitive capability. Applied Sensory Systems Trauma Technology ? Identify and assess treatment for unconventionally-acquired brain injury (UBI) threat technologies. ? Conduct UBI human-like animal assessments. ? Validate UBI threat source symptomology and assess injury mechanisms. ? Transition understanding of injury mechanisms to enable direct medical diagnosis, treatment and clinical management. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** Funds realigned to other efforts within Project MM4 (Battlefield Pain Control without Physiological Impairment and Unconventionally-acquired Brain Injury) and Project MK4 (Forward Neuro-Muscular Skeletal Injury Assessment) and 0603002A (Medical Advanced Technology) Project MN7 (Forward Neuro-Muscular Skeletal Injury Assessment to Reduce Unnecessary Evacuations).			
Accomplishments/Planned Programs Subtotals	7.302	6.720	-

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* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** VB4 *I System Biology And Network Science 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**
VB4: *System Biology And Network Science Technology*	-	0.575	-	-	-	-	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

This Project supports biological and clinical applied research using the data analysis and integration grid (Sys Bio Cube) as an overarching means of complex data usage to solve critical health problems. The primary capability of systems biology (field of study that focuses on complex interactions within biological systems, using a holistic approach) is the integration and analysis of complex human and animal study data and development of computational disease models, using global multi-omic methods to identify and discriminate unique combinations of biological molecules corresponding to clinical conditions (physiologic, immunologic, endocrine, etc.), supporting transition of research to clinical applications. This capability applies a systematic integrated approach to trace progression of illnesses and diseases and has already shown that the approach significantly reduces time, funds and effort invested in medical product development and refinement.

The cited work is consistent with the Under 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 Medical Research and Development Command (USAMRDC), Fort Detrick, MD.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2020	**FY 2021**	**FY 2022**
Title: Systems Biology	0.575	-	-
Description: The core capability for multidisciplinary applied research in systems biology enables integration and analysis of complex data from human and animal studies and development of computational network models, allowing researchers to differentiate among molecular signatures (unique combinations of biological molecules corresponding to clinical conditions) of disease, and supports transition of research to clinical applications for diseases of military relevance. Applied research is being conducted to identify biological networks that are causative of illness in Post-traumatic stress disorder (PTSD) and co-morbidities (presence of one or more diseases or disorders), coagulopathy (impaired ability to clot blood) of trauma, traumatic brain injury, pain, suicide, infectious disease, and immune responses. In particular, the studies of PTSD are directed to refine biomarkers for screening, early diagnosis and therapeutic target discovery.			
Accomplishments/Planned Programs Subtotals	0.575	-	-

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

Exhibit R-2A, **RDT&E Project Justification:** PB 2022 Army		**Date:** May 2021
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602787A *I Medical Technology*	**Project (Number/Name)** VB4 *I System Biology And Network Science Technology*

D. Acquisition Strategy

  N/A

PE 0602787A: *Medical Technology*
Army

UNCLASSIFIED
Page 40 of 40

R-1 Line #25

Volume 1b - 521