Department of Defense
Fiscal Year (FY) 2020 Budget Estimates

March 2019

Army

Justification Book of

Research, Development, Test & Evaluation, Army

RDT&E − Volume 1, Budget Activity 1

Table of Contents

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

For expenses necessary for basic and applied scientific research, development, test and evaluation, including maintenance, rehabilitation, lease, and operation of facilities and equipment, $12,396,895,000.00 to remain available for obligation until September 30, 2021.

OCO for Direct War Costs ($182,624,000.00): 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.

OCO for Enduring Requirements ($21,500,000.00): OCO for 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.

COST STATEMENT

The following Justification Books were prepared at a cost of $366,803: 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 6, and Budget Activity 7.

FY 2020 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 2020.

2. Relationship of the FY 2020 Budget Submitted to Congress to the FY 2019 Budget Submitted to Congress. This paragraph provides a list of program elements/projects that are major new starts, restructures, developmental transitions, and terminated programs. Explanations for these changes can be found in the narrative sections of the Program Element R-2A Exhibits.

New Start Programs:

Budget Activity	***OSDPE / Project***	***Project Title***
02	0602145A / BJ9	Autonomous Mobility Tech
02	0602145A / BK2	Virtual Prototyping Technology
02	0602145A / BK3	Next Gen Intelligent Fire Control (NG-IFC) Tech
02	0602145A / BK5	Adv Direct In-Direct Armament Sys (ADIDAS) Tech
03	0603002A / MM7	Enabling Med Cap to Support Dispersed OPS Adv Tech
04	0603619A / BU5	Standoff Volcano Obstacle (SAVO) Adv Tech
04	0603639A / EU3	.50 Caliber All-Purpose Tactical Cartridge (APTC)
04	0603774A / VT8	SOLDIER PRECISION TARGETING DEVICES - ADV DEV
04	0603827A / CF2	Integrated Soldier Systems Prototyping (SL CFT)
04	0604021A / AW7	Electronic Warfare Technology Maturation (MIP)
04	0604115A / AX8	Adv Leth and Accuracy Sys for Med Calber (ALAS-MC)
04	0604115A / AX9	Adv Mobility Experimental Prototype Adv Tech
04	0604115A / AY1	MUM-T Platform Enabler
04	0604115A / AY2	Army Operational Fires
04	0604115A / AY3	Strategic Long Range Cannon
04	0604182A / HX1	Land-Based Hypersonic Missile

04	0604403A / FM3	Future Interceptor
04	0604541A / BT1	Interoperability
04	0604541A / BT2	Command Post Mobility/Survivability
04	0604541A / BT3	Common Operating Environment (COE)
04	0604541A / BT4	Network Technology Maturation Initiatives (NTMI)
04	0604541A / BT5	Integrated Tactical Network/Enterprise Network
04	0604644A / MR1	Mobile Medium Range Missile
05	0604601A / CF3	Integrated Soldier Systems (SL CFT)
05	0604802A / EP2	Shoulder-Launched Munitions
05	0604827A / FK4	Soldier Borne Sensor (SBS)
05	0604854A / HB6	Mobile Howitzer
05	0605041A / CY5	CYBER Situational Understanding
05	0605625A / CF6	Next Generation Combat Vehicle (NGCV)
07	0205778A / EG2	GMLRS Alternative Warheads
07	0607145A / FD5	Apache Product Improvement
07	1203142A / FI8	Protected Anti-JAM Tactical SATCOM

Program Element/Project Restructures:

Budget Activity	***Old OSDPE / Project: Title***	***New OSDPE / Project***
01	0601101A / 91A: ILIR-AMC	0601102A / AA1
01	0601101A / F16: ILIR-SMDC	0601102A / AA2
01	0601102A / 305: ATR Research	0601102A / AA9
01	0601102A / 31B: Infrared Optics Rsch	0601102A / AA8
01	0601102A / 52C: Mapping & Remote Sens	0601102A / AB2
01	0601102A / 53A: Battlefield Env & Sig	0601102A / AA7
01	0601102A / 74A: Human Engineering	0601102A / AA4
01	0601102A / 74F: Pers Perf & Training	0601102A / AA4

01	0601102A / ET6: BASIC RESCH IN CLINICAL & REHABILITATIVE MED	0601102A / AB1
01	0601102A / F20: Adv Propulsion Rsch	0601102A / AA6
01	0601102A / F22: Rsch In Veh Mobility	0601102A / AA6
01	0601102A / H42: Materials & Mechanics	0601102A / AA7
01	0601102A / H43: Research In Ballistics	0601102A / AA7
01	0601102A / H44: Adv Sensors Research	0601102A / AA5, AA7, & AA8
01	0601102A / H45: Air Mobility	0601102A / AA6
01	0601102A / H47: Applied Physics Rsch	0601102A / AA9
01	0601102A / H48: Battlespace Info & Comm Rsc	0601102A / AA9
01	0601102A / H52: Equip For The Soldier	0601102A / AA8
01	0601102A / H57: Single Investigator Basic Research	0601102A / AA3
01	0601102A / H66: Adv Structures Rsch	0601102A / AA6
01	0601102A / H67: Environmental Research	0601102A / AA7
01	0601102A / S13: Sci BS/Med Rsh Inf Dis	0601102A / AB1
01	0601102A / S14: Sci BS/Cbt Cas Care Rs	0601102A / AB1
01	0601102A / S15: Sci BS/Army Op Med Rsh	0601102A / AB1
01	0601102A / T22: Soil & Rock Mech	0601102A / AB2
01	0601102A / T23: Basic Res Mil Const	0601102A / AB2
01	0601102A / T24: Signature Physics And Terrain State Basic Research	0601102A / AB2
01	0601102A / T25: Environmental Science Basic Research	0601102A / AB2
01	0601102A / T63: Robotics Autonomy, Manipulation, & Portability Rsh	0601102A / AA6
01	0601102A / T64: Sci BS/System Biology And Network Science	0601102A / AB1
01	0601102A / VR9: Surface Science Research	0601102A / AA7
01	0601103A / D55: University Research Initiative	0601103A / AB3
01	0601104A / EA6: Cyber Collaborative Research Alliance	0601104A / AB7
01	0601104A / F17: Neuroergonomics Collaborative Technology Alliance	0601104A / AB7
01	0601104A / FF5: Distributed Collaborative Intelligent Systems CTA	0601104A / AB7
01	0601104A / FF7: Internet of Battlefield Things CTA	0601104A / AB7
01	0601104A / H04: HBCU/MI Programs	0601104A / AB4

01	0601104A / H05: Institute For Collaborative Biotechnologies	0601104A / AB7 & AB4
01	0601104A / H59: International Tech Centers	0601104A / AC6
01	0601104A / H73: Automotive Research Center (ARC)	0601104A / AB4
01	0601104A / J08: Institute For Creative Technologies (ICT)	0601104A / AB4
01	0601104A / J12: Institute For Soldier Nanotechnology (ISN)	0601104A / AB4
01	0601104A / J14: Army Educational Outreach Program	0601104A / AB8
01	0601104A / J15: Network Sciences ITA	0601104A / AB7
01	0601104A / J17: Vertical Lift Research Center Of Excellence	0601104A / AB4
01	0601104A / VS2: Multi-Scale Materials Modeling Centers	0601104A / AB7
01	0601104A / VS3: Center For Quantum Science Research	0601104A / AB7
02	0602105A / H84: Materials	0602141A / AH8, 0602143A / AZ5 & BE6, 0602145A / BI4
02	0602105A / XW4: Manufacturing Science	0602144A / BL1
02	0602120A / H16: S3I Technology	0602145A / BI2, 0602146A / AP5 & AR1, 0602148A / AL8, 0602150A / AD5
02	0602120A / TS1: Tactical Space Research	0602146A / AO5
02	0602120A / TS2: Robotics Technology	0602145A / BF8
02	0602211A / 47A: AERON & ACFT Wpns Tech	0602148A / AJ6, AJ4, AJ8, AM2, AI7, AK2, AL2, AI5, AJ2, AK1
02	0602211A / 47B: Veh Prop & Struct Tech	0602148A / AK9, AL5, AI9, AL4
02	0602270A / 906: Tactical Electronic Warfare Applied Research	0602146A / AN7, AO2, 0602148A / AK2
02	0602270A / CYB: Applied Offensive Cyber	0602146A / AQ3
02	0602303A / 214: Missile Technology	0602147A / AF8, AF3, AG2, AE7, AG1, AG9, AF9, AF5, AH2, AF6, AF7, 0602148A / AK4, 0602150A / AD3, AD7
02	0602307A / 042: High Energy Laser Technology	0602150A / AC9
02	0602308A / C90: Advanced Distributed Simulation	0602143A / BC3, BE8, 0602145A / BF6
02	0602308A / D02: Modeling & Simulation For Training And Design	0602143A / BE8
02	0602601A / C05: Armor Applied Research	0602145A / BG6, BH9
02	0602601A / H77: National Automotive Center	0602145A / BJ3, BI9
02	0602601A / H91: Ground Vehicle Technology	0602145A / BF1, BF3, BF6, BH7, BH5
02	0602618A / H80: Survivability And Lethality Technology	0602141A / AH5, AH6, AH7, 0602143A / AY6, 0602145A / BG6, 0602147A / AH4
02	0602622A / 552: Smoke/Novel Effect Mun	0602144A / BL2, 0602145A / BG8

02	0602623A / H21: Jt Svc Sa Prog (JSSAP)	0602143A / AY6
02	0602624A / H18: Weapons & Munitions Technologies	0602147A / AG6, AG4, BN4, 0602148A / AK6
02	0602624A / H28: Warheads/Energetics Technologies	0602145A / AH9, 0602147A / AG8, AG6, 0602148A / AK2
02	0602705A / EM8: High Power And Energy Component Technology	0602145A / BH7, 0602146A / AP4, AO2, 0602150A / AD2
02	0602705A / H11: Tactical And Component Power Technology	0602143A / BD8, 0602148A / AM4
02	0602705A / H94: Elec & Electronic Dev	0602144A / BL1, 0602146A / AV9, AO4, AV5, 0602148A / AK2
02	0602709A / H95: Night Vision And Electro-Optic Technology	0602143A / BD1, 0602145A / BH2, BF9, BJ2, 0602148A / AK2
02	0602712A / H24: Countermine Tech	0602143A / BD1, 0602144A / BL4, 0602145A / BJ7
02	0602712A / H35: Camouflage & Counter-Recon Tech	0602145A / BI2
02	0602716A / H70: Human Fact Eng Sys Dev	0602143A / AY6, BB7, BC3, BE8, 0602145A / BF6
02	0602720A / 048: Ind Oper Poll Ctrl Tec	0602144A / BK7
02	0602720A / 835: Mil Med Environ Crit	0602146A / AR5
02	0602720A / 896: Base Fac Environ Qual	0602146A / AR5
02	0602782A / 779: Command, Control And Platform Electronics Tech	0602146A / AV6, AW1, AQ9, AW3, AW5
02	0602782A / CY2: Applied Defensive Cyber	0602146A / AP1, AO8
02	0602782A / H92: Communications Technology	0602143A / AN1, 0602146A / AP7, AM6, AN3, AM8, AN5, AO2, AN9
02	0602783A / Y10: Computer/Info Sci Tech	0602146A / AP3
02	0602784A / 855: Topographical, Image Intel & Space	0602146A / AU5, AU3, AT7, AT9
02	0602784A / H71: Meteorological Research For Battle Command	0602146A / AV7
02	0602784A / T40: Mob/Wpns Eff Tech	0602144A / BL7, BL9, 0602145A / BF1, BG2, 0602146A / AR9, AT2, 0602150A / AE2
02	0602784A / T41: Mil Facilities Eng Tec	0602144A / BK7
02	0602784A / T42: Terrestrial Science Applied Research	0602146A / AT7
02	0602784A / T45: Energy Tec Apl Mil Fac	0602144A / BK7
02	0602786A / H98: Clothing & Equipm Tech	0602143A / AZ2, AZ9, BB4, BB5, BB9, BC2, BC6, BD6
02	0602786A / H99: Joint Service Combat Feeding Technology	0602143A / BE3
02	0602786A / XW5: Small Unit Expeditionary Maneuver Technology	0602143A / BE1, BE3, BR9
02	0602787A / 869: Warfighter Health Prot & Perf Stnds	0602787A / MK4
02	0602787A / 870: Dod Med Def Ag Inf Dis	0602787A / MM8
02	0602787A / 874: Cbt Casualty Care Tech	0602787A / MM4

02	0602787A / ET4: Appl Resch in Clinical and Rehabilitative Medicine	0602787A / MN1
02	0602787A / XV5: Medical Capabilities to Support Dispersed Ops	0602787A / MM6
03	0603001A / 242: Airdrop Equipment	0603118A / BE5
03	0603001A / C07: Joint Service Combat Feeding Tech Demo	0603118A / BE2
03	0603001A / FF6: Individual Protection	0603118A / AY9, AZ6, AZ8, BB3
03	0603001A / J50: Future Warrior Technology Integration	0603118A / BB6, BC1, BC4, BD7, BD9, BB8
03	0603001A / XW6: Small Unit Expeditionary Maneuver	0603118A / BE5
03	0603002A / 810: Ind Base Id Vacc&Drug	0603002A / MN8, MM9, MO9
03	0603002A / 840: Combat Injury Mgmt	0603002A / MO4, MN3, MO7, MN5, MM5, MO2
03	0603002A / MM3: Warfighter Medical Protection & Performance	0603002A / MN6, MO8, MN9, MO3, MN7, MG4
03	0603003A / 313: Adv Rotarywing Veh Tech	0603465A / AI4, AI6, AJ3, AJ5, AJ9, AK3, AK8, AL6 AL9, & AM3
03	0603003A / 436: Rotarywing MEP Integ	0603465A / AL1
03	0603003A / 447: ACFT Demo Engines	0603465A / AI8 & AJ1
03	0603004A / 232: Advanced Lethality & Survivability Demo	0603118A / AY7, 0603462A / BF5, BG5, BI1, BK4, BK6, 0603464A / AE6, AG3, AG5, AG7, 0603465A / AK7
03	0603004A / L96: High Energy Laser Technology Demo	0603466A / AD1
03	0603004A / L97: Smoke And Obscurants Advanced Technology	0603119A / BL3, 0603462A / BG7, BG9
03	0603005A / 221: Combat Veh Survivablty	0603462A / BG7, BH1, BI1, BI5
03	0603005A / 441: Combat Vehicle Mobilty	0603119A / BK9, 0603462A / BF7, BG4, BH6, BI8, BJ1, BJ6
03	0603005A / 497: Combat Vehicle Electro	0603462A / BH8
03	0603005A / 515: Robotic Ground Systems	0603462A / BF2, BF4, BK1
03	0603006A / 592: Space Application Tech	0603463A / AO6
03	0603015A / S29: Modeling & Simulation - Adv Tech Dev	0603118A / BC8, BE9
03	0603015A / S31: Modeling And Simulation Infrastructure Technology	0603118A / BC4, BC8, BE9
03	0603125A / DF5: Agile Integration & Demonstration	0602145A / BH5, BI4
03	0603125A / DW4: Energy Technologies (Congressional Adds (CAs))	0602145A / BH5, BI4
03	0603270A / CY3: Offensive Cyber Operations Mirror Adv Tech	0603463A / AQ4
03	0603270A / K15: Advanced Comm Ecm Demo	0603463A / AN8, AO7, AO3, AO1
03	0603270A / K16: Non-Commo Ecm Tech Dem	0603465A / AK3, 0603462A / BG7, 0603463A / AO1
03	0603313A / 206: Missile Simulation	0603464A / AF4

03	0603313A / 263: Future Msl Tech Integr(FMTI)	0603464A / AE8, AE9, AH3, BS3, 0603462A / BG7
03	0603313A / 704: Advanced Missile Demo	0603466A / AC8 & AD4, 0603465A / AK5
03	0603606A / 608: Countermine & Bar Dev	0603118A / BC9, 0603462A / BJ8
03	0603606A / 683: Area Denial Sensors	0603462A / BG1
03	0603607A / 627: Jt Svc Sa Prog (JSSAP)	0603118A / AY5
03	0603710A / K70: Night Vision Adv Tech	0603118A / BC9, 0603462A / BI3, BG1, 0603463A / AQ5
03	0603710A / K86: Night Vision, Abn Sys	0603465A / AK3, AL6, AL7
03	0603728A / 002: Environmental Compliance Technology	0603119A / BK8
03	0603728A / 03E: Environmental Restoration Technology	0603119A / BM1, 0603463A / AR4, AR6
03	0603734A / T08: Combat Eng Systems	0603119A / BL6, BL8, BM1, 0603462A / BG3, 0603463A / AS9, AU6, AU4, AT8, AT3, AU1, 0603466A / AE3
03	0603772A / 101: Tactical Command and Control	0603462A / BH3, 0603463A / AW2, AW4, AR2, AV8
03	0603772A / 243: Sensors And Signals Processing	0603466A / AD6
03	0603794A / EL4: Tactical Comms and Networking Technology Int	0603463A / AP6, AP8, AM7, AP9, AN4, AN6, AO3, AQ1, AO1
03	0603794A / EL5: Secure Tactical Information Integration	0603463A / AP2, AO9
04	0603774A / VT7: Soldier Maneuver Sensors - Adv Dev	0603774A / BQ5
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	0604319A / DU3: IFPC2	0605052A / EY7
05	0604710A / L67: Soldier Night Vision Devices	0604710A / BQ6
05	0604798A / FG7: Emerging Technology Initiatives	0605054A / FI3
05	0605013A / 738: AcqBiz	0605013A / FL9
05	0605053A / FB8: Soldier Borne Sensor (SBS)	0604827A / FK4
06	0604256A / 976: Army Threat Sim (ATS)	0604759A / FF1
07	0205402A / EF2: Integrated Base Defense	0604785A / DS4

Program Terminations:

Budget Activity	***OSDPE / Project***	***OSDPE Title / Project Title***
01	0601103A / V72	University Research Initiatives / Minerva
01	0601104A / H09	University and Industry Research Centers / Robotics CTA
01	0601104A / H50	University and Industry Research Centers / Network Sciences Cta
02	0602105A / H7G	Materials Technology / Nanomaterials Applied Research
02	0602120A / SA2	Sensors and Electronic Survivability / Biotechnology Applied Research
02	0602624A / H19	Weapons and Munitions Technology / Asymmetric & Counter Measure Technologies
02	0602705A / H17	Electronics and Electronic Devices / Flexible Display Center
02	0602720A / 895	Environmental Quality Technology / Pollution Prevention
02	0602786A / 283	Warfighter Technology / Airdrop Adv Tech
02	0602786A / VT4	Warfighter Technology / Expeditionary Mobile Base Camp Technology
03	0603001A / 543	Warfighter Advanced Technology / Ammunition Logistics
03	0603001A / VT5	Warfighter Advanced Technology / Expeditionary Mobile Base Camp Demonstration
03	0603002A / ET5	Medical Advanced Technology / Adv Tech Dev in Clinical & Rehabilitative Medicine
03	0603728A / 025	Environmental Quality Technology Demonstrations / Pollution Prevention Technology
04	0603619A / 606	Landmine Warfare and Barrier - Adv Dev / Cntrmn/Barrier Adv Dev
04	0603639A / EL8	Tank and Medium Caliber Ammunition / LIGHTWEIGHT CARTRIDGE CASE FOR SMALL CALIBER
04	0603804A / EW8	Logistics and Engineer Equipment - Adv Dev / Armored Engineer Vehicles
04	0603804A / K39	Logistics and Engineer Equipment - Adv Dev / Field Sustainment Support Ad
04	0603804A / K41	Logistics and Engineer Equipment - Adv Dev / Water And Petroleum Distribution - Ad
04	0603804A / VR8	Logistics and Engineer Equipment - Adv Dev / Combat Service Support Systems - Ad
04	0604020A / CF1	Cross Functional Team (CFT) Advanced Development & Prototyping / CFT Advanced Development & Prototyping
04	0604115A / DS3	Technology Maturation Initiatives / Technology Maturation Initiatives
04	1206308A / FE6	Army Space Systems Integration / Army Space System Enhancement/Integration
05	0210609A / ED8	Paladin Integrated Management (PIM) / Paladin Integrated Management (PIM)
05	0604321A / B41	All Source Analysis System / CI/HUMINT Software Products (MIP)
05	0604321A / B51	All Source Analysis System / Machine - Foreign Language Translation System
05	0604601A / S62	Infantry Support Weapons / Counter-Defilade Target Engagement - SDD

05	0604601A / S70	Infantry Support Weapons / Personnel Recovery Support System (PRSS)
05	0604622A / E50	Family of Heavy Tactical Vehicles / TRAILER DEVELOPMENT
05	0604713A / EL2	Combat Feeding, Clothing, and Equipment / Army Field Feeding Equipment
05	0604741A / FG5	Air Defense Command, Control and Intelligence - Eng Dev / Counter Unmanned Aerial Systems (UAS)
05	0604768A / P01	Brilliant Anti-Armor Submunition (BAT) / MULTI - MODE SEEKER DEVELOPMENT AND TEST
05	0604780A / 571	Combined Arms Tactical Trainer (CATT) Core / Close Cbt Tact Trainer
05	0604780A / 577	Combined Arms Tactical Trainer (CATT) Core / Gaming Technology In Support Of Army Training
05	0604780A / 585	Combined Arms Tactical Trainer (CATT) Core / Aviation Combined Arms Tactical Trainer
05	0604804A / EC9	Logistics and Engineer Equipment - Eng Dev / Contingency Basing Infrastructure
05	0604804A / H01	Logistics and Engineer Equipment - Eng Dev / Combat Engineer Eq Ed
05	0604804A / H14	Logistics and Engineer Equipment - Eng Dev / Materials Handling Equipment - Ed
05	0604804A / VR7	Logistics and Engineer Equipment - Eng Dev / Combat Service Support Systems
05	0604818A / 334	Army Tactical Command & Control Hardware & Software / Common Software
05	0604823A / L87	Firefinder / Hypervelocity Armament System (HAS)
05	0604827A / EY3	Soldier Systems - Warrior Dem/Val / Soldier Power Generator
05	0605013A / FE9	Information Technology Development / ALTESS (P&R Forms)
05	0605029A / EQ2	Integrated Ground Security Surveillance Response Capability (IGSSR-C) / IntegGrdSecSurvRespC(IGSSR-C)
05	0605037A / EQ6	Evidence Collection and Detainee Processing / Evidence Collection and Detainee Processing
05	0605380A / EG6	AMF Joint Tactical Radio System (JTRS) / Small Airborne Networking Radio (SANR)
06	0303260A / FA9	Defense Military Deception Initiative / Security Initiatives
06	0604759A / 986	Major T&E Investment / Major Operational Test Instrumentation
06	0604759A / FA4	Major T&E Investment / Warrior Injury Assessment Manikin (WIAMan)
06	0605803A / 720	Technical Information Activities / Tech Info Func Actv
06	0605803A / 730	Technical Information Activities / Pers & Trng Analys Act
06	0605803A / C16	Technical Information Activities / FAST
06	0605803A / C18	Technical Information Activities / BAST
07	0203735A / 431	Combat Vehicle Improvement Programs / M113 IMPROVEMENTS
07	0203735A / FD8	Combat Vehicle Improvement Programs / Light Armored Vehicle Improvement
07	0203740A / 484	Maneuver Control System / Maneuver Control System
07	0203801A / DT5	Missile/Air Defense Product Improvement Program / Stinger Product Improvement

07	0203802A / 788	Other Missile Product Improvement Programs / ATACMS PIP
07	0205410A / EE9	Materials Handling Equipment / Material Handling Equipment - Advance Development
07	0303140A / FF8	Information Systems Security Program / Unit Activity Monitoring (UAM)
07	0303150A / EA5	WWMCCS/Global Command and Control System / Strategic and Joint Mission Command
07	0305219A / MQ1	MQ-1 Gray Eagle UAV / MQ-1 Gray Eagle - Army UAV (MIP)
07	0607135A / ES2	Apache Product Improvement Program / Apache Product Improvement Program
07	0607140A / ES7	Emerging Technologies from NIE / Emerging Technologies from NIE
07	0607665A / DT2	Family of Biometrics / Non-MIP Biometrics

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 (ASA(ALT)) Special Programs Office.

Department of Defense
FY 2020 President's Budget
Exhibit R-1 FY 2020 President's Budget
Total Obligational Authority
(Dollars in Thousands)

12 Feb 2019

Appropriation	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted
Research, Development, Test & Eval, Army	11,633,461	11,074,556	300,604	11,375,160
Total Research, Development, Test & Evaluation	11,633,461	11,074,556	300,604	11,375,160

Department of Defense
FY 2020 President's Budget
Exhibit R-1 FY 2020 President's Budget
Total Obligational Authority
(Dollars in Thousands)

12 Feb 2019

Appropriation	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)
Research, Development, Test & Eval, Army	12,192,771		204,124	204,124	12,396,895
Total Research, Development, Test & Evaluation	12,192,771		204,124	204,124	12,396,895

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Summary Recap of Budget Activities	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted
Basic Research	464,187	506,444		506,444
Applied Research	1,342,832	1,578,725		1,578,725
Advanced Technology Development	1,503,959	1,585,778		1,585,778
Advanced Component Development & Prototypes	1,563,615	1,264,647	4,000	1,268,647
System Development & Demonstration	3,349,488	2,965,361	236,863	3,202,224
RDT&E Management Support	1,579,102	1,438,536		1,438,536
Operational Systems Development	1,830,278	1,735,065	59,741	1,794,806
Total Research, Development, Test & Evaluation	11,633,461	11,074,556	300,604	11,375,160

Summary Recap of FYDP Programs				
General Purpose Forces	668,082	666,757	10,000	676,757
Intelligence and Communications	401,118	252,771	40,613	293,384
Research and Development	10,369,821	9,830,755	249,991	10,080,746
Central Supply and Maintenance	118,410	108,696		108,696
Administration and Associated Activities	654			
Space	68,222	209,622		209,622
Classified Programs	7,154	5,955		5,955
Total Research, Development, Test & Evaluation	11,633,461	11,074,556	300,604	11,375,160

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Summary Recap of Budget Activities	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)
Basic Research	454,980				454,980
Applied Research	893,990				893,990
Advanced Technology Development	1,099,564				1,099,564
Advanced Component Development & Prototypes	2,929,355		17,114	17,114	2,946,469
System Development & Demonstration	3,549,431		111,917	111,917	3,661,348
RDT&E Management Support	1,286,625		1,875	1,875	1,288,500
Operational Systems Development	1,978,826		73,218	73,218	2,052,044
Total Research, Development, Test & Evaluation	12,192,771		204,124	204,124	12,396,895
Summary Recap of FYDP Programs					
General Purpose Forces	866,366				866,366
Intelligence and Communications	257,681		76,418	76,418	334,099
Research and Development	10,659,601		127,706	127,706	10,787,307
Central Supply and Maintenance	59,848				59,848
Administration and Associated Activities					
Space	342,002				342,002
Classified Programs	7,273				7,273
Total Research, Development, Test & Evaluation	12,192,771		204,124	204,124	12,396,895

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Summary Recap of Budget Activities	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted
Basic Research	464,187	506,444		506,444
Applied Research	1,342,832	1,578,725		1,578,725
Advanced Technology Development	1,503,959	1,585,778		1,585,778
Advanced Component Development & Prototypes	1,563,615	1,264,647	4,000	1,268,647
System Development & Demonstration	3,349,488	2,965,361	236,863	3,202,224
RDT&E Management Support	1,579,102	1,438,536		1,438,536
Operational Systems Development	1,830,278	1,735,065	59,741	1,794,806
Total Research, Development, Test & Evaluation	11,633,461	11,074,556	300,604	11,375,160

Summary Recap of FYDP Programs				
General Purpose Forces	668,082	666,757	10,000	676,757
Intelligence and Communications	401,118	252,771	40,613	293,384
Research and Development	10,369,821	9,830,755	249,991	10,080,746
Central Supply and Maintenance	118,410	108,696		108,696
Administration and Associated Activities	654			
Space	68,222	209,622		209,622
Classified Programs	7,154	5,955		5,955
Total Research, Development, Test & Evaluation	11,633,461	11,074,556	300,604	11,375,160

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Summary Recap of Budget Activities	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)
Basic Research	454,980				454,980
Applied Research	893,990				893,990
Advanced Technology Development	1,099,564				1,099,564
Advanced Component Development & Prototypes	2,929,355		17,114	17,114	2,946,469
System Development & Demonstration	3,549,431		111,917	111,917	3,661,348
RDT&E Management Support	1,286,625		1,875	1,875	1,288,500
Operational Systems Development	1,978,826		73,218	73,218	2,052,044
Total Research, Development, Test & Evaluation	12,192,771		204,124	204,124	12,396,895
Summary Recap of FYDP Programs					
General Purpose Forces	866,366				866,366
Intelligence and Communications	257,681		76,418	76,418	334,099
Research and Development	10,659,601		127,706	127,706	10,787,307
Central Supply and Maintenance	59,848				59,848
Administration and Associated Activities					
Space	342,002				342,002
Classified Programs	7,273				7,273
Total Research, Development, Test & Evaluation	12,192,771		204,124	204,124	12,396,895

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Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
1	0601101A	In-House Laboratory Independent Research	01	11,783	11,579		11,579	U
2	0601102A	Defense Research Sciences	01	274,098	315,660		315,660	U
3	0601103A	University Research Initiatives	01	74,349	65,202		65,202	U
4	0601104A	University and Industry Research Centers	01	103,957	114,003		114,003	U
5	0601121A	Cyber Collaborative Research Alliance	01					U
	Basic Research			464,187	506,444		506,444	
6	0602105A	Materials Technology	02	73,136	83,586		83,586	U
7	0602120A	Sensors and Electronic Survivability	02	83,581	80,849		80,849	U
8	0602122A	TRACTOR HIP	02	8,627	8,674		8,674	U
9	0602126A	TRACTOR JACK	02		400		400	U
10	0602141A	Lethality Technology	02					U
11	0602142A	Army Applied Research	02					U
12	0602143A	Soldier Lethality Technology	02					U
13	0602144A	Ground Technology	02					U
14	0602145A	Next Generation Combat Vehicle Technology	02					U
15	0602146A	Network C3I Technology	02					U
16	0602147A	Long Range Precision Fires Technology	02					U
17	0602148A	Future Verticle Lift Technology	02					U

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
1	0601101A	In-House Laboratory Independent Research	01						U
2	0601102A	Defense Research Sciences	01	297,976				297,976	U
3	0601103A	University Research Initiatives	01	65,858				65,858	U
4	0601104A	University and Industry Research Centers	01	86,164				86,164	U
5	0601121A	Cyber Collaborative Research Alliance	01	4,982				4,982	U
	Basic Research			454,980				454,980	
6	0602105A	Materials Technology	02						U
7	0602120A	Sensors and Electronic Survivability	02						U
8	0602122A	TRACTOR HIP	02						U
9	0602126A	TRACTOR JACK	02						U
10	0602141A	Lethality Technology	02	26,961				26,961	U
11	0602142A	Army Applied Research	02	25,319				25,319	U
12	0602143A	Soldier Lethality Technology	02	115,274				115,274	U
13	0602144A	Ground Technology	02	35,199				35,199	U
14	0602145A	Next Generation Combat Vehicle Technology	02	219,047				219,047	U
15	0602146A	Network C3I Technology	02	114,516				114,516	U
16	0602147A	Long Range Precision Fires Technology	02	74,327				74,327	U
17	0602148A	Future Verticle Lift Technology	02	93,601				93,601	U

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Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
18	0602150A	Air and Missile Defense Technology	02					U
19	0602211A	Aviation Technology	02	72,170	81,805		81,805	U
20	0602213A	C3I Applied Cyber	02					U
21	0602270A	Electronic Warfare Technology	02	33,683	25,558		25,558	U
22	0602303A	Missile Technology	02	52,858	91,647		91,647	U
23	0602307A	Advanced Weapons Technology	02	36,959	44,468		44,468	U
24	0602308A	Advanced Concepts and Simulation	02	27,662	28,470		28,470	U
25	0602601A	Combat Vehicle and Automotive Technology	02	78,759	104,404		104,404	U
26	0602618A	Ballistics Technology	02	83,299	85,491		85,491	U
27	0602622A	Chemical, Smoke and Equipment Defeating Technology	02	3,895	5,027		5,027	U
28	0602623A	Joint Service Small Arms Program	02	6,473	12,380		12,380	U
29	0602624A	Weapons and Munitions Technology	02	241,344	383,410		383,410	U
30	0602705A	Electronics and Electronic Devices	02	90,613	96,760		96,760	U
31	0602709A	Night Vision Technology	02	38,243	33,573		33,573	U
32	0602712A	Countermine Systems	02	25,329	27,223		27,223	U
33	0602716A	Human Factors Engineering Technology	02	23,813	24,121		24,121	U
34	0602720A	Environmental Quality Technology	02	34,118	19,469		19,469	U
35	0602782A	Command, Control, Communications Technology	02	32,458	54,956		54,956	U
36	0602783A	Computer and Software Technology	02	13,707	14,948		14,948	U

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18	0602150A	Air and Missile Defense Technology	02	50,771				50,771	U
19	0602211A	Aviation Technology	02						U
20	0602213A	C3I Applied Cyber	02	18,947				18,947	U
21	0602270A	Electronic Warfare Technology	02						U
22	0602303A	Missile Technology	02						U
23	0602307A	Advanced Weapons Technology	02						U
24	0602308A	Advanced Concepts and Simulation	02						U
25	0602601A	Combat Vehicle and Automotive Technology	02						U
26	0602618A	Ballistics Technology	02						U
27	0602622A	Chemical, Smoke and Equipment Defeating Technology	02						U
28	0602623A	Joint Service Small Arms Program	02						U
29	0602624A	Weapons and Munitions Technology	02						U
30	0602705A	Electronics and Electronic Devices	02						U
31	0602709A	Night Vision Technology	02						U
32	0602712A	Countermine Systems	02						U
33	0602716A	Human Factors Engineering Technology	02						U
34	0602720A	Environmental Quality Technology	02						U
35	0602782A	Command, Control, Communications Technology	02						U
36	0602783A	Computer and Software Technology	02						U

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37	0602784A	Military Engineering Technology	02	114,947	101,124		101,124	U
38	0602785A	Manpower/Personnel/Training Technology	02	19,791	21,847		21,847	U
39	0602786A	Warfighter Technology	02	58,476	56,532		56,532	U
40	0602787A	Medical Technology	02	88,891	92,003		92,003	U
		Applied Research		1,342,832	1,578,725		1,578,725	
41	0603001A	Warfighter Advanced Technology	03	53,763	41,795		41,795	U
42	0603002A	Medical Advanced Technology	03	103,908	101,442		101,442	U
43	0603003A	Aviation Advanced Technology	03	172,545	169,411		169,411	U
44	0603004A	Weapons and Munitions Advanced Technology	03	195,345	241,581		241,581	U
45	0603005A	Combat Vehicle and Automotive Advanced Technology	03	154,084	176,622		176,622	U
46	0603006A	Space Application Advanced Technology	03	39,277	48,985		48,985	U
47	0603007A	Manpower, Personnel and Training Advanced Technology	03	5,063	8,038		8,038	U
48	0603009A	TRACTOR HIKE	03	39,302	22,631		22,631	U
49	0603015A	Next Generation Training & Simulation Systems	03	15,778	28,650		28,650	U
50	0603117A	Army Advanced Technology Development	03					U
51	0603118A	Soldier Lethality Advanced Technology	03					U
52	0603119A	Ground Advanced Technology	03					U

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
37	0602784A	Military Engineering Technology	02						U
38	0602785A	Manpower/Personnel/Training Technology	02	20,873				20,873	U
39	0602786A	Warfighter Technology	02						U
40	0602787A	Medical Technology	02	99,155				99,155	U
		Applied Research		893,990				893,990	
41	0603001A	Warfighter Advanced Technology	03						U
42	0603002A	Medical Advanced Technology	03	42,030				42,030	U
43	0603003A	Aviation Advanced Technology	03						U
44	0603004A	Weapons and Munitions Advanced Technology	03						U
45	0603005A	Combat Vehicle and Automotive Advanced Technology	03						U
46	0603006A	Space Application Advanced Technology	03						U
47	0603007A	Manpower, Personnel and Training Advanced Technology	03	11,038				11,038	U
48	0603009A	TRACTOR HIKE	03						U
49	0603015A	Next Generation Training & Simulation Systems	03						U
50	0603117A	Army Advanced Technology Development	03	63,338				63,338	U
51	0603118A	Soldier Lethality Advanced Technology	03	118,468				118,468	U
52	0603119A	Ground Advanced Technology	03	12,593				12,593	U

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Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
53	0603125A	Combating Terrorism - Technology Development	03	44,088	36,757		36,757	U
54	0603130A	TRACTOR NAIL	03	4,880	4,896		4,896	U
55	0603131A	TRACTOR EGGS	03	4,326	6,041		6,041	U
56	0603270A	Electronic Warfare Technology	03	33,249	41,458		41,458	U
57	0603313A	Missile and Rocket Advanced Technology	03	133,433	94,561		94,561	U
58	0603322A	TRACTOR CAGE	03	12,323	16,845		16,845	U
59	0603457A	C3I Cyber Advanced Development	03					U
60	0603461A	High Performance Computing Modernization Program	03	214,100	218,098		218,098	U
61	0603462A	Next Generation Combat Vehicle Advanced Technology	03					U
62	0603463A	Network C3I Advanced Technology	03					U
63	0603464A	Long Range Precision Fires Advanced Technology	03					U
64	0603465A	Future Vertical Lift Advanced Technology	03					U
65	0603466A	Air and Missile Defense Advanced Technology	03					U
66	0603606A	Landmine Warfare and Barrier Advanced Technology	03	18,473	17,097		17,097	U
67	0603607A	Joint Service Small Arms Program	03	5,628	22,799		22,799	U
68	0603710A	Night Vision Advanced Technology	03	45,617	61,313		61,313	U

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
53	0603125A	Combating Terrorism - Technology Development	03						U
54	0603130A	TRACTOR NAIL	03						U
55	0603131A	TRACTOR EGGS	03						U
56	0603270A	Electronic Warfare Technology	03						U
57	0603313A	Missile and Rocket Advanced Technology	03						U
58	0603322A	TRACTOR CAGE	03						U
59	0603457A	C3I Cyber Advanced Development	03	13,769				13,769	U
60	0603461A	High Performance Computing Modernization Program	03	184,755				184,755	U
61	0603462A	Next Generation Combat Vehicle Advanced Technology	03	160,035				160,035	U
62	0603463A	Network C3I Advanced Technology	03	106,899				106,899	U
63	0603464A	Long Range Precision Fires Advanced Technology	03	174,386				174,386	U
64	0603465A	Future Vertical Lift Advanced Technology	03	151,640				151,640	U
65	0603466A	Air and Missile Defense Advanced Technology	03	60,613				60,613	U
66	0603606A	Landmine Warfare and Barrier Advanced Technology	03						U
67	0603607A	Joint Service Small Arms Program	03						U
68	0603710A	Night Vision Advanced Technology	03						U

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Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
69	0603728A	Environmental Quality Technology Demonstrations	03	29,150	29,132		29,132	U
70	0603734A	Military Engineering Advanced Technology	03	96,586	101,438		101,438	U
71	0603772A	Advanced Tactical Computer Science and Sensor Technology	03	50,637	43,856		43,856	U
72	0603794A	C3 Advanced Technology	03	32,404	52,332		52,332	U
		Advanced Technology Development		1,503,959	1,585,778		1,585,778	
73	0603305A	Army Missle Defense Systems Integration	04	23,558	60,472		60,472	U
74	0603327A	Air and Missile Defense Systems Engineering	04	58,812	45,231	1,000	46,231	U
75	0603619A	Landmine Warfare and Barrier - Adv Dev	04	69,237	45,198		45,198	U
76	0603627A	Smoke, Obscurant and Target Defeating Sys-Adv Dev	04	8,920	20,674		20,674	U
77	0603639A	Tank and Medium Caliber Ammunition	04	45,448	41,921		41,921	U
78	0603645A	Armored System Modernization - Adv Dev	04	41,431	84,297		84,297	U
79	0603747A	Soldier Support and Survivability	04	15,759	8,735	3,000	11,735	U
80	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	27,733	35,667		35,667	U
81	0603774A	Night Vision Systems Advanced Development	04	501,816	7,341		7,341	U
82	0603779A	Environmental Quality Technology - Dem/Val	04	15,039	14,731		14,731	U

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
69	0603728A	Environmental Quality Technology Demonstrations	03						U
70	0603734A	Military Engineering Advanced Technology	03						U
71	0603772A	Advanced Tactical Computer Science and Sensor Technology	03						U
72	0603794A	C3 Advanced Technology	03						U
		Advanced Technology Development		1,099,564				1,099,564	
73	0603305A	Army Missle Defense Systems Integration	04	10,987				10,987	U
74	0603327A	Air and Missile Defense Systems Engineering	04	15,148		500	500	15,648	U
75	0603619A	Landmine Warfare and Barrier - Adv Dev	04	92,915				92,915	U
76	0603627A	Smoke, Obscurant and Target Defeating Sys-Adv Dev	04						U
77	0603639A	Tank and Medium Caliber Ammunition	04	82,146				82,146	U
78	0603645A	Armored System Modernization - Adv Dev	04	157,656				157,656	U
79	0603747A	Soldier Support and Survivability	04	6,514		3,000	3,000	9,514	U
80	0603766A	Tactical Electronic Surveillance System - Adv Dev	04	34,890				34,890	U
81	0603774A	Night Vision Systems Advanced Development	04	251,011				251,011	U
82	0603779A	Environmental Quality Technology - Dem/Val	04	15,132				15,132	U

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83	0603790A	NATO Research and Development	04	2,485	3,682		3,682	U
84	0603801A	Aviation - Adv Dev	04	9,653	86,180		86,180	U
85	0603804A	Logistics and Engineer Equipment - Adv Dev	04	29,619	17,230		17,230	U
86	0603807A	Medical Systems - Adv Dev	04	36,279	39,244		39,244	U
87	0603827A	Soldier Systems - Advanced Development	04	60,774	31,022		31,022	U
88	0604017A	Robotics Development	04	38,051	74,368		74,368	U
89	0604020A	Cross Functional Team (CFT) Advanced Development & Prototyping	04		9,488		9,488	U
90	0604021A	Electronic Warfare Technology Maturation (MIP)	04					U
91	0604100A	Analysis Of Alternatives	04	7,307	9,753		9,753	U
92	0604113A	Future Tactical Unmanned Aircraft System (FTUAS)	04		12,393		12,393	U
93	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04	57,437	89,248		89,248	U
94	0604115A	Technology Maturation Initiatives	04	145,618	95,229		95,229	U
95	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04	19,201	79,016		79,016	U
96	0604118A	TRACTOR BEAM	04	10,400	52,894		52,894	U
97	0604119A	Army Advanced Component Development & Prototyping	04					U
98	0604120A	Assured Positioning, Navigation and Timing (PNT)	04	132,810				U

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83	0603790A	NATO Research and Development	04	5,406				5,406	U
84	0603801A	Aviation - Adv Dev	04	459,290				459,290	U
85	0603804A	Logistics and Engineer Equipment - Adv Dev	04	6,254		1,085	1,085	7,339	U
86	0603807A	Medical Systems - Adv Dev	04	31,175				31,175	U
87	0603827A	Soldier Systems - Advanced Development	04	22,113				22,113	U
88	0604017A	Robotics Development	04	115,222				115,222	U
89	0604020A	Cross Functional Team (CFT) Advanced Development & Prototyping	04						U
90	0604021A	Electronic Warfare Technology Maturation (MIP)	04	18,043				18,043	U
91	0604100A	Analysis Of Alternatives	04	10,023				10,023	U
92	0604113A	Future Tactical Unmanned Aircraft System (FTUAS)	04	40,745				40,745	U
93	0604114A	Lower Tier Air Missile Defense (LTAMD) Sensor	04	427,772				427,772	U
94	0604115A	Technology Maturation Initiatives	04	196,676				196,676	U
95	0604117A	Maneuver - Short Range Air Defense (M-SHORAD)	04	33,100		6,000	6,000	39,100	U
96	0604118A	TRACTOR BEAM	04						U
97	0604119A	Army Advanced Component Development & Prototyping	04	115,116		4,529	4,529	119,645	U
98	0604120A	Assured Positioning, Navigation and Timing (PNT)	04						U

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99	0604121A	Synthetic Training Environment Refinement & Prototyping	04	109,165	39,890		39,890	U
100	0604182A	Hypersonics	04					U
101	0604319A	Indirect Fire Protection Capability Increment 2-Intercept (IFPC2)	04	10,871	40,979		40,979	U
102	0604403A	Future Interceptor	04					U
103	0604541A	Unified Network Transport	04					U
104	0604644A	Mobile Medium Range Missile	04					U
105	0604785A	Integrated Base Defense (Budget Activity 4)	04					U
106	0305251A	Cyberspace Operations Forces and Force Support	04	56,071	52,817		52,817	U
107	1206120A	Assured Positioning, Navigation and Timing (PNT)	04		128,640		128,640	U
108	1206308A	Army Space Systems Integration	04	30,121	38,307		38,307	U
		Advanced Component Development & Prototypes		1,563,615	1,264,647	4,000	1,268,647	
109	0604201A	Aircraft Avionics	05	30,812	32,253		32,253	U
110	0604270A	Electronic Warfare Development	05	68,935	58,627		58,627	U
111	0604321A	All Source Analysis System	05	4,774				U
112	0604328A	TRACTOR CAGE	05	30,252	17,050	12,000	29,050	U
113	0604601A	Infantry Support Weapons	05	99,145	63,793		63,793	U
114	0604604A	Medium Tactical Vehicles	05	5,798	3,699		3,699	U
115	0604611A	JAVELIN	05	20,252	5,616		5,616	U

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99	0604121A	Synthetic Training Environment Refinement & Prototyping	04	136,761				136,761	U
100	0604182A	Hypersonics	04	228,000				228,000	U
101	0604319A	Indirect Fire Protection Capability Increment 2-Intercept (IFPC2)	04						U
102	0604403A	Future Interceptor	04	8,000				8,000	U
103	0604541A	Unified Network Transport	04	39,600				39,600	U
104	0604644A	Mobile Medium Range Missile	04	20,000				20,000	U
105	0604785A	Integrated Base Defense (Budget Activity 4)	04			2,000	2,000	2,000	U
106	0305251A	Cyberspace Operations Forces and Force Support	04	52,102				52,102	U
107	1206120A	Assured Positioning, Navigation and Timing (PNT)	04	192,562				192,562	U
108	1206308A	Army Space Systems Integration	04	104,996				104,996	U
		Advanced Component Development & Prototypes		2,929,355		17,114	17,114	2,946,469	
109	0604201A	Aircraft Avionics	05	29,164				29,164	U
110	0604270A	Electronic Warfare Development	05	70,539				70,539	U
111	0604321A	All Source Analysis System	05						U
112	0604328A	TRACTOR CAGE	05						U
113	0604601A	Infantry Support Weapons	05	106,121				106,121	U
114	0604604A	Medium Tactical Vehicles	05	2,152				2,152	U
115	0604611A	JAVELIN	05	17,897				17,897	U

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116	0604622A	Family of Heavy Tactical Vehicles	05	10,086	11,935		11,935	U
117	0604633A	Air Traffic Control	05	3,433	12,332		12,332	U
118	0604642A	Light Tactical Wheeled Vehicles	05	3,619	1,276		1,276	U
119	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05	34,794	373,337		373,337	U
120	0604710A	Night Vision Systems - Eng Dev	05	184,389	144,442		144,442	U
121	0604713A	Combat Feeding, Clothing, and Equipment	05	8,561	4,502		4,502	U
122	0604715A	Non-System Training Devices - Eng Dev	05	51,900	44,381		44,381	U
123	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	190,385	93,073	119,300	212,373	U
124	0604742A	Constructive Simulation Systems Development	05	17,921	22,600		22,600	U
125	0604746A	Automatic Test Equipment Development	05	7,054	11,782		11,782	U
126	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	10,890	9,134		9,134	U
127	0604768A	Brilliant Anti-Armor Submunition (BAT)	05	7,886	6,886		6,886	U
128	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	17,855	21,936		21,936	U
129	0604798A	Brigade Analysis, Integration and Evaluation	05	139,386	49,250		49,250	U
130	0604802A	Weapons and Munitions - Eng Dev	05	144,389	172,744		172,744	U

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116	0604622A	Family of Heavy Tactical Vehicles	05	16,745				16,745	U
117	0604633A	Air Traffic Control	05	6,989				6,989	U
118	0604642A	Light Tactical Wheeled Vehicles	05	10,465				10,465	U
119	0604645A	Armored Systems Modernization (ASM) - Eng Dev	05	310,152				310,152	U
120	0604710A	Night Vision Systems - Eng Dev	05	181,732				181,732	U
121	0604713A	Combat Feeding, Clothing, and Equipment	05	2,393				2,393	U
122	0604715A	Non-System Training Devices - Eng Dev	05	27,412				27,412	U
123	0604741A	Air Defense Command, Control and Intelligence - Eng Dev	05	43,502				43,502	U
124	0604742A	Constructive Simulation Systems Development	05	11,636				11,636	U
125	0604746A	Automatic Test Equipment Development	05	10,915				10,915	U
126	0604760A	Distributive Interactive Simulations (DIS) - Eng Dev	05	7,801				7,801	U
127	0604768A	Brilliant Anti-Armor Submunition (BAT)	05	25,000				25,000	U
128	0604780A	Combined Arms Tactical Trainer (CATT) Core	05	9,241				9,241	U
129	0604798A	Brigade Analysis, Integration and Evaluation	05	42,634				42,634	U
130	0604802A	Weapons and Munitions - Eng Dev	05	181,023				181,023	U

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131	0604804A	Logistics and Engineer Equipment - Eng Dev	05	76,030	76,388		76,388	U
132	0604805A	Command, Control, Communications Systems - Eng Dev	05	9,559	15,950		15,950	U
133	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	36,685	44,495		44,495	U
134	0604808A	Landmine Warfare/Barrier - Eng Dev	05	26,188	43,064		43,064	U
135	0604818A	Army Tactical Command & Control Hardware & Software	05	157,852	169,607		169,607	U
136	0604820A	Radar Development	05	31,651	39,289		39,289	U
137	0604822A	General Fund Enterprise Business System (GFEBS)	05	47,575	36,810		36,810	U
138	0604823A	Firefinder	05	43,762	27,439		27,439	U
139	0604827A	Soldier Systems - Warrior Dem/Val	05	15,490	10,382		10,382	U
140	0604852A	Suite of Survivability Enhancement Systems - EMD	05	90,187	52,839		52,839	U
141	0604854A	Artillery Systems - EMD	05	3,892	1,779		1,779	U
142	0605013A	Information Technology Development	05	62,613	77,686		77,686	U
143	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	188,637	164,899		164,899	U
144	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	184,300	111,821		111,821	U
145	0605029A	Integrated Ground Security Surveillance Response Capability (IGSSR-C)	05	4,241	3,207		3,207	U
146	0605030A	Joint Tactical Network Center (JTNC)	05	15,242	15,869		15,869	U

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131	0604804A	Logistics and Engineer Equipment - Eng Dev	05	103,226				103,226	U
132	0604805A	Command, Control, Communications Systems - Eng Dev	05	12,595				12,595	U
133	0604807A	Medical Materiel/Medical Biological Defense Equipment - Eng Dev	05	48,264				48,264	U
134	0604808A	Landmine Warfare/Barrier - Eng Dev	05	39,208				39,208	U
135	0604818A	Army Tactical Command & Control Hardware & Software	05	140,637				140,637	U
136	0604820A	Radar Development	05	105,243				105,243	U
137	0604822A	General Fund Enterprise Business System (GFEBS)	05	46,683				46,683	U
138	0604823A	Firefinder	05	17,294				17,294	U
139	0604827A	Soldier Systems - Warrior Dem/Val	05	5,803				5,803	U
140	0604852A	Suite of Survivability Enhancement Systems - EMD	05	98,698				98,698	U
141	0604854A	Artillery Systems - EMD	05	15,832				15,832	U
142	0605013A	Information Technology Development	05	126,537				126,537	U
143	0605018A	Integrated Personnel and Pay System-Army (IPPS-A)	05	142,773				142,773	U
144	0605028A	Armored Multi-Purpose Vehicle (AMPV)	05	96,730				96,730	U
145	0605029A	Integrated Ground Security Surveillance Response Capability (IGSSR-C)	05	6,699				6,699	U
146	0605030A	Joint Tactical Network Center (JTNC)	05	15,882				15,882	U

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147	0605031A	Joint Tactical Network (JTN)	05	46,051	41,920		41,920	U
148	0605032A	TRACTOR TIRE	05	118,570	41,166	66,760	107,926	U
149	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05	20,661	5,169		5,169	U
150	0605034A	Tactical Security System (TSS)	05	3,998	4,490		4,490	U
151	0605035A	Common Infrared Countermeasures (CIRCM)	05	97,746	31,139	2,670	33,809	U
152	0605036A	Combating Weapons of Mass Destruction (CWMD)	05	6,650	11,297		11,297	U
153	0605037A	Evidence Collection and Detainee Processing	05	206				U
154	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05	15,481	15,135		15,135	U
155	0605041A	Defensive CYBER Tool Development	05	41,441	33,796		33,796	U
156	0605042A	Tactical Network Radio Systems (Low-Tier)	05	8,845	3,825		3,825	U
157	0605047A	Contract Writing System	05	19,574	41,876		41,876	U
158	0605049A	Missile Warning System Modernization (MWSM)	05	12,480	8,266		8,266	U
159	0605051A	Aircraft Survivability Development	05	169,752	21,938	34,933	56,871	U
160	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05	156,361	132,283		132,283	U
161	0605053A	Ground Robotics	05	60,530	71,435		71,435	U

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147	0605031A	Joint Tactical Network (JTN)	05	40,808				40,808	U
148	0605032A	TRACTOR TIRE	05						U
149	0605033A	Ground-Based Operational Surveillance System - Expeditionary (GBOSS-E)	05	3,847				3,847	U
150	0605034A	Tactical Security System (TSS)	05	6,928				6,928	U
151	0605035A	Common Infrared Countermeasures (CIRCM)	05	34,488		11,770	11,770	46,258	U
152	0605036A	Combating Weapons of Mass Destruction (CWMD)	05	10,000				10,000	U
153	0605037A	Evidence Collection and Detainee Processing	05						U
154	0605038A	Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV) Sensor Suite	05	6,054				6,054	U
155	0605041A	Defensive CYBER Tool Development	05	62,262				62,262	U
156	0605042A	Tactical Network Radio Systems (Low-Tier)	05	35,654				35,654	U
157	0605047A	Contract Writing System	05	19,682				19,682	U
158	0605049A	Missile Warning System Modernization (MWSM)	05	1,539				1,539	U
159	0605051A	Aircraft Survivability Development	05	64,557		77,420	77,420	141,977	U
160	0605052A	Indirect Fire Protection Capability Inc 2 - Block 1	05	243,228				243,228	U
161	0605053A	Ground Robotics	05	41,308				41,308	U

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162	0605054A	Emerging Technology Initiatives	05		42,813		42,813	U
163	0605203A	Army System Development & Demonstration	05					U
164	0605380A	AMF Joint Tactical Radio System (JTRS)	05	18,639	15,964		15,964	U
165	0605450A	Joint Air-to-Ground Missile (JAGM)	05	28,539	11,758		11,758	U
166	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	339,051	322,263		322,263	U
167	0605625A	Manned Ground Vehicle	05					U
168	0605766A	National Capabilities Integration (MIP)	05	9,382	12,340		12,340	U
169	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	22,530				U
170	0605830A	Aviation Ground Support Equipment	05	6,653	7,703		7,703	U
171	0210609A	Paladin Integrated Management (PIM)	05	5,868				U
172	0303032A	TROJAN - RH12	05	5,631	4,521	1,200	5,721	U
173	0303267A	Auctioned Spectrum Relocation Fund	05	15,885				U
174	0304270A	Electronic Warfare Development	05	14,616	8,922		8,922	U
175	1205117A	Tractor Bears	05	17,928	23,170		23,170	U
		System Development & Demonstration		3,349,488	2,965,361	236,863	3,202,224	
176	0604256A	Threat Simulator Development	06	31,401	47,322		47,322	U
177	0604258A	Target Systems Development	06	13,467	32,120		32,120	U

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162	0605054A	Emerging Technology Initiatives	05	45,896				45,896	U
163	0605203A	Army System Development & Demonstration	05	164,883		19,527	19,527	184,410	U
164	0605380A	AMF Joint Tactical Radio System (JTRS)	05						U
165	0605450A	Joint Air-to-Ground Missile (JAGM)	05	9,500				9,500	U
166	0605457A	Army Integrated Air and Missile Defense (AIAMD)	05	208,938				208,938	U
167	0605625A	Manned Ground Vehicle	05	378,400				378,400	U
168	0605766A	National Capabilities Integration (MIP)	05	7,835				7,835	U
169	0605812A	Joint Light Tactical Vehicle (JLTV) Engineering and Manufacturing Development Ph	05	2,732				2,732	U
170	0605830A	Aviation Ground Support Equipment	05	1,664				1,664	U
171	0210609A	Paladin Integrated Management (PIM)	05						U
172	0303032A	TROJAN - RH12	05	3,936				3,936	U
173	0303267A	Auctioned Spectrum Relocation Fund	05						U
174	0304270A	Electronic Warfare Development	05	19,675		3,200	3,200	22,875	U
175	1205117A	Tractor Bears	05						U
		System Development & Demonstration		3,549,431		111,917	111,917	3,661,348	
176	0604256A	Threat Simulator Development	06	14,117				14,117	U
177	0604258A	Target Systems Development	06	8,327				8,327	U

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178	0604759A	Major T&E Investment	06	113,516	82,893		82,893	U
179	0605103A	Rand Arroyo Center	06	19,336	19,796		19,796	U
180	0605301A	Army Kwajalein Atoll	06	234,010	246,275		246,275	U
181	0605326A	Concepts Experimentation Program	06	28,701	30,394		30,394	U
182	0605502A	Small Business Innovative Research	06	284,080				U
183	0605601A	Army Test Ranges and Facilities	06	313,589	315,634		315,634	U
184	0605602A	Army Technical Test Instrumentation and Targets	06	57,395	84,805		84,805	U
185	0605604A	Survivability/Lethality Analysis	06	41,296	40,480		40,480	U
186	0605606A	Aircraft Certification	06	4,612	3,936		3,936	U
187	0605702A	Meteorological Support to RDT&E Activities	06	7,070	9,759		9,759	U
188	0605706A	Materiel Systems Analysis	06	21,694	21,223		21,223	U
189	0605709A	Exploitation of Foreign Items	06	12,684	13,026		13,026	U
190	0605712A	Support of Operational Testing	06	50,723	52,705		52,705	U
191	0605716A	Army Evaluation Center	06	56,003	57,039		57,039	U
192	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	1,756	2,798		2,798	U
193	0605801A	Programwide Activities	06	54,383	60,921		60,921	U
194	0605803A	Technical Information Activities	06	39,613	29,024		29,024	U
195	0605805A	Munitions Standardization, Effectiveness and Safety	06	65,709	72,279		72,279	U

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
178	0604759A	Major T&E Investment	06	136,565				136,565	U
179	0605103A	Rand Arroyo Center	06	13,113				13,113	U
180	0605301A	Army Kwajalein Atoll	06	238,691				238,691	U
181	0605326A	Concepts Experimentation Program	06	42,922				42,922	U
182	0605502A	Small Business Innovative Research	06						U
183	0605601A	Army Test Ranges and Facilities	06	334,468				334,468	U
184	0605602A	Army Technical Test Instrumentation and Targets	06	46,974				46,974	U
185	0605604A	Survivability/Lethality Analysis	06	35,075				35,075	U
186	0605606A	Aircraft Certification	06	3,461				3,461	U
187	0605702A	Meteorological Support to RDT&E Activities	06	6,233				6,233	U
188	0605706A	Materiel Systems Analysis	06	21,342				21,342	U
189	0605709A	Exploitation of Foreign Items	06	11,168				11,168	U
190	0605712A	Support of Operational Testing	06	52,723				52,723	U
191	0605716A	Army Evaluation Center	06	60,815				60,815	U
192	0605718A	Army Modeling & Sim X-Cmd Collaboration & Integ	06	2,527				2,527	U
193	0605801A	Programwide Activities	06	58,175				58,175	U
194	0605803A	Technical Information Activities	06	25,060				25,060	U
195	0605805A	Munitions Standardization, Effectiveness and Safety	06	44,458				44,458	U

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Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
196	0605857A	Environmental Quality Technology Mgmt Support	06	4,883	3,211		3,211	U
197	0605898A	Army Direct Report Headquarters - R&D - MHA	06	54,177	54,130		54,130	U
198	0606001A	Military Ground-Based CREW Technology	06	7,600	4,890		4,890	U
199	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06	59,042	62,940		62,940	U
200	0606003A	CounterIntel and Human Intel Modernization	06		2,636		2,636	U
201	0606942A	Assessments and Evaluations Cyber Vulnerabilities	06		88,300		88,300	U
202	0303260A	Defense Military Deception Initiative	06	1,708				U
203	0909999A	Financing for Cancelled Account Adjustments	06	654				U
	RDT&E	Management Support		1,579,102	1,438,536		1,438,536	
204	0603778A	MLRS Product Improvement Program	07	10,286	6,877		6,877	U
205	0603813A	TRACTOR PULL	07	4,014	4,067		4,067	U
206	0605024A	Anti-Tamper Technology Support	07	4,009	7,251		7,251	U
207	0607131A	Weapons and Munitions Product Improvement Programs	07	16,302	16,003	2,548	18,551	U
208	0607133A	TRACTOR SMOKE	07	12,143	4,577	7,780	12,357	U
209	0607134A	Long Range Precision Fires (LRPF)	07	80,690	159,278		159,278	U
210	0607135A	Apache Product Improvement Program	07	55,565	24,019		24,019	U

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
196	0605857A	Environmental Quality Technology Mgmt Support	06	4,681				4,681	U
197	0605898A	Army Direct Report Headquarters - R&D - MHA	06	53,820				53,820	U
198	0606001A	Military Ground-Based CREW Technology	06	4,291				4,291	U
199	0606002A	Ronald Reagan Ballistic Missile Defense Test Site	06	62,069				62,069	U
200	0606003A	CounterIntel and Human Intel Modernization	06	1,050		1,875	1,875	2,925	U
201	0606942A	Assessments and Evaluations Cyber Vulnerabilities	06	4,500				4,500	U
202	0303260A	Defense Military Deception Initiative	06						U
203	0909999A	Financing for Cancelled Account Adjustments	06						U
	RDT&E	Management Support		1,286,625		1,875	1,875	1,288,500	
204	0603778A	MLRS Product Improvement Program	07	22,877				22,877	U
205	0603813A	TRACTOR PULL	07						U
206	0605024A	Anti-Tamper Technology Support	07	8,491				8,491	U
207	0607131A	Weapons and Munitions Product Improvement Programs	07	15,645				15,645	U
208	0607133A	TRACTOR SMOKE	07						U
209	0607134A	Long Range Precision Fires (LRPF)	07	164,182				164,182	U
210	0607135A	Apache Product Improvement Program	07						U

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Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
211	0607136A	Blackhawk Product Improvement Program	07	48,241	35,196		35,196	U
212	0607137A	Chinook Product Improvement Program	07	155,433	144,722		144,722	U
213	0607138A	Fixed Wing Product Improvement Program	07	7,782	2,280		2,280	U
214	0607139A	Improved Turbine Engine Program	07	167,532	188,903		188,903	U
215	0607140A	Emerging Technologies from NIE	07	26,112				U
216	0607142A	Aviation Rocket System Product Improvement and Development	07	9,662	38,452		38,452	U
217	0607143A	Unmanned Aircraft System Universal Products	07	36,926	38,331		38,331	U
218	0607145A	Apache Future Development	07					U
219	0607312A	Army Operational Systems Development	07					U
220	0607665A	Family of Biometrics	07	3,032	2,397		2,397	U
221	0607865A	Patriot Product Improvement	07	77,391	75,288		75,288	U
222	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	32,256	30,915		30,915	U
223	0203735A	Combat Vehicle Improvement Programs	07	293,921	336,063		336,063	U
224	0203740A	Maneuver Control System	07	6,443				U
225	0203743A	155mm Self-Propelled Howitzer Improvements	07	39,154	37,155		37,155	U
226	0203744A	Aircraft Modifications/Product Improvement Programs	07	34,228	17,684		17,684	U

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
211	0607136A	Blackhawk Product Improvement Program	07	13,039				13,039	U
212	0607137A	Chinook Product Improvement Program	07	174,371				174,371	U
213	0607138A	Fixed Wing Product Improvement Program	07	4,545				4,545	U
214	0607139A	Improved Turbine Engine Program	07	206,434				206,434	U
215	0607140A	Emerging Technologies from NIE	07						U
216	0607142A	Aviation Rocket System Product Improvement and Development	07	24,221				24,221	U
217	0607143A	Unmanned Aircraft System Universal Products	07	32,016				32,016	U
218	0607145A	Apache Future Development	07	5,448				5,448	U
219	0607312A	Army Operational Systems Development	07	49,526				49,526	U
220	0607665A	Family of Biometrics	07	1,702				1,702	U
221	0607865A	Patriot Product Improvement	07	96,430				96,430	U
222	0203728A	Joint Automated Deep Operation Coordination System (JADOCS)	07	47,398				47,398	U
223	0203735A	Combat Vehicle Improvement Programs	07	334,463				334,463	U
224	0203740A	Maneuver Control System	07						U
225	0203743A	155mm Self-Propelled Howitzer Improvements	07	214,246				214,246	U
226	0203744A	Aircraft Modifications/Product Improvement Programs	07	16,486				16,486	U

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Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
227	0203752A	Aircraft Engine Component Improvement Program	07	139	146		146	U
228	0203758A	Digitization	07	4,611	6,308		6,308	U
229	0203801A	Missile/Air Defense Product Improvement Program	07	43,615	1,641	2,000	3,641	U
230	0203802A	Other Missile Product Improvement Programs	07	4,800	4,941		4,941	U
231	0203808A	TRACTOR CARD	07	37,883	34,050		34,050	U
232	0205402A	Integrated Base Defense - Operational System Dev	07			8,000	8,000	U
233	0205410A	Materials Handling Equipment	07	1,519	1,462		1,462	U
234	0205412A	Environmental Quality Technology - Operational System Dev	07	187	249		249	U
235	0205456A	Lower Tier Air and Missile Defense (AMD) System	07	69,558	77,188		77,188	U
236	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	93,900	118,955		118,955	U
238	0303028A	Security and Intelligence Activities	07	35,652	12,277	23,199	35,476	U
239	0303140A	Information Systems Security Program	07	108,755	42,520		42,520	U
240	0303141A	Global Combat Support System	07	45,372	53,855		53,855	U
241	0303150A	WWMCCS/Global Command and Control System	07	10,055	2,031		2,031	U
244	0305172A	Combined Advanced Applications	07	1,100	1,500		1,500	U
245	0305179A	Integrated Broadcast Service (IBS)	07		450		450	U

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
227	0203752A	Aircraft Engine Component Improvement Program	07	144				144	U
228	0203758A	Digitization	07	5,270				5,270	U
229	0203801A	Missile/Air Defense Product Improvement Program	07	1,287				1,287	U
230	0203802A	Other Missile Product Improvement Programs	07						U
231	0203808A	TRACTOR CARD	07						U
232	0205402A	Integrated Base Defense - Operational System Dev	07						U
233	0205410A	Materials Handling Equipment	07						U
234	0205412A	Environmental Quality Technology - Operational System Dev	07	732				732	U
235	0205456A	Lower Tier Air and Missile Defense (AMD) System	07	107,746				107,746	U
236	0205778A	Guided Multiple-Launch Rocket System (GMLRS)	07	138,594				138,594	U
238	0303028A	Security and Intelligence Activities	07	13,845		22,904	22,904	36,749	U
239	0303140A	Information Systems Security Program	07	29,185				29,185	U
240	0303141A	Global Combat Support System	07	68,976				68,976	U
241	0303150A	WWMCCS/Global Command and Control System	07	2,073				2,073	U
244	0305172A	Combined Advanced Applications	07						U
245	0305179A	Integrated Broadcast Service (IBS)	07	459				459	U

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Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
246	0305204A	Tactical Unmanned Aerial Vehicles	07	16,925	6,000		6,000	U
247	0305206A	Airborne Reconnaissance Systems	07	20,080	12,416	14,000	26,416	U
248	0305208A	Distributed Common Ground/Surface Systems	07	24,700	27,109		27,109	U
249	0305219A	MQ-1C Gray Eagle UAS	07	10,531				U
250	0305232A	RQ-11 UAV	07	12,691	6,180		6,180	U
251	0305233A	RQ-7 UAV	07	12,773	17,863		17,863	U
252	0307665A	Biometrics Enabled Intelligence	07	8,573	4,310	2,214	6,524	U
253	0708045A	End Item Industrial Preparedness Activities	07	118,410	108,696		108,696	U
254	1203142A	SATCOM Ground Environment (SPACE)	07	9,945	12,105		12,105	U
255	1208053A	Joint Tactical Ground System	07	10,228	7,400		7,400	U
9999	9999999999	Classified Programs		7,154	5,955		5,955	U
		Operational Systems Development		1,830,278	1,735,065	59,741	1,794,806	
		Total Research, Development, Test & Eval, Army		11,633,461	11,074,556	300,604	11,375,160	

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
246	0305204A	Tactical Unmanned Aerial Vehicles	07	5,097		34,100	34,100	39,197	U
247	0305206A	Airborne Reconnaissance Systems	07	11,177		14,000	14,000	25,177	U
248	0305208A	Distributed Common Ground/Surface Systems	07	38,121				38,121	U
249	0305219A	MQ-1C Gray Eagle UAS	07						U
250	0305232A	RQ-11 UAV	07	3,218				3,218	U
251	0305233A	RQ-7 UAV	07	7,817				7,817	U
252	0307665A	Biometrics Enabled Intelligence	07	2,000		2,214	2,214	4,214	U
253	0708045A	End Item Industrial Preparedness Activities	07	59,848				59,848	U
254	1203142A	SATCOM Ground Environment (SPACE)	07	34,169				34,169	U
255	1208053A	Joint Tactical Ground System	07	10,275				10,275	U
9999	9999999999	Classified Programs		7,273				7,273	U
		Operational Systems Development		1,978,826		73,218	73,218	2,052,044	
Total Research, Development, Test & Eval, Army				12,192,771		204,124	204,124	12,396,895	

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601101A *I In-House Laboratory Independent Research*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	-	11.783	11.579	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
91A: *ILIR-AMC*	-	10.867	10.620	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
F16: *ILIR-SMDC*	-	0.916	0.959	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

Note

In Fiscal Year (FY) 2020 this Program Element (PE) is realigned with continuity of effort to the following:
? PE 0601102A Defense Research Sciences

A. Mission Description and Budget Item Justification

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

This PE supports ILIR at the Army Futures Command's six Research, Development, and Engineering Centers (Project 91A), and at the United States (US) Space and Missile Defense Command (SMDC) (Project F16).

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

All FY 2020 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army					Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*			R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*		
B. Program Change Summary ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Previous President's Budget	12.010	11.585	11.779	-	11.779
Current President's Budget	11.783	11.579	0.000	-	0.000
Total Adjustments	-0.227	-0.006	-11.779	-	-11.779
• Congressional General Reductions	-0.005	-0.006			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.222	-			
• Adjustments to Budget Years	-	-	-11.779	-	-11.779

Change Summary Explanation

FY20 reduction related to Science and Technology financial restructuring.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*	Project (Number/Name) 91A / *ILIR-AMC*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
91A: *ILIR-AMC*	-	10.867	10.620	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

Note

In Fiscal Year (FY) 2020, this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA1 ILIR - AMC

A. Mission Description and Budget Item Justification

This Project funds basic research within the Army Materiel Command's (AMC) Research, Development, and Engineering Centers (RDECs) and lays the foundation for future developmental efforts by identifying the fundamental principles governing various phenomena and appropriate pathways to exploit this knowledge.

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 2018	FY 2019	FY 2020
Title: Edgewood Chemical Biological Center	1.071	0.955	-
Description: Funds basic research in chemistry, biology, biotechnology, and aerosol for countering improvised explosive devices (IEDs), obscurants, and/or target defeat. Work in this Project provides theoretical underpinnings for PE 0602622A (Chemical, Smoke, and Equipment Defeating Technologies). ***FY 2019 Plans:*** Conduct fundamental research in hierarchical systems through selective deposition and growth of metal-organic frameworks; synthetic biology focuses on understanding genetic drift, mutation rates, as well as the structure function relationships of proteins; and extend physical and mathematical investigations into aerosol particle charge behaviors that will help develop knowledge on their behavior during deposition into the atmosphere as well as in the respiratory tract. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** PE 0601101A Project 91A will move to PE 0601102A Defense Research Sciences / Project AA1 ILIR - AMC in FY20.			
Title: Armaments Research, Development and Engineering Center	1.386	1.409	-
Description: Funds basic research in weapons component development, explosives synthesis/detection and area denial. Work in this Project provides theoretical underpinnings for PE 0602307A (Advanced Weapons Technology). ***FY 2019 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Continue to conduct basic research that provides the underpinnings necessary for developing new explosives and propellants, smaller and more lethal warheads, lighter and stronger composite materials for guns and weapon platforms, algorithms for future intelligent munitions, and area denial technologies. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** PE 0601101A Project 91A will move to PE 0601102A Defense Research Sciences / Project AA1 ILIR - AMC in FY20.			
Title: Tank-Automotive Research, Development and Engineering Center ***Description:*** Funds basic research in ground vehicle technologies to include power, mobility, and unmanned systems. Work in this Project provides theoretical underpinnings for PE 0602601A (Combat Vehicle and Automotive Technology). ***FY 2019 Plans:*** Solicit research proposals to improve understanding and accelerate technology development focused on those topics of strategic importance to the Army ground vehicle community such as; semi-, fully-, and multiple autonomous vehicle operation and control, ground vehicle cybersecurity threat detection algorithms and resilience, lightweight materials and dissimilar material joining for thick section materials, advanced energy storage materials, corrosion modeling, and early detection mechanisms, and electrophoretic displays. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** PE 0601101A Project 91A will move to PE 0601102A Defense Research Sciences / Project AA1 ILIR - AMC in FY20.	1.277	1.208	-
Title: Natick Soldier Research, Development, and Engineering Center ***Description:*** Funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection. Work in this Project provides theoretical underpinnings for PE 0601102A (Defense Research Sciences), Project H52 (Equipment for the Soldier). ***FY 2019 Plans:*** Combine theoretical and experimental studies to investigate point contact antenna response to infrared/visible laser beams and understand photon-assisted tunneling (PAT), conductance, and rectification to advance future capability of lightweight, tunable visible/infrared Soldier borne power harvesting systems. Explore creating liquid crystals with tunable melting points and establish an understanding of the phases, and phase transitions of liquid crystals when confined in polymer matrices to enable future development of lightweight ?smart? textiles that can efficiently respond to external stimuli. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** PE 0601101A Project 91A will move to PE 0601102A Defense Research Sciences / Project AA1 ILIR - AMC in FY20.	1.125	1.102	-
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts	2.388	2.302	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Funds basic research in guided missile and rocket systems, directed energy weapons, unmanned vehicles, and related components. Work in this Project provides theoretical underpinnings for PE 0602303A (Missile Technology). ***FY 2019 Plans:*** Investigate optimal signal detection using mutual information to improve radar performance; explore the connection between nonlinear dynamics and communication theory to engineer chaotic oscillators in wireless datalinks, radar, and acoustic sensor devices; design hybrid nano-antennas based on nested and nearly overlapping plasmonic resonant modes for enhanced sensing, detection, energy harvesting, and nanoscale light manipulation; explore effects of low pressure collision broadening and interatomic forces for atom-based inertial navigation sensors; investigate linear and nonlinear optical materials with dielectric constant near zero for accurate clocks used for Global Positioning System (GPS) and inertial navigation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** PE 0601101A Project 91A will move to PE 0601102A Defense Research Sciences / Project AA1 ILIR - AMC in FY20.			
Title: Aviation and Missile Research, Development and Engineering Center: Aviation Efforts ***Description:*** Funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science. Work in this Project provides theoretical underpinnings for PE 0602211A (Aviation Technology). ***FY 2019 Plans:*** Conduct research on measurement techniques such as a hub-based camera system for rotor blade deformation measurements, microelectromechanical systems based sensors for unsteady airfoil pressure gradient measurements, and tomographic particle image velocimetry for volumetric flow measurements; conduct research on parallel-in-time computational fluid dynamics algorithms to realize the computation speed benefits of emerging peta-scale computer architecture. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** PE 0601101A Project 91A will move to PE 0601102A Defense Research Sciences / Project AA1 ILIR - AMC in FY20.	1.380	1.313	-
Title: Communications-Electronics Research, Development, and Engineering Center ***Description:*** Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors. Work in this Project provides theoretical underpinnings for PE 0602705A (Electronics and Electronic Devices). ***FY 2019 Plans:*** Conduct research on techniques for reducing the computational complexity and burden associated with massive multiple input ? multiple output antenna arrays; will research the mathematical relationship between the electric permittivity, magnetic permeability	2.240	2.143	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** 91A / *ILIR-AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
and thickness of the metamaterial in a conformal antenna; research energy harvesting which has a net zero or net positive effect on the metabolic rate by only harvesting energy during certain stages of the gait cycle; research deep learning algorithms and confidence-based likelihoods associated with classification decisions; innovate and create new integrable material solutions to enable smaller, lower cost phase shifters and tunable filters for use in radar, electronic warfare and communications systems; research phase shifting diode networks to use with 2-dimensional planar phased array with integrated antennas that operate at 60GHz ~ 1 THz; and research material parameters and device models for high fidelity simulation of III-V and II-VI optoelectronics. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** PE 0601101A Project 91A will move to PE 0601102A Defense Research Sciences / Project AA1 ILIR - AMC in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.188	-
Accomplishments/Planned Programs Subtotals	10.867	10.620	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601101A / *In-House Laboratory Independent Research*	Project (Number/Name) F16 / *ILIR-SMDC*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
F16: *ILIR-SMDC*	-	0.916	0.959	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

Note

In Fiscal Year (FY) 2020, this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA2 ILIR - SMDC

A. Mission Description and Budget Item Justification

This Project provides In-house Laboratory Independent Research (ILIR) at the United States (US) Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT). This basic research on lasers and directed energy lays the foundation for future developmental efforts on high energy lasers and directed energy systems by identifying the fundamental principles governing various directed energy phenomena.

Work in this Project is related to, and fully coordinated with, efforts in PE 0602307A (Advanced Weapons 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 2018	FY 2019	FY 2020
Title: SMDC In-house Laboratory Independent Research	0.916	0.959	-
Description: Funds basic research to investigate laser propagation phenomenology for application in modeling and simulation and future directed energy weapons design. Activities in this Project transition to High Energy Laser Technology in PE 0602307A (Advanced Weapons Technology). ***FY 2019 Plans:*** Complete data analysis and verification of engineering models to understand the viability of increasing the power to 10?s of watts for a diode pumped Xenon gas laser; investigate a laboratory bench top experiment of a direct diode concept to combine 10?s of diode sources into a single laser beam at the milli-watt level to understand key laser metrics and begin to evaluate scalability of the approach to watt class; and complete investigation of the beaconless adaptive optics approach for correcting a high energy laser beam (greater than 10kW) for propagation in the presence of particulates beyond 1km. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** PE 0601101A Project F16 will move to PE 0601102A Defense Research Sciences / Project AA2 ILIR - SMDC in FY20.			
Accomplishments/Planned Programs Subtotals	0.916	0.959	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601101A / *In-House Laboratory Independent Research*	**Project (Number/Name)** F16 / *ILIR-SMDC*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	-	274.098	315.660	297.976	-	297.976	302.259	311.198	319.500	323.126	0.000	2,143.817
305: *ATR Research*	-	2.071	2.141	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.212
31B: *Infrared Optics Rsch*	-	3.700	3.747	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.447
52C: *Mapping & Remote Sens*	-	2.077	2.140	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.217
53A: *Battlefield Env & Sig*	-	3.857	3.970	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.827
74A: *Human Engineering*	-	13.710	15.519	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	29.229
74F: *Pers Perf & Training*	-	5.278	5.579	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	10.857
AA1: *ILIR - AMC*	-	0.000	0.000	10.800	-	10.800	11.018	11.242	11.464	11.591	0.000	56.115
AA2: *ILIR - SMDC*	-	0.000	0.000	0.971	-	0.971	0.989	1.008	1.040	1.052	0.000	5.060
AA3: *Single Investigator Basic Research*	-	0.000	0.000	101.042	-	101.042	102.377	106.358	109.839	111.121	0.000	530.737
AA4: *Training and Human Science Research*	-	0.000	0.000	21.503	-	21.503	21.892	22.305	22.823	23.080	0.000	111.603
AA5: *Biotechnology and Systems Biology*	-	0.000	0.000	5.944	-	5.944	6.094	6.219	6.344	6.415	0.000	31.016
AA6: *Robotics and Mobile Energy*	-	0.000	0.000	22.442	-	22.442	22.817	22.970	23.428	23.688	0.000	115.345
AA7: *Mechanics and Ballistics*	-	0.000	0.000	35.306	-	35.306	36.082	37.486	38.238	38.668	0.000	185.780
AA8: *Sensing and Electromagnetics*	-	0.000	0.000	8.875	-	8.875	9.075	9.576	9.768	9.877	0.000	47.171
AA9: *Information and Networking*	-	0.000	0.000	40.449	-	40.449	41.075	41.491	42.322	42.793	0.000	208.130
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	0.000	0.000	33.224	-	33.224	33.085	33.956	35.048	35.441	0.000	170.754
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	0.000	0.000	17.420	-	17.420	17.755	18.587	19.186	19.400	0.000	92.348
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	4.589	4.860	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.449

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army												Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*							
F20: *Adv Propulsion Rsch*	-	3.443	3.544	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.987
F22: *Rsch In Veh Mobility*	-	0.720	0.749	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	1.469
H42: *Materials & Mechanics*	-	9.480	12.200	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	21.680
H43: *Research In Ballistics*	-	11.035	11.714	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.749
H44: *Adv Sensors Research*	-	8.711	9.908	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	18.619
H45: *Air Mobility*	-	2.354	2.456	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.810
H47: *Applied Physics Rsch*	-	5.549	5.843	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.392
H48: *Battlespace Info & Comm Rsc*	-	30.490	32.263	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	62.753
H52: *Equip For The Soldier*	-	1.130	1.177	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	2.307
H57: *Single Investigator Basic Research*	-	92.806	101.319	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	194.125
H66: *Adv Structures Rsch*	-	3.065	3.152	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.217
H67: *Environmental Research*	-	1.036	1.065	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	2.101
S13: *Sci BS/Med Rsh Inf Dis*	-	10.807	11.263	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.070
S14: *Sci BS/Cbt Cas Care Rs*	-	5.121	5.604	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	10.725
S15: *Sci BS/Army Op Med Rsh*	-	7.002	6.439	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	13.441
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	18.000	39.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	57.000
T22: *Soil & Rock Mech*	-	4.489	4.691	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.180
T23: *Basic Res Mil Const*	-	1.742	1.814	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.556
T24: *Signature Physics And Terrain State Basic Research*	-	1.684	1.719	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.403
T25: *Environmental Science Basic Research*	-	6.493	6.838	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	13.331
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	8.554	9.536	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	18.090
T64: *Sci BS/System Biology And Network Science*	-	2.904	3.076	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.980

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army													Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*								
VR9: *Surface Science Research*	-	2.201	2.334	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.535	

Note

In Fiscal Year (FY) 2020 portions of this Program Element (PE) were previously funded, with continuity of effort realigned from the following PE:
? PE 0601101A In-House Laboratory Independent Research

A. Mission Description and Budget Item Justification

This PE builds fundamental scientific knowledge contributing to the sustainment of United States (US) Army scientific and technological superiority in land warfighting capability and to solving military problems related to long-term national security needs, investigates new concepts and technologies for the Army's future force, and provides the means to exploit scientific breakthroughs and avoid technological surprises. This PE fosters innovation in Army niche areas (e.g., lightweight armor, energetic materials, and night vision capability) and areas where there is no commercial investment due to limited markets (e.g., vaccines for tropical diseases). It also focuses university single investigator research on areas of high interest to the Army (e.g., high-density compact power and novel sensor phenomenology). The in-house portion of the program capitalizes on the Army's scientific talent and specialized facilities to transition knowledge and technology into appropriate developmental activities. The extramural program leverages the research efforts of other government agencies, academia, and industry. This PE also supports basic research at the Army laboratories through the In-House Laboratory Independent Research (ILIR) program. The ILIR program serves as a catalyst for major technology breakthroughs by providing laboratory directors flexibility in implementing novel research ideas, by nurturing promising young scientists and engineers, and is used to attract and retain top doctoral degreed scientists and engineers. The ILIR program also provides a source of competitive funds for peer reviewed efforts at Army laboratories to stimulate high quality, innovative research with significant opportunity for payoff to Army warfighting capability.

All FY 2020 adjustments align program financial structure to Army Modernization Priorities in support of the National Defense Strategy.

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

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	263.590	276.912	290.545	-	290.545
Current President's Budget	274.098	315.660	297.976	-	297.976
Total Adjustments	10.508	38.748	7.431	-	7.431
• Congressional General Reductions	-0.153	-0.252			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	18.000	39.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.709	-			
• SBIR/STTR Transfer	-6.630	-			
• Adjustments to Budget Years	-	-	7.431	-	7.431

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army	Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*		
Congressional Add: *Open Campus Pilot Program*	8.000	-
Congressional Add: *Collaborative Research in the Human Dimension*	10.000	-
Congressional Add: *Basic Research Program Increase*	-	35.000
Congressional Add: *Counter UAS Technology*	-	3.000
Congressional Add: *UAV fuel systems enhancements*	-	1.000
Congressional Add Subtotals for Project: T14	18.000	39.000
Congressional Add Totals for all Projects	18.000	39.000

Change Summary Explanation

FY19 increase related to Congressional Adds totaling $39 million.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army				Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) 305 / *ATR Research*		

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
305: *ATR Research*	-	2.071	2.141	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.212

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA9 Information and Networking

A. Mission Description and Budget Item Justification

This Project fosters research for automatic target recognition (ATR) concepts to enhance the effectiveness of Army systems while simultaneously reducing the workload on the Soldier. This Project focuses on the fundamental underpinnings of aided and unaided target detection and identification techniques for land warfare scenarios. This research enables Army systems that can act independently of the human operator to detect and track targets including clandestine tracking of non-cooperative targets. Such capabilities are needed for smart munitions, unattended ground sensors, and as replacements for existing systems. Critical technology issues include low depression angle, relatively short range, and highly competing background clutter. The resulting research will provide a fundamental capability to predict, explain, and characterize target and background signature content, and reduce the workload on the analyst. This research is aimed at determining the complexity and variability of target and clutter signatures and ultimately utilizing that knowledge to conceptualize and design advanced ATR paradigms to enhance robustness and effectiveness of land warfare systems. ATR research strategies include emerging sensor modalities such as spectral and multi-sensor imaging. Research in this Project builds knowledge for several technology efforts including multi-domain smart sensors, third generation Forward Looking Infrared (FLIR), and advanced multi-function laser radar (LADAR).

Work is this Project supports key Army needs and provides the technical underpinnings to PE 0602270A (Electronic Warfare Technology)/Project 906 (Tactical Electronic Warfare Applied Research).

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: ATR Algorithms	2.071	2.141	-
Description: Investigate new algorithms to improve aided/unaided target detection and identification.			
FY 2019 Plans: Investigate approaches for image and video analytics and scene understanding at the tactical edge using resource constrained computation platforms for Soldiers and unmanned vehicle/robotic systems; investigate joint text and video approaches for semantic summarization of unconstrained videos; create algorithms for producing and fusing photogrammetry-based point clouds			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 305 / *ATR Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
and multimodal image data collected from multiple flying platforms; investigate light-field based image processing for enhancing situational awareness in degraded visibility environments. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY 2020.			
Accomplishments/Planned Programs Subtotals	2.071	2.141	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 31B / *Infrared Optics Rsch*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
31B: *Infrared Optics Rsch*	-	3.700	3.747	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.447

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA8 Sensing and Electromagnetics

A. Mission Description and Budget Item Justification

This Project supports Army research in materials and devices for active and passive infrared (IR) imaging systems; radio frequency (RF) photonics for radar, communications, and electronic warfare applications; and laser technology for missile threat countermeasure protection. This research aims to generate new technologies for unprecedented battlefield situational awareness and to continue the dominance of Army units during night operations. To achieve these objectives, IR focal plane arrays (FPAs) and lasers with significantly improved performance, lower cost, and increased operating temperatures are required. This research has direct application to Army ground vehicles, aviation platforms, weapon systems, and the individual Soldier. Research is focused on material growth, detector and laser design, and processing for large-area, multicolor IR FPAs, ultraviolet (UV) avalanche photodiodes (APDs), and mid-wavelength IR and UV lasers. The principal efforts are directed towards novel materials for detectors and lasers, and investigating energy band-gap structures in semiconductor materials to enhance the performance of lasers, IR FPAs and UV APDs. In the area of RF Photonics, near-IR modeling and nanofabrication techniques are applied to the design and fabrication of IR photonic-crystal waveguide structures having customized IR properties. This research also is intended to lay the foundation for the development of integrated optoelectronic circuits using active and passive devices and components such as lasers, waveguides, and detectors in conjunction with fiber optic interconnects for the generation, distribution, processing, and control of microwaves. The fundamental physics of signal processing and noise generation as well as the conversion between the time and frequency domains and the optical and electrical domains in these optoelectronic circuits/systems will also be studied. The technical goals are to: 1) manage and control defects in the raw, unprocessed materials, maintaining quality control in the fabrication of the devices and arrays, 2) limit introduction of impurities in the material, shielding device surfaces so that they are resistant to degradation over time and 3) thermal management, particularly as it applies to lasers. In the area of Advanced Materials, the research is to investigate the fundamental physics of energy, charge, and spin transport along and across active heterogeneous interfaces such as topological insulators, van der Waals heterostructures, solid/liquid interfaces, and bio/a-bio interfaces, and in new materials to achieve new electronic/optoelectronic device functionalities.

Work in this Project supports key Army needs and provides the technical underpinning to PE 0602709A (Night Vision Technology)/Project H95 (Night Vision and Electro-Optic Technology).

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 31B / *Infrared Optics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Optoelectronic and Integrated Photonic Materials and Device Research	0.994	0.991	-
Description: Conduct research into materials and structures used for IR devices, UV emitters and detectors, and integrated photonic devices to increase situational awareness in open and complex terrains; improve target detection, identification, and discrimination; and create new device functionality while reducing size, weight, and power requirements. ***FY 2019 Plans:*** Explore the deposition of cadmium telluride (CdTe) passivation layers by low temperature atomic layer deposition (ALD) to reduce leakage currents in mercury cadmium telluride (MCT) based infrared detectors; investigate carrier transport studies on semi-polar and non-polar III-Nitride semiconductor heterostructures to improve radiative and injection efficiencies in ultraviolet light emitting structures; and perform fundamental studies on chip-scale integrated photonic structures with the goal of identifying critical features, such as interaction length for appropriate Stimulated Brillouin Scattering (SBS), then examine a parametric trade space of photonic structures and materials capable of providing needed response to achieve narrowband filtering over a large RF photonic bandwidth. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to Project AA8 Sensing and Electromagnetics in FY 2020.			
Title: Advanced Materials	2.706	2.723	-
Description: Investigation of the fundamental physics of energy, charge, and spin materials with an emphasis on understanding the transport along and across novel designed surfaces and active heterogeneous interfaces to achieve new electronic/ optoelectronic device functionalities. Additionally, study beta-photovoltaic and beta-voltaic energy capture. ***FY 2019 Plans:*** Measure the transport properties, triple-point topological state characteristics, and bulk bandgap tunability and conductivity of indium-containing quantum well structures; investigate Indium Gallium Nitride (InGaN) electrodes integrated with catalysts to understand and quantify photovoltage boost under photo-electrochemical conditions and study doping characteristics of GaNSb for energy production applications utilizing water splitting; study transport properties and defect chemistries of intrinsic vacancy materials developed using atomic layer deposition; and investigate diamond-based semiconductor devices to exceed Gallium Nitride (GaN) performance in frequency and power handling of RF energy. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to Project AA8 Sensing and Electromagnetics in FY 2020.			
Title: FY 2019 SBIR / STTR Transfer	-	0.033	-
Description: FY 2019 SBIR / STTR Transfer			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 31B / *Infrared Optics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer			
Accomplishments/Planned Programs Subtotals	3.700	3.747	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 52C / *Mapping & Remote Sens*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
52C: *Mapping & Remote Sens*	-	2.077	2.140	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.217

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB2 Protection, Maneuver, Geospatial, Natural Sciences

A. Mission Description and Budget Item Justification

This Project increases knowledge of terrain and human geography with a focus on improving the generation, management, analysis/reasoning, and modeling of geospatial data, and the exploitation of multi-source data. This fundamental knowledge forms the scientific "springboard" for the future development of applications, techniques, and tools to improve the tactical commander's knowledge of the operating environment. Results of this research are used to: extract and characterize natural and man-made features from reconnaissance imagery in near-real time; understand socio-cultural influences; exploit terrain analysis and reasoning techniques; and explore the potential of space, airborne, and terrestrial geospatial sensor technologies to provide real-time geospatial intelligence to all Army Warfighting functions. This research uses terrain and socio-cultural data to improve situational awareness and enhance information dominance, leading to increased survivability, lethality, and mobility.

Work in this Project provides theoretical underpinnings for PE 0602784A (Military Engineering Technology), Project 855 (Topographical, Image Intel & Space).

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Sensor Phenomenology and Spatial-Temporal Pattern Discovery	2.077	2.109	-
Description: Conduct fundamental research to inform the development of applications, techniques, and tools to improve the tactical commander's knowledge of the operating environment.			
FY 2019 Plans: Statistically analyze collected laboratory data to examine for spectral and angular differences between undisturbed and disturbed soil samples and determine if relationships found in laboratory data apply to collected field data; quantitatively discriminate emitted dust particle size distributions by emission mechanism to better quantify and inform dust transport models and impacts on military operations.			
FY 2019 to FY 2020 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 52C / *Mapping & Remote Sens*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This Project is moved to PE 0601102A Defense Research Sciences / Project AB2 Protection, Maneuver, Geospatial, Natural Sciences in FY 2020.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.031	-
Accomplishments/Planned Programs Subtotals	2.077	2.140	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 53A / *Battlefield Env & Sig*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
53A: *Battlefield Env & Sig*	-	3.857	3.970	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.827

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA7 Mechanics and Ballistics

A. Mission Description and Budget Item Justification

This Project focuses on research to seek an in-depth understanding of the complex atmospheric boundary layer associated with high-resolution meteorology; the transport, dispersion, optical properties and characterization of chemical and biological aerosols; and the propagation of full-spectrum electro-magnetic and acoustic energy. The future Army will operate in very complex environments (e.g., urban, mountainous, forested and jungle terrain) requiring new approaches to understand, characterize, and depict environmental phenomena and their effects on military systems, personnel and operations. The lack of a complete understanding of the meteorological aspects of the complex microscale boundary layer in which the Army operates continues to impact our ability to provide predictable, actionable, accurate and timely tactical environmental intelligence to battlefield commanders and small Soldier units. This Project focuses on producing the foundational environmental science research to characterize the atmospheric boundary layer and deliver novel capabilities and techniques including urban turbulence characterization for its effects on micro platforms and sensor payloads, high resolution urban wind flow modeling for more efficient and accurate prediction of the transport and dispersion of obscurants and chemicals, battlefield aerosol characterization and the interaction between aerosols and meteorological processes for Soldier health initiatives, characterization and detection of bio-warfare agent aerosols, environmental effects on acoustic and electromagnetic signal propagation in urban and other complex domains for improved target location and imaging, exploration of previously unexploited regions of the acoustic and electro-magnetic spectrum, and formulation of objective analysis tools that can assimilate on-scene all-source weather observations, atmospheric composition, and fuse this information with forecasts to provide immediate Nowcast products and actionable information. These capabilities will have a direct impact on ensuring Soldier survivability, weapon system lethality, effective surveillance and reconnaissance, and the mobility required for future warfighter mission planning and execution operations.

Work in this Project supports key Army needs and provides the theoretical underpinnings for PE 0602784A (Military Engineering Technology) / Project H71 (Meteorological Research for Battle Command).

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Predictive Modeling of the Boundary Layer	3.857	3.940	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 53A / *Battlefield Env & Sig*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Increase survivability and improve situational awareness for a variety of sensors, optics, and flying objects (e.g., projectiles, unmanned aircraft systems, etc.) through fundamental research to enhance accuracy of predictive modeling of the atmospheric boundary layer and improve the ability to function effectively in adverse conditions. ***FY 2019 Plans:*** Gather and apply Meteorological Sensor Array (MSA) data to study near-surface processes that impact the flux of sediment, causing wind erosion and dust emission, and investigate fixed-wing and multi-rotor instrumented unmanned aircraft system (UAS) sampling strategies. Study and enhance the understanding of atmospheric effects on high data rate optical communications between systems. Expand radiative transfer modeling into environments with forest canopy; begin coupling radiative transfer model and land surface energy budget in urban domains; develop initial concepts in constraining machine learning for environmental prediction using physical modeling; explore new environmental remote sensing techniques of atmospheric parameters, exploiting advances in Stimulated Raman Gain capabilities; identify new methodologies to accelerate the characterization and analysis of ambient atmospheric aerosol composition. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY 2020.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.030	-
Accomplishments/Planned Programs Subtotals	3.857	3.970	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) 74A / *Human Engineering*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
74A: *Human Engineering*	-	13.710	15.519	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	29.229

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA4 Training and Human Science Research

A. Mission Description and Budget Item Justification

This Project focuses on research that improves Soldier-system performance in future force environments by looking at key phenomena underlying Soldier performance such as auditory spatial orientation (e.g., perception of azimuth, elevation and distance of sounds) within uncertain, degraded acoustic conditions; extending and protecting auditory and cognitive performance; human performance in automated, mixed-initiative (human control-machine control) environments; communications in hearing-degraded conditions; visual scanning and target detection; Soldier emotion and fatigue states; integration across multiple sensory modalities; perceptual-motor behavior; collaborative (team) and independent multi-task, multi-modal, multi-echelon Soldier-system performance - all cast against the influx of emerging transformation-driven technological solutions and opportunities. Technical barriers include lack of methods for describing, measuring, modeling, analyzing and managing the interplay of these phenomena due to the dynamic nature of human behavior and to the situational complexity and ambiguity that characterize operations in the future force. Technical solutions are being pursued in the areas of data generation and algorithm development in these emerging environments in order to update and improve our understanding of performance boundaries and requirements and enable neuroengineering. These solutions include multi-disciplinary partnerships, metrics, simulation capabilities, and modeling tools for characterizing Soldier-system performance, and provide a shared conceptual and operational framework for militarily relevant research on cognitive and perceptual processes. In the area of translational neuroscience, which is the transition of basic neuroscience research to relevant applications, research is carried out to examine leading edge methodologies and technologies to improve the measurement and classification of neural states and behavior in operationally-relevant environments, to examine the potential application of neuroscience theories to autonomous systems to improve Soldier-system interactions, to model the relationship between brain structure and cognitive performance for understanding individual differences and injury, and to assess how neural pathways implicated in functional processing can be enhanced through dynamic system interface technologies for improving in-theatre performance and training. In the area of cybernetics, which is a scientific discipline that bridges the fields of control theory and communication theory for the study and modeling of behavior in complex systems, research is carried out to examine the complex human-system-environment relationships that define, constrain, and influence the interactions between Soldier and system. Research efforts are pursued to advance theory, models, and methodological approaches that capture the dynamic and multidimensional nature of human behavior, including the temporal dependencies inherent to human behavior, through an integrated program of research efforts focused on: novel cybernetic models of human multisensory integration and human-system communication; neuro-inspired, bio-inspired, and engineering approaches to computational algorithms for multisensory integration and multi-sensor fusion to enable enhanced and augmented Soldier perception in human-system interactions; new methodological approaches for the design of multisensory displays and human-system communications; and multisensory test bed platforms for examining experimental hypotheses driven by model predictions and proof-of-principle applications of identified algorithms and methods.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

Work in this Project supports key Army needs and provides the technical underpinnings to several PEs to include PE 0601104A (University and Industry Research Centers) / Project H09 (Robotics Collaborative Technology Alliance) and PE 0602716A (Human Factors Engineering Technology) / H70 (Human Factors Engineering System Development).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Translational Neuroscience	3.623	3.713	-
Description: Integrating neuroscience with traditional approaches to understanding Soldier behavior to enable systems designs that maximize Soldier performance. ***FY 2019 Plans:*** Identify predictive models of visual search with Army-relevant stimulus luminance properties based on cognitive modeling of brain states and naturalistic eye movements; investigate the impact of naturalistic sleep fluctuations on functional brain networks and task performance in a variety of cognitive tasks; and understand the controllability of neural nodes and networks with electrical neurostimulation and functional brain activity to estimate impact on task performance. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A / Project AA4 in FY20.			
Title: Human System Integration ? Cybernetics	5.077	5.070	-
Description: Apply a cybernetic approach (i.e., a theoretical study and comparison of communication and control processes in biological and artificial systems) to human systems integration to achieve tighter control of devices and communications among humans and between machines and humans. Use social, computational, and information approaches to extend the scope of interaction beyond individual systems to the full network context. ***FY 2019 Plans:*** Leverage novel models of complex, functional, and adaptive behaviors to improve understanding of the underlying neural mechanisms involved in human information processing, including perception and sensorimotor control; examine the role of temporal information integration in the adaptive changes underlying human perception, including how individuals adapt to changes in the relationships among multiple sensory inputs; investigate how closed-loop (e.g., neuro- and bio-feedback, augmented reality) human-computer interactions can mediate cognitive task performance under varying conditions affecting neural, physiological, and/or cognitive state; and apply statistical modeling approaches, including machine learning and big data approaches, to account			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
for state-based changes in human behavior and physiology within novel cybernetic approaches to enhance human-system communications and interactions. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE0601102A / Project AA4 in FY20.			
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***Description:*** This effort will investigate technologies that provide the foundation for future Army systems to adapt to individual Soldier?s states, behaviors, and intentions in real-time. Enable high fidelity, continuous prediction that can account for continuous changes in Soldier?s physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. ***FY 2019 Plans:*** Understand prediction of individual task performance over time through analysis of longitudinal, multi-faceted, real-world dataset; examine behavioral, physiological, environmental, and task-based factors influencing social dynamics; identify methods to enable modeling of state variability over time using multi-level, systems-based approaches. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A / Project AA4 in FY20.	3.777	4.116	-
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance and behavior. Understand the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to affect performance similar to that in an operational environment. Characterize the appropriate use of different classes of simulated environments to ensure valid results. Develop guidelines for using mobility platforms in simulators to induce physical and cognitive stress representative of the operational environment, implementation of these guidelines will enhance training effectiveness. ***FY 2019 Plans:*** Identify models of the impact of presence and other state/trait measures on relationships between immersion, gamification, other training environment design elements, individual user differences, and training outcomes. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A / Project AA4 in FY20.	1.233	1.251	-
Title: Novel Forms of Joint Human-Intelligent Agent Decision Making ***Description:*** This effort will develop novel methods for joint human / intelligent agent learning and decision making so that strengths of individual humans and intelligent agents are accentuated and weaknesses are mitigated for improved, emergent	-	0.974	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74A / *Human Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
group performance, emphasizing deep learning approaches that function under conditions of limited, mismatched, or dynamic data. ***FY 2019 Plans:*** Develop a novel human-in-the-loop method of training artificial intelligence that outperforms standard AI training methods after similar amounts of trained time and data. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A / Project AA4 in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.395	-
Accomplishments/Planned Programs Subtotals	13.710	15.519	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army				Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) 74F / *Pers Perf & Training*		

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
74F: *Pers Perf & Training*	-	5.278	5.579	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	10.857

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA4 Training and Human Science Research

A. Mission Description and Budget Item Justification

This Project provides the funding to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development, as well as provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. The research within these domains will enable advances in psychometrics to support the development of the next generation of psychological assessments for selection, classification, and assignment. The research also will target how to improve the assessment of difficult-to-measure skills and enable theoretical advances to inform and support the accelerated development of complex cognitive and social skills. This research lays the foundation for future applications that address the behavioral and organizational dynamics that impact Army flexibility, effectiveness, and resilience.

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Personnel Measures (previously Human Behavior) ***Description:*** Basic research to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development. ***FY 2019 Plans:*** Conduct research to identify job-performance measures that can inform assignment and to examine the validity of using non-traditional data for personnel assessment. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA4 Training and Human Science Research in FY 2020.	1.865	1.845	-
Title: Climate, Readiness, and Resilience (previously Human in Complex Organizations)	3.413	3.540	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** 74F / *Pers Perf & Training*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Basic research that will provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. ***FY 2019 Plans:*** Conduct research to advance theoretical understanding of learning methods and principles to maximize development and transfer of complex cognitive skills; conduct research to identify methods and computational models to better understand organizational processes and dynamics (e.g., team resilience, trust development, and adaptive flexibility). ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA4 Training and Human Science Research in FY 2020.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.194	-
Accomplishments/Planned Programs Subtotals	5.278	5.579	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA1 / *ILIR - AMC*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
AA1: *ILIR - AMC*	-	0.000	0.000	10.800	-	10.800	11.018	11.242	11.464	11.591	0.000	56.115

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601101A In-House Laboratory Independent Research
* Project 91A ILIR-AMC

A. Mission Description and Budget Item Justification

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

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Edgewood Chemical Biological Center (ECBC)	-	-	1.004
Description: Basic research in chemistry, biology, biotechnology, and aerosols for creating the science base needed for countering improvised explosive devices (IEDs), obscurants, and defeating targets. ***FY 2020 Plans:*** Will conduct fundamental research in rational molecular synthesis, abiotic structures, nanoparticles, and self-organizing systems; synthetic biology and design and construction of new biological parts, devices, and systems; aerosol sciences and behaviors of aerosols and reaerosolization processes; and the mathematics involved in data processing and interpretation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601101A In-House Laboratory Independent Research / Project 91A ILIR-AMC.			
Title: Armaments Research, Development and Engineering Center (ARDEC)	-	-	1.446

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Funds basic research in weapons component physics, explosives synthesis/detection, and the fundamental science base of area denial. ***FY 2020 Plans:*** Will conduct innovative basic research that would ultimately result in new more powerful and less sensitive explosives to enhance lethality, lighter and advanced structural materials for guns and weapon platforms, new materials and sensors for area denial, and more lethal, multipurpose, and compact warheads. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601101A In-House Laboratory Independent Research / Project 91A ILIR-AMC.			
Title: Tank Automotive Research, Development and Engineering Center (TARDEC) ***Description:*** This effort funds basic research in ground vehicle technologies to include power, mobility, and unmanned systems. ***FY 2020 Plans:*** Will conduct basic research to improve understanding and the establish the underlying physics supporting the Army ground vehicle community in such areas as; semi- , fully-, and multiple autonomous vehicle operation and control, ground vehicle cybersecurity threat detection algorithms and resilience, lightweight materials and additive manufacturing, active protection and signature management, advanced combustion engine thermal control, soft soil mobility modeling, cognitive loading and crew station design, advanced energy storage materials, corrosion modeling, and early detection mechanisms. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601101A In-House Laboratory Independent Research / Project 91A ILIR-AMC.	-	-	1.237
Title: Natick Soldier Research, Development and Engineering Center (NSRDEC) ***Description:*** This effort funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection. ***FY 2020 Plans:*** Will create an understanding of fibers of liquid crystals confined in polymer matrices for fiber quality, phase transition characteristics of the liquid crystals, and temperature responsive behavior to inform the future development of lightweight "smart" textiles that efficiently respond to external stimuli. Will conduct fluid structure interface modeling of a braided cord using cyber-physical fluid dynamics and molecular-tagging-velocimetry techniques to gain understanding of the physical relationship between fluid flow features and the unsteady forces exhibited by braided cords undergoing gallop oscillations for informing the design of gliding parachute systems. Will investigate human control schemes of a swarm of robotic agents in a 3D environment to elucidate	-	-	1.128

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
how humans perceive and guide small swarms of semi-autonomous agents across a range of conditions for determining the most effective and intuitive control schemes for efficient human-machine combat teaming. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601101A In-House Laboratory Independent Research / Project 91A ILIR-AMC.			
Title: Aviation and Missile Research, Development and Engineering Center: Missile Efforts (AMRDEC-MI) ***Description:*** This effort funds the underlying fundamental science of Lethality and Protection Superiority for guided missile and rocket systems, directed energy weapons, unmanned vehicles, and related components. ***FY 2020 Plans:*** Will enhance optical nonlinearities using materials with dielectric constant near zero for sensor protection; will study collisional broadening of rubidium vapor by low-density contaminant gases to detect aging in atomic clocks; will investigate use of mutual information to detect dependencies between random processes to improve radar tracking in noisy environments; will explore how chaos appears in optimal communication systems and how performance may be improved for wireless datalinks in noisy environments; will explore nested plasmonic resonances in a hybrid nanoantenna for laser protection. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601101A In-House Laboratory Independent Research / Project 91A ILIR-AMC.	-	-	2.400
Title: Aviation and Missile Research, Development and Engineering Center: Aviation Efforts (AMRDEC-AV) ***Description:*** This effort funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science. ***FY 2020 Plans:*** Will conduct analytical and experimental study of induced flow effects on coaxial rotor wake and performance; will explore use of advanced measurement techniques such as volumetric particle image velocimetry to measure time resolved unsteady flow phenomena in rotor wakes; will explore advanced grid generation techniques and higher-order flow solvers to enable automated high-fidelity solutions for complex geometry full vehicle configurations. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601101A In-House Laboratory Independent Research / Project 91A ILIR-AMC.	-	-	1.346
Title: Communications Electronics Research and Engineering Directorate (CERDEC) ***Description:*** Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors. ***FY 2020 Plans:***	-	-	2.239

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA1 / *ILIR - AMC*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Will conduct research on resource-aware algorithms based on artificial intelligence for performing content summarization, awareness to autonomous node placement, and multimodal selection for resource information delivery at the tactical edge. Will conduct research utilizing an innovative approach to collecting visual data in order to mimic a biological vision system that navigates using ultraviolet and visible light to ultimately determine if the addition of the ultraviolet spectrum is better for navigation than navigating with the visible spectrum alone. Will conduct research on the Manganese Oxide structure and bonding mechanisms through the addition of Sulphur doping to formulate, synthesize, and characterize Sulphur doped Manganese Oxide materials for potential use in robust cathode materials. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601101A In-House Laboratory Independent Research / Project 91A ILIR-AMC.			
Accomplishments/Planned Programs Subtotals	-	-	10.800

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army												Date: March 2019
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA2 / *ILIR - SMDC*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
AA2: *ILIR - SMDC*	-	0.000	0.000	0.971	-	0.971	0.989	1.008	1.040	1.052	0.000	5.060

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 061101A In-House Laboratory Independent Research
* Project F16 ILIR-SMDC

A. Mission Description and Budget Item Justification

This Project provides In-house Laboratory Independent Research (ILIR) at the United States Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT). This basic research on lasers and directed energy lays the foundation for future developmental efforts on high energy lasers and directed energy systems by identifying the fundamental principles governing various directed energy phenomena with the goal of developing technologies that will significantly reduce size, weight and power requirements for laser systems.

Work in this Project is related to, and fully coordinated with, efforts in PE 0602307A (Advanced Weapons Technology).

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: SMDC In-house Laboratory Independent Research (ILIR)	-	-	0.971
Description: Funds basic research to investigate laser propagation phenomenology for application in modeling and simulation and future directed energy weapons design. Activities in this Project transition to High Energy Laser Technology in PE 0602150A (Air and Missile Defense Technology). ***FY 2020 Plans:*** Will improve diode coherence for direct-diode High Energy Laser concepts. Will explore concepts for scaling both spectrally beam combined and coherently beam combined direct-diode approaches. Will establish methods for adaptive optics branch point, speckle, as well as scintillation measurements and compensation for atmospheric turbulence compensation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601101A In-House Laboratory Independent Research, Project F16 ILIR-SMDC.			
Accomplishments/Planned Programs Subtotals	-	-	0.971

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA2 / *ILIR - SMDC*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AA3 / *Single Investigator Basic Research*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
AA3: *Single Investigator Basic Research*	-	0.000	0.000	101.042	-	101.042	102.377	106.358	109.839	111.121	0.000	530.737

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601102A Defense Research Sciences
* Project H57 Single Investigator Basic Research

A. Mission Description and Budget Item Justification

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

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Basic Research in Life Sciences	-	-	12.753
Description: This effort fosters fundamental discoveries in life sciences with the ultimate goal of facilitating the development of novel biomaterials to greatly enhance Soldier protection and performance. More specifically, i) molecular genetics research that pursues fundamental studies in molecular and systems biology, and genetics, ii) neurosciences research to investigate the physiology underlying perception, neuro-motor output, and potential methods of monitoring cognitive states during activity, iii) biochemistry research focused on studies in structural and cell biology, metabolic processes, and biophysics, iv) research in microbiology that pursues studies in microbial physiology, ecology, and evolution, v) social science research that aims to elucidate			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
the social, cultural, and other influences to human actions, and vi) auditory and signal processing research that maps the cognitive implications of multisensory information integration. ***FY 2020 Plans:*** Will use spectral-domain optical coherence tomography to reveal fine details of brain hemodynamic (blood flow) signals and clarify the correlation between these two observable quantities and the level and spatial distribution of neural activity in the living brain with electrophysiology and optogenetic (using light) manipulation, that in the long term may lead to new avenues for the treatment of brain injuries, training methods for the future soldier, or methods to establish direct, remote control for future combat vehicles, in line with the Soldier Lethality and Next Generation Combat Vehicle Army Modernization Priorities. Will determine whether key intracellular regulators can be inactivated by forming a self-seeding aggregate and whether such a protein aggregate can then attract other proteins, thereby inactivating them as well, that in the long term may enable new methods for preventing, detecting, and treating Post-Traumatic Stress Disorder. Will employ genetics and molecular biology methods to create a comprehensive glycan library where the glycans are bound to a biotin-labelled polymer, and utilize the new system to target the depletion or enrichment of specific microbial species from a given community of organisms and determine the effect of these changes in the composition of a mock community of skin bacteria, that in the long term may lead to more effective methods for portable water purification, insect resistance, and wound healing. Will genetically engineer novel green fluorescent protein ?protomers? that will utilize engineered electrostatic interactions to explore whether proteins can be programmed to self-assemble into a range of useful higher order structures similar to synthetic polymers but with the information rich properties of proteins, that in the long term may enable Army-relevant applications ranging from protective materials to chemical detection and decontamination systems. Will integrate sociological and psychological theory on status, influence, and attentional control with biological measurements, to create a method for predicting or simulating how threat impacts team performance and communication impedance, which in the long term may provide a new paradigm for training Soldiers and assessing individual and squad capabilities in more realistic simulated environments where decisions must be made rapidly in the face of the rapidly changing battlefield dynamics. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H57 Single Investigator Basic Research in FY 2019.			
Title: Basic Research in Chemical Sciences ***Description:*** This effort fosters basic research to achieve advanced energy control, improved threat detection, and novel responsive materials for Soldier protection. Research efforts will lead to: light-weight, reliable, compact power sources, more effective, lower vulnerability propellants and explosives for tailored precision strikes with minimum collateral damage, new approaches for shielding the Soldier and Army platforms from ballistic, chemical, and biological threats, and reducing signatures for identification by the enemy, and advance warning of explosive, chemical, and biological weapons and dangerous industrial chemicals.	-	-	17.378

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2020 Plans: Will use a combined experimental-computational approach to develop mechanistic descriptions of catalysis by metal nanostructures when excited by photon or other non-thermal energy sources to determine the most efficient photoelectrocatalysis approaches for driving chemical conversion at metal nanoparticle surfaces, that in the long term may enable the development of lower-weight power storage and generation in support of the Army Modernization Priorities of Future Vertical Lift and Soldier Lethality. Will develop two innovative single-molecule approaches to define the catalytic kinetics and dynamics of living polymerization reactions in real time, at the single-polymer level, and down to single-monomer resolution, that in the long term may enable new polymer structures with novel properties ranging from protective coatings on vehicles and aircraft to more rapid and cost-effective manufacturing methods, in support of the Army Modernization Priorities of Future Vertical Lift, Next Generation Combat Vehicle, and Soldier Lethality. Will synthesize a unique set of fluorescent ester probe catalysts with variable mobility and reactivity within the structured pore space and investigate reactions of these porous catalysts at the single particle level using advanced imaging and spectroscopic techniques, that in the long term will provide a novel catalyst design to enable new fuel cells and chemical neutralization methods in support of the Army Network and Soldier Lethality Army Modernization Priorities. Will develop a first-principles framework for predicting the structure of molecular interfaces and designing molecular interfaces with enhanced properties that in the long term may enable new methods for chemical manufacturing, such as energetic materials, in support of the Army Modernization Priorities of Long-Range Precision Fires, Air and Missile Defense, and Soldier Lethality. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H57 Single Investigator Basic Research in FY 2019.			
Title: Basic Research in Physics	-	-	17.383
Description: This effort fosters research in many subfields of physics, including condensed matter physics, optical physics, atomic and molecular physics and quantum information, with an emphasis on discovering new realms of quantum and optical phenomena. Pursuit of fundamental physics in these subfields provides new opportunities for future developments in superior optics, ultra-sensitive sensors, and novel electronic architectures for classical and quantum computing. ***FY 2020 Plans:*** Will create and demonstrate novel linear and nonlinear supersymmetry-enabled optical materials and structures that in the long term may enable a new generation of invisibility technologies and secure optical communications through low-power switching and wave-length conversion techniques, all of which are in direct support of the Army Network and Future Vertical Lift Army Modernization Priorities. Will electrically induce topological superconductivity in a single material system to explore the related electronic phases that comprise and enable this possibility, that in the long term will enable low-power electronics, coding, communications, and logistical support applications orders of magnitude more powerful than is possible with conventional computers, thereby in direct support of the Army Network Modernization Priority. Will create new cold atom platforms to host			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
anyons and exotic emergent excitations which are expected to be key building blocks in topological quantum memory, quantum computer architectures, and robust quantum interferometry schemes that in the long term may reveal new states of quantum matter with applications ranging from sensors and computers with orders of magnitude greater sensitivity and power than conventional systems. Will develop new algorithms and applications for the realization of nearer-term quantum computers (QCs) that are inspired by underlying physical principles rather than the traditional methods using only pure mathematical techniques, and subsequently perform quantum supremacy experiments, that if successful will directly support the Army Network Modernization Priority as a successful QC and will enable coding, communications, and logistical support applications orders of magnitude more complex than is possible with conventional computers. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H57 Single Investigator Basic Research in FY 2019.			
Title: Basic Research in Electronics and Photonics ***Description:*** This effort fosters discoveries in electronic sensing, optoelectronics, solid state and high frequency science, electromagnetics, microwaves, and power electronics for situational awareness, communications, information processing, electro-magnetic warfare, and power efficiency. ***FY 2020 Plans:*** Will investigate quantum hydrodynamic (forces exerted by fluids) charge transport in heterostructure of two dimensional (2D) materials including monolayer and bilayer graphene, 2D superconductors and atomically thin hexagonal boron nitride (hBN) and its interaction with electromagnetic radiation spanning from radio frequencies to terahertz (THz) frequencies, and to realize novel Radio Frequency (RF) and THz device concepts based on quantum hydrodynamic behaviors. Will establish approaches to achieve background-limited photo-detection in mid-infrared spectral regimes using colloidal metal nanoparticle based artificial materials and microcavity enhanced thermal effects. Will pursue use of carbon nanotubes and 2D materials within microcavities to achieve room temperature exciton-polariton lasers with orders of magnitude reduced threshold current densities compared to normal photon laser regimes. Will develop a new biomolecule capable of sensing and modulating the local electric field at specific locations inside a single cell, controlled by optical input and providing optical output. Will develop a new liquid scanning, non-invasive, microwave microscopy methodology capable of measuring the electrical interactions between intracellular organelles at high spatial and temporal resolution. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H57 Single Investigator Basic Research in FY 2019.	-	-	7.105
Title: Basic Research in Materials Sciences	-	-	12.655

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Research that provides innovations in materials design and process through the elucidation of fundamental relationships linking composition, microstructure, defect structure, processing and properties of materials. Revolutionary materials provide support for the Army in firepower, mobility, communications, personnel protection, infrastructure and installations, and will directly affect virtually all mission areas. ***FY 2020 Plans:*** Will establish the feasibility of using newly developed nuclear magnetic diffraction techniques to obtain atomic resolution structural and functional information about nanocrystalline membrane proteins. Will utilize nuclear magnetic resonance to identify the phase transitions in metallic liquids, the conditions under which they occur, and the influence they have on mechanical properties. This knowledge could be utilized to develop advanced processing methods for high performance lightweight metallic alloys. Will synthesize and characterize novel nano-structured hybrid inorganic-organic crystals and understand how the variations in organic spacer and chalcogen elements affect the excitonic effects to achieve tuning of extraordinary physical properties. Will investigate recently identified aramid nanofibers (ANFs) as a reinforcing material. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H57 Single Investigator Basic Research in FY 2019.			
Title: Basic Research in Mechanical Sciences ***Description:*** This effort focuses on improved understanding of propulsion and combustion for improved efficiency and fuel flexibility, energetics initiation for insensitive munitions, fluid dynamics for rotorcraft, complex dynamic systems for novel sensors, energy generation and multi-dimensional systems, and solid mechanics especially at high strain rates in composite materials for novel armor and protection systems. ***FY 2020 Plans:*** Will couple machine learning control with sparse identification of nonlinear dynamics to create novel flow regimes and generate interpretable models of their underlying physics, providing the potential to create, understand and control new types of flows. Will create an experimental microscopy method for probing sub-surface sample volumes in opaque and scattering condensed phases via Raman and Laser Induced Fluorescence (LIF) spectroscopy which will provide chemical reaction information on opaque reacting materials in-situ. Will determine the dependency of size, microstructure, and surface chemistry on the mechanics of neat nanocellulose thin films from a molecular viewpoint, and establish design principles for maximizing the performance of these nanostructured materials under microballistic impact. Will extend underlying physics of wheeled locomotion and general intrusion on complex terrain by extending Resistive Force Theory (RFT) to faster intruding motions; rapid localized granular intrusion experiments. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	6.939

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project H57 Single Investigator Basic Research in FY 2019.			
Title: Basic Research in Computing Sciences ***Description:*** This effort provides the backbone for performing complex, multi-system analysis, modeling and simulation for understanding information systems. Advancements in computer sciences have a direct impact on enhancing the Warfighters' decision-making and situation awareness. ***FY 2020 Plans:*** Will establish new scientific understandings in learning and modeling of adversarial mental states and decision processes for driving cyber deception schemes and to build an integrated framework of deception composition and projection methods to successfully manipulate adversaries' mental state and decision-making process to our advantage. Will create a novel computational framework for the modeling and analysis of multisensory neural information processing. Will integrate information from multimodal brain data toward enhanced brain-computer communications. Will establish computational method and data structures for fast and efficient tensor factorization. Such systems can scale to large number of modes and can efficiently process multi-way data which arrive in a streaming fashion. Will devise efficient techniques for tensor factorization which are necessary for a large number of Army applications, including but not limited to dimensionality reduction and clustering in machine learning, latent parameter estimation and source separation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H57 Single Investigator Basic Research in FY 2019.	-	-	7.062
Title: Basic Research In Network Sciences ***Description:*** This effort focuses on gaining an understanding of the fundamental aspects of how networks develop, function, and adapt to the environment and the rate of information flow in man-made and naturally occurring networks. This understanding will have a direct impact on net-centric force operations, such as better communication system design and operations, and more efficient logistics or communications support. ***FY 2020 Plans:*** Will expand current methods for obtaining consensus in distributed setting, typically limited to linear control and constraints to deal with temporal and non-linear constraints. Will extend traditional linear methods to carry out optimization computation, allowing for distributed learning on top of distributed consensus and control. The results should have an impact on research in Internet of Battlefield Things. Will create a framework for effective use of crowdsourcing? a technique that has gained popularity in Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) applications, where the wisdom of crowds is harnessed by taking into account the cognitive ability of each individual person in the crowd. Will design	-	-	13.818

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
algorithms to route data to their destination, using locally available information, which is optimal with respect to the use of available resources by using coding techniques throughout their span. Will design networks to enable distributed trust services using Blockchain methodologies, which are robust to impairments in connectivity and to asymmetries in computational capabilities at the nodes. Will predict dynamic human behaviors through mapping physical movements and shared mental models. Will extend the boundaries of cognitive science into shared mental models within multi-team systems. This includes theoretical advancements based on iterative experimental and computational modeling towards the development of a predictive model of team dynamics in isolated, high stress, and complex environments. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H57 Single Investigator Basic Research in FY 2019.			
Title: Basic Research in Mathematical Sciences ***Description:*** This effort fosters the creation of new mathematical tools and methods for performing complex, multi-system analysis and modeling to enhance soldier and weapon-system performance. More specifically, the focus is on creating mathematical principles and practical algorithms for stochastic analysis and control, analysis and control of biological systems, numerical computation of infinite-dimensional systems, and modeling of irregular geometric and social phenomena. ***FY 2020 Plans:*** Will create new mathematical tools and methods for performing complex, multi-system analysis and modeling to enhance soldier and weapon-system performance. Central to this effort is the development of mathematical principles and practical algorithms for stochastic analysis and control, numerical computation of infinite-dimensional systems, analysis and control of biological systems, and modeling of irregular geometric and social phenomena. Will develop new methodologies for the mechanistic modeling of biological systems, particularly by utilizing fields of mathematics, such as differential geometry, algebra, topology, and Bayesian statistics, not traditionally brought to bear on biological problems, as well as hybrid methods optimizing mechanistic, and data-driven approaches. Will uncover fundamental principles and relationships in biological structure, function, and development using mathematical modeling. Of special interest are robustness and resilience, stochasticity, neurobiology, and biological timekeeping. Will develop modeling techniques specifically for describing the collective behavior of smaller scale heterogeneous elements, as well as solving the related inverse problem. These improved methods combined with the understanding of modeling will allow greater fidelity and more efficient studies of any biological system, and will be especially transformational for the Army in understanding circadian rhythms, Post Traumatic Stress Disorder (PTSD), and traumatic injury. Will create methods to analyze, control, and model stochastic differential equations which include separable methods for stochastic partial differential equations. Will investigate geometric structures to create techniques for large-scale limit laws, asymptotic analysis, and solutions in optimal control. Will develop innovative geometric and topological data modeling frameworks, with a particular focus on bridging the scientific gap between current topological data analysis methods and practical statistical inference, and machine learning techniques. Will develop data-based and non-smooth analytical techniques for modeling complex, spatio-temporal dynamical	-	-	5.949

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA3 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
systems that provide explanatory, as well as predictive results. Will create models and computational methods for material-related issues in layered and two dimensional geometries, energetic crystals, and porous media that include geometric methods for multiscale computation, octree discretizations for massively parallel architectures, new quasi-continuum material models for sharp interfaces, and methods for ordered material incommensurability. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H57 Single Investigator Basic Research in FY 2019.			
Accomplishments/Planned Programs Subtotals	-	-	101.042

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA4 / *Training and Human Science Research*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
AA4: *Training and Human Science Research*	-	0.000	0.000	21.503	-	21.503	21.892	22.305	22.823	23.080	0.000	111.603

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601102A Defense Research Sciences
* Project 74A Human Engineering
* Project 74F Pers Perf & Training

A. Mission Description and Budget Item Justification

This Project focuses on research that improves Soldier-system performance in future force environments by looking at key phenomena underlying Soldier integration with intelligent technologies and autonomous agents, with a focus on researching how optimal methods for information exchanged between Soldiers and intelligent technologies including human performance in automated, mixed-initiative (human control-machine control) environments; visual scanning and target detection; performance-related Soldier state changes; integration across multiple sensory modalities; collaborative (team) and independent multi-task, multi-modal, multi-echelon Soldier-system performance - all cast against the influx of emerging intelligent technologies and autonomous systems. Technical solutions are being pursued in the areas of data generation and algorithm development in these emerging environments in order to update and improve our understanding of performance boundaries and requirements. These solutions include multi-disciplinary partnerships, metrics, simulation capabilities, and modeling tools for characterizing Soldier-system performance, and provide a shared conceptual and operational framework for militarily relevant research on critical aspects of human-agent teaming. In the area of translational neuroscience, which is the transition of basic neuroscience research to relevant applications, research is carried out to examine leading edge methodologies and technologies to improve the measurement and classification of neural states and behavior in operationally-relevant environments, to examine the potential application of neuroscience theories to autonomous systems to improve Soldier-system interactions, to model the relationship between brain structure and cognitive performance for understanding individual differences and injury, and to assess how neural pathways implicated in functional processing can be enhanced through dynamic system interface technologies for improving in-theatre performance and training. In the area of cybernetics, which is a scientific discipline that bridges the fields of control theory and communication theory for the study and modeling of behavior in complex systems, research is carried out to examine the complex human-system-environment relationships that define, constrain, and influence the interactions between Soldier and system. Research efforts are pursued to advance theory, models, and methodological approaches that capture the dynamic and multidimensional nature of human behavior, including the temporal dependencies inherent to human behavior, through an integrated program of research efforts focused on: novel cybernetic models of human multisensory integration and human-system communication; neuro-inspired, bio-inspired, and engineering approaches to computational algorithms for multisensory integration and multi-sensor fusion to enable enhanced and augmented Soldier perception in human-system interactions; new methodological approaches for the design of multisensory displays and human-system communications; and multisensory test bed platforms for examining experimental hypotheses driven by model predictions and proof-of-principle applications of identified algorithms and methods.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

This Project also develops innovative theories, models, and methods to improve personnel assessment, training, and leader development, as well as provide a better understanding of individual, unit, and organizational behavior and performance within the context of complex organizational and operational environments. The research within these domains will enable advances in psychometrics to support the development of the next generation of psychological assessments for selection, classification, and assignment. The research also will target how to improve the assessment of difficult-to-measure skills and enable theoretical advances to inform and support the accelerated development of complex cognitive and social skills. This research lays the foundation for future applications that address the behavioral and organizational dynamics that impact Army flexibility, effectiveness, and resilience.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Translational Neuroscience	-	-	3.881
Description: This effort integrates neuroscience with traditional approaches to understanding Soldier behavior to enable systems designs that maximize Soldier performance. ***FY 2020 Plans:*** Will identify multimodal neural correlates of vigilance in Army-relevant tasks; will create novel methods for exploration and understanding of relationships between performance and long-term longitudinal neural data; and will understand interactions between properties of visual scene and improved performance at real-world target detection tasks. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 74A Human Engineering in FY 2019.			
Title: Human System Integration	-	-	5.350
Description: This effort applies a cybernetic approach (i.e., a theoretical study and comparison of communication and control processes in biological and artificial systems) to human systems integration to achieve tighter control of devices and communications among humans and between machines and humans. Use social, computational, and information approaches to extend the scope of interaction beyond individual systems to the full network context. ***FY 2020 Plans:*** Will create methods for modeling and understanding critical aspects of closed-loop human-system interactions; will establish machine learning approaches to improve effective human-agent collaborations within Army-relevant crew station environments; will create learning interfaces that mitigate performance decrements due to heterogeneous human-agent interactions; and will identify approaches to understand effects of individual agent performance on hybrid team performance. ***FY 2019 to FY 2020 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project 74A Human Engineering in FY 2019.			
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***Description:*** This effort will investigate technologies that provide the foundation for future Army systems to adapt to individual Soldier?s states, behaviors, and intentions in real-time. Enable high fidelity, continuous prediction that can account for continuous changes in Soldier?s physical, cognitive, and social states, such as stress, fatigue, task difficulty, trust, and situational awareness. ***FY 2020 Plans:*** Will establish just-in-time modeling approaches to adapt individualized level of appropriate risk in single-human single-agent interaction; will create algorithmic forecasting approaches for anticipating changes in Soldier state; and will generate novel metrics of team interactions and performance though multifaceted environmental and social data. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 74A Human Engineering in FY 2019.	-	-	4.289
Title: Training and Soldier Performance ***Description:*** Research relationship between training environment fidelity/level of immersion and Soldier performance and behavior. Understand the level of physical, perceptual, and cognitive interaction necessary for a simulated environment to affect performance similar to that in an operational environment. Characterize the appropriate use of different classes of simulated environments to ensure valid results. Develop guidelines for using mobility platforms in simulators to induce physical and cognitive stress representative of the operational environment, implementation of these guidelines will enhance training effectiveness. ***FY 2020 Plans:*** Will identify behavioral and physiological correlates of positive and negative gamification feedback mechanisms for adaptive individualized training. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 74A Human Engineering in FY 2019.	-	-	1.305
Title: Novel Forms of Joint Human-Intelligent Agent Decision Making ***Description:*** This effort will develop novel methods for joint human / intelligent agent learning and decision making so that strengths of individual humans and intelligent agents are accentuated and weaknesses are mitigated for improved, emergent group performance, emphasizing deep learning approaches that function under conditions of limited, mismatched, or dynamic data. ***FY 2020 Plans:***	-	-	0.994

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Will create interaction and algorithmic mechanisms for human reward shaping of reinforcement learning algorithms to develop collaborative and interpretable agent behavior. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 74A Human Engineering in FY 2019.			
Title: Science of Measurement of Individuals and Collectives ***Description:*** This research develops advanced psychometric theory and measurement of Soldiers and teams to maximize talent management. ***FY 2020 Plans:*** Will conduct research in computational psychometrics to identify promising approaches to develop valid simulation-based tests; will conduct research on spatial skills and abilities related to navigation in 3-dimensions and complex terrain. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 74F Pers Perf & Training in FY 2019.	-	-	2.893
Title: Understanding Multilevel and Organizational Dynamics ***Description:*** This research develops methods and models to understand the relationship of human states, traits, and behaviors on individual, group, and organizational dynamics. ***FY 2020 Plans:*** Will conduct research to develop approaches for unobtrusive measurement of team performance in unconstrained, outdoor environments; will conduct research to understand and model unit-based learning and knowledge diffusion in organizations. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 74F Pers Perf & Training in FY 2019.	-	-	2.791
Accomplishments/Planned Programs Subtotals	-	-	21.503

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA4 / *Training and Human Science Research*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA5 / *Biotechnology and Systems Biology*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
AA5: *Biotechnology and Systems Biology*	-	0.000	0.000	5.944	-	5.944	6.094	6.219	6.344	6.415	0.000	31.016

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601102A Defense Research Sciences
* Project H44 Adv Sensors Research

A. Mission Description and Budget Item Justification

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

This work addresses Army Modernization Priorities & future Army needs including Solider Lethality for Expeditionary Solider Power Generation, Solider Sensor Integration & Interfaces, Autonomous Systems (Unmanned Aerial Vehicles, Unmanned Ground Vehicles), Sensored Soldier and Soldier Performance Monitoring.

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Biological and Bio-derived Materials and Devices Research	-	-	2.555
Description: This effort creates biological materials for devices and sensors that can be used by the Army to improve force protection and reduce logistical burden. Investigates biological construction of novel materials, structures, and processes to develop biologically derived materials, sensing materials, information processing, and power and energy to transcend critical gaps in adaptability, manufacturability, and stability in Army relevant environments.			
FY 2020 Plans: Will establish a framework using computational models and iterative biopanning of investigated microbial interactions to identify biologically enabled device and process specific consortia; will extend fundamental understanding of microbial communities using			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA5 / *Biotechnology and Systems Biology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
systems biology techniques for agile bioprocessing; and will identify responses of engineered bacteria to surfaces of electronic materials for adhesion, release, signaling and survival. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H44 Adv Sensors Research in FY 2019. Program funding increase will extend effort to create fundamental understanding of microbial communities using systems biology techniques for agile bioprocessing.			
Title: Synthetic Biology for Dynamic Materials ***Description:*** This effort will research the concept of responsive materials imparting living functions for operation in Army-relevant environments to enable disruptive capabilities, such as self-healing, adaptation, protection, and situational awareness. Perform research to enable design and synthesis of materials both enabled by and including biological entities to provide these living functions. This effort will research the concept of responsive materials imparting living functions for operation in Army-relevant environments to enable disruptive capabilities, such as self-healing, adaptation, protection, and situational awareness. Perform research to enable design and synthesis of materials both enabled by and including biological entities to provide these living functions. ***FY 2020 Plans:*** Will identify synthetic biology routes to engineer robust host organisms with sense-and-respond genetic circuits; will utilize synthetic biology techniques to investigate the use of biological processes to synthesize hierarchical materials from biologically available small molecules; and will create biological tools to explore and understand the feasibility of dynamic, bio-hybrid materials. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H44 Adv Sensors Research in FY 2019.	-	-	3.389
Accomplishments/Planned Programs Subtotals	-	-	5.944

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA5 / *Biotechnology and Systems Biology*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA6 / *Robotics and Mobile Energy*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
AA6: *Robotics and Mobile Energy*	-	0.000	0.000	22.442	-	22.442	22.817	22.970	23.428	23.688	0.000	115.345

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601102A Defense Research Sciences
* Project F20 Adv Propulsion Rsch
* Project F22 Rsch In Veh Mobility
* Project H45 Air Mobility
* Project H66 Adv Structures Rsch
* Project T63 Robotics Autonomy, Manipulation, & Portability Rsh
* Project H47 Applied Physics Rsch

A. Mission Description and Budget Item Justification

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

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

The work in this Project supports PE 0602148A (Future Vertical Lift Technology) / Project AL5 (Air Vehicle Structures and Dynamics Technology), Project AK9 (Adv Teaming for Tactical Aviation Operations Tech), Project AL4 (Digital Vehicle Management and Control Technology), and Project AI9 (Future UAS Engine Technology), PE 0602145A (Next Generation Combat Vehicle Technology) / Project BF8 (Artificial Intelligence & Machine Learning Tech), PE 0601104A (University and Industry Research Centers) / Project AB7 (Army Collaborative Research and Tech Alliances).

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

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 2018	FY 2019	FY 2020
Title: Vehicle Propulsion and Power Research ***Description:*** Basic research to investigate concepts and theories to provide enhanced tools, methods, and innovative concepts to enable improvements in propulsion power density, energy efficiency, reliability, and lifecycle costs for increased performance and capabilities in future Army systems. ***FY 2020 Plans:*** Will increase understanding of liquid-gas interactions at extreme environmental conditions, articulating blade mechanisms, and additive chemistry in heat activated polymers. This research will enable novel pathways for increased performance, reliability and survivability of platform propulsion systems. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project F20 Adv Propulsion Rsch in FY 2020. Funding decreased in Vehicle Propulsion and Power Research to support Novel Multi-fuel Tolerant Small Vehicle Power and will result in reducing efforts to improve debris tolerance and thermal management of highly loaded mechanical interfaces.	-	-	1.037
Title: Novel multi-fuel tolerant small vehicle power ***Description:*** Basic research to enable highly efficient, multi-fuel conversion in small engines with reduced sensitivity to fuel property variation and extreme ambient conditions. This includes research to characterize and investigate extreme fuel properties on ignition chemistry, variable spark enabling concepts for robust ignition, and lightweight highly durable materials for reduced heat loss and wear characteristics. ***FY 2020 Plans:*** Will determine ignition chemistry of extremely low ignition quality fuels to determine mechanisms for assisted ignition. Will understand tribological materials for extreme low viscosity fuels to advance the materials for lower wear and scuffing, and novel light-weight/reliable coatings that can overcome higher thermo-mechanical stress. Will increase understanding of aeroelasticity at high pressure ratio conditions to increase aero-damping to mitigate excitation or resonance. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work represents an increase in program requirements for novel multi-fuel tolerant small vehicle power efforts.	-	-	4.000
Title: Fundamentals for Alternative Energy ***Description:*** Explore novel concepts in energy generation and capture in technologies for efficient conversion of ambient energy to electrical energy for use and storage. Design novel structures to include microscale power devices for multimodal harvesting and efficient distributed power conversion. Focus areas include: energy storage and release from atomic nuclei, new materials for topological insulators for energy conversion, and new designs for solar cells.	-	-	1.225

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2020 Plans: Will establish concepts for efficient conversion of ambient energy to electrical energy; will understand, design, fabricate, prepare and characterize advanced catalysts for sustainable energy, and to enhance carbon monoxide oxidation and water splitting using infrared radiation; and will determine the feasibility of using radioisotopes and nuclear isomers to access energy storage, without fission, that would enable greatly enhanced mission duration beyond that of current batteries and with reduced size and weight. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H47 Applied Physics Rsch. Funding decreased in Fundamentals for Alternative Energy to enable new start in Novel Multi-fuel Tolerant Small Vehicle Power will result in decreased efforts on gallium nitride devices for energy conversion.			
Title: Materials, Structures, and Analytics for Enduring Platform Operations ***Description:*** Basic research to establish fundamental understanding in structural damage tracking methods, novel material/ structures, and prognostic and diagnostic techniques to improve vehicle performance and capability. This includes the advancement of machine learning algorithms for deep learning, and the exploration of novel lightweight, durable, self-sensing structures for improved maneuver and reduced maintenance. ***FY 2020 Plans:*** Will identify novel structures that will enable the realization of advanced air vehicle architectures, and increase the fundamental understanding of dynamic phenomena important to novel air vehicle design. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H66 Adv Structures Rsch in FY 2019.	-	-	1.397
Title: Reconfigurable Platform Mechanics and Propulsion ***Description:*** Basic research in reconfigurable platform mechanics and propulsion science to investigate technologies to enable subsystem configuration concepts for efficient hover and high-speed/range Vertical Take-Off and Landing (VTOL) aircraft. ***FY 2020 Plans:*** Create additively manufactured nanocomposites with engineered interfacial properties using ?structural? polymers and novel structural morphing concepts to enable high vibration damping. Establish control theories for active-matter systems that self-organize to desirable emergent properties. Identify new materials and mechanical processes to enable reconfigurable and structurally adaptive platforms. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	1.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project H66 Adv Structures Rsch in FY 2019.			
Title: Robotics Autonomy and Human Robotic Interface Research ***Description:*** Basic research focused on enabling robust autonomous mobility for small and human-scale robotic systems, including autonomous teaming behavior with hybrid human-robotic teams. Enablers for robust autonomous mobility include planning, behaviors, energy efficient maneuver, and the interface of manipulation technologies to support manned-unmanned teaming constructs. ***FY 2020 Plans:*** Will identify methods to enhance robotic situational awareness in mission-relevant and hybrid teaming contexts. Will understand mechanisms to efficiently share and exchange situational awareness with robotic and human team members. Will create methods to increase robotic operational tempo under supervised and unsupervised autonomous operating conditions. Will explore impacts and methods to mitigate sporadic network connectivity, including fail-safe and fail-over paradigms in human-in-the-loop and human-on-the-loop scenarios. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project T63 Robotics Autonomy, Manipulation, & Portability Rsh in FY 2019. Funding decrease will result in shifting emphasis of research away from improving ability of robots to have a deeper understanding of the world using dirty, complex data and towards human-machine teaming.	-	-	1.372
Title: Intelligent Systems ***Description:*** Pursue in-house research in autonomous systems that supports and unburdens Soldiers in a flexible, robust, survivable and comprehensive manner. This work will address the cognitive requirements of humans and (non-human) agents, both hardware and software based, operating individually or in collaboration, on the battlefield. Emphasis will be placed on perception, reasoning, and collaboration techniques that can apply to and transfer between a broad range of systems (such as: adaptive communication and data collection networks, crowd-sourcing and information retrieval software agents; and predictive and explanatory decision support systems). ***FY 2020 Plans:*** Will establish methods to enable the teaming of intelligent systems with Soldiers through the exploration of techniques for online learning from human example, coordinated intelligent exploration of complex environments and online semantic labeling for shared understanding. Will investigate perceptual and intelligence methods to enable an autonomous system to conduct op-tempo operations in military relevant environments. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	6.140

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project T63 Robotics Autonomy, Manipulation, & Portability Rsh in FY 2019.			
Title: Structurally-Adaptive Unmanned Air Systems Research ***Description:*** Basic research focused on topics that contribute to the body of knowledge required to create future intelligent, unmanned air systems that can effectively team with manned and unmanned aircraft, ground platforms, and human teammates. Emphasis will be placed on topics of control and aeromechanics that will expand the operational envelope for unmanned systems and enable maneuverability in complex, interactive, and mission relevant environments. ***FY 2020 Plans:*** Will establish control methods to increase vehicle endurance and energy efficient operations, including new energy aware autonomous behaviors, as well as novel concepts to enable cooperative multi-domain maneuver capabilities in mission-relevant environments. Will identify novel vehicle configurations and materials that enable significant enhancements to small unmanned aerial system range, endurance, payload, and maneuverability, including emerging actuation concepts. Will incorporate uncertainty quantification physics into flight dynamic models. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project T63 Robotics Autonomy, Manipulation, & Portability Rsh in FY 2019. Funding increase will expand research to include control methods to increase vehicle endurance and energy efficient operations, including new energy aware autonomous behaviors, as well as novel concepts to enable cooperative multi-domain maneuver capabilities in mission-relevant environments.	-	-	3.000
Title: Air Mobility ***Description:*** Create robust experimental and computational approaches for understanding, modeling, and predicting the complex fluid flow and aerodynamics of next generation rotorcraft concepts. This research includes innovative numerical methods for capturing the details of steady state and non-steady state aerodynamics and acoustics occurring with multi-rotor, rotor-propeller, and rotor hub configurations; and associated experimental techniques needed to verify modeling results. ***FY 2020 Plans:*** Will conduct experimental investigation of active flow control technology for hub/pylon drag reduction; will conduct experimental measurements of hovering rotor wake to better understand vortex instabilities and identify flow physics that leads to these; will apply high-fidelity computational tools for fundamental flow physics studies of interactional aerodynamics and rotor wakes, and their effects on steady/unsteady air loads and performance of rotors and complete aircraft configurations. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	2.506

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA6 / *Robotics and Mobile Energy*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project H45 Air Mobility in FY 2019.			
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency ***Description:*** Research in support of advanced military mobility technologies with emphasis on Terramechanics (vehicle-terrain interaction), and complex vehicle dynamics and simulation. This includes developing the data and underlying models to simulate and predict autonomous vehicle mobility in soft soil and complex organic terrain under a variety of environments. Research is directed at understanding advanced mathematical and computational methodologies using state-of-the-art analytical and empirical procedures. ***FY 2020 Plans:*** Will review and quantify the effectiveness and efficiency of the multi-scale computational algorithms for modeling a military ground vehicle traversing over fine soil particles to their true size and geometry; will expand and apply deep learning algorithms for generating Go/NoGo maps to other geographic regions; will expand human cognitive models based on use cases and human roles (e.g., driver, gunner, etc.) for integration into autonomy modeling and operational use case evaluation software. Will examine how these algorithms support shared control relative to complete human operators. Will also identify high performance computing demands on these models and algorithms. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project F22 Rsch In Veh Mobility in FY 2019.	-	-	0.765
Accomplishments/Planned Programs Subtotals	-	-	22.442

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA7 / *Mechanics and Ballistics*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
AA7: *Mechanics and Ballistics*	-	0.000	0.000	35.306	-	35.306	36.082	37.486	38.238	38.668	0.000	185.780

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601102A Defense Research Sciences
* Project 53A Battlefield Env & Sig
* Project H42 Materials & Mechanics
* Project H43 Research In Ballistics
* Project H44 Adv Sensors Research
* Project H67 Environmental Research
* Project VR9 Surface Science Research

A. Mission Description and Budget Item Justification

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

Work in this Project supports key Army needs and provides the technical underpinnings for several PEs to include PE 0602145A (Next Generation Combat Vehicle Technology) / Project BG6 (Advanced Concepts for Active Defense Technology), and Project BI4 (Materials - Application & Integration Technology); 0602146A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

(Networks C3I Technology); 0602147A (Long Range Precision Fires); PE 0602141A (Lethality Technology), PE 0602143 Soldier Lethality Technology / Project AY6 (Soldier Squad Small Arms Armaments Technology) and Project AZ5 (Soldier Protection Technology - Vulnerability).

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Protection Sciences	-	-	5.367
Description: This effort investigates, designs and develops fundamental knowledge of mechanisms that can be exploited to ensure the next generation of lightweight and efficient armor technologies. Provides physics-based discovery of novel Soldier protection mechanisms through increased understanding of wave propagation through tissue, and the resulting deformation and damage of tissue during ballistic and blast events. ***FY 2020 Plans:*** Will perform ballistic model experiments on lightweight metal alloys and brittle materials to deepen understanding of fundamental ballistic events, failure and fracture mechanics, and high strain rate behavior; will identify the physics and mechanics of materials with electromagnetic fields and forces that fluctuate on timescales of influence during an impact event; will conduct experiments to understand stress wave propagation and dispersion through biological constituents to identify regions more susceptible to damage, and design next-generation Personal Protective Equipment that mitigates damage to these regions. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H42 Materials & Mechanics and PE 0601102A Defense Research Sciences / Project H43 Research In Ballistics in FY 2019.			
Title: Microscopic/Nanostructural Materials	-	-	3.198
Description: This effort explores new materials and creates new computational capabilities based upon fundamental concepts derived from studies of structure, process, and property relationships at the microscopic and nanostructural levels. Research includes synthesis, processing, characterization, and modeling of novel metal alloys and armor ceramics, including control and manipulation of nanostructural features, grain boundaries, texture, and other nano-to-microscale structure. ***FY 2020 Plans:*** Will design, characterize, and conduct ballistic experiments of a high-strength, multi-phase alloy with targeted precipitates to produce a maximum transformation volume so that once the penetrator forms shear bands in the high strength material, the deformation cannot be accommodated by lateral cracking, and short-circuit the transition to plugging failure. Will identify next			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
generation ceramic material synthesis techniques by using multi-modal diamond particle sizes and novel powdered silicon-carbon mixtures to hot-press high diamond content (60?90%) diamond / silicon-carbon composites rapidly in an inert atmosphere. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H42 Materials & Mechanics in FY 2019.			
Title: High Deformation Rate Materials ***Description:*** This research addresses Army-unique issues in fundamental materials research involving the performance of advanced materials at high deformation rates for applications including armor and armaments. Fundamental understanding is developed to enable design, processing, and characterization of materials specifically intended for high loading-rate applications, including improved physics based models, methods to characterize materials microstructure, interfaces, and defects and their role on materials response, and the determination of rate-dependent constitutive and failure/fracture behavior of materials. ***FY 2020 Plans:*** Will extend the large-scale atomistic simulations combined with virtual diffraction to Iron-Nickel-Zirconium; will investigate via Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), and Atom Probe Tomography analyses on the shock-recovered samples to study deformation mechanisms, texture evolution and their contribution to failure process; will identify novel modeling strategies that link molecular dynamics simulations to continuum models of microfibril structure within single fibers of ultrahigh molecular weight polyethylene (UHMWPE). Will understand the influence of chemistry and structure on the rate dependent mechanical response of crosslinked polymer networks. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H42 Materials & Mechanics in FY 2019.	-	-	3.323
Title: Materiel Research and Processing Using High Energy Fields ***Description:*** Explore interactions between materials and intense energy fields (magnetic, electric, pressure, etc.) to discover new pathways and mechanisms for controlling and altering material structure, enabling the development of new materials with unique property combinations and abilities to respond adaptively to battlefield conditions. ***FY 2020 Plans:*** Will exploit field-assisted processing methods to tailor phases that demonstrate improvements in mechanical and functional behavior (such as fracture resistance). Will create new models at multiple length scales (including molecular and mesoscale) to	-	-	2.480

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
simulate the evolution of microstructural features under the application of energy fields and perform validation using customized experimental apparatus. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H42 Materials & Mechanics in FY 2019.			
Title: 1D and 2D Materials and Processing Research ***Description:*** Discover novel building block materials that provide disruptive protection mechanisms. Research includes synthesis, processing, characterization, and modeling to discover new 1-dimensional (1D) and 2-dimensional (2D) building block materials and associated assembly into protective membranes, smart fibers and films, and other molecular composite architectures. ***FY 2020 Plans:*** Will identify synthesis methods for novel 2D polymer molecules assembled with intermolecular hydrogen bonding to create graphene-like materials with enhanced toughness relative to graphene. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H42 Materials & Mechanics in FY 2019. Funding decrease will focus research from one-dimensional and two-dimensional (2D) material systems to 2D polymer molecules.	-	-	1.512
Title: Bio-enabled Precision Materials Synthesis and Assembly ***Description:*** Explore new biology-based methods for controlled synthesis and assembly to create materials with precise chemistries, microstructures, properties, and responsive functionalities through controlled molecular placement, spatial architectures, and interfacial structures. This research utilizes biological platforms that can act as micro-environments to control local thermodynamics and kinetics to govern reactions and molecular assembly, thereby providing completely new pathways for materials discovery. ***FY 2020 Plans:*** Will identify methods for genetic control over biological organisms, with particular focus on diatoms, to develop new pathways for hierarchically structured materials with nanoscale resolution of features to control optical, structural and reactive performance for potential application in adaptive coatings. Will create generalized molecular and coarse grained computational tools for copolymers made from a diverse range of synthetic and bio-derived monomeric feedstocks enabling design and optimization of complex copolymers with tunable micro-structure, mechanical, or functional performance. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	1.749

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project H42 Materials & Mechanicsin FY 2019.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles ***Description:*** Improve the fundamental understanding of the mechanisms controlling the launch and flight of gun-launched projectiles and missiles, and understand the interaction of these weapons with armored targets. ***FY 2020 Plans:*** Will link multi-physics (fluids, thermal, structures, dynamics and controls) tools to computationally investigate high-speed flight phenomena (interactions with shocks and vortices, aero-thermal, aero-optical) and improve munition maneuverability and survivability. Will formulate theory and algorithms for flight control and estimation exploiting understanding of unique dynamics and constraints to guide advanced munitions in denied environments. Will conduct time resolved analysis of inelastic and plastic deformation of brittle materials under 1D strain and combined loading in conjunction with computational modeling. Will understand the neural mechanisms of movement initiation and directional control. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H42 Materials & Mechanics and PE 0601102A Defense Research Sciences / Project H43 Research In Ballistics in FY 2019.	-	-	3.082
Title: Energetic Materials Research ***Description:*** Expand and confirm physics based models and validation techniques to enable design of novel insensitive propellants/explosives with tailored energy release for revolutionary future force survivability and weapons effectiveness. ***FY 2020 Plans:*** Will synthesize of new energetic ingredients for use in rocket and gun propellants with properties/performance equal to or greater than nitroglycerine, Will identify stand-alone energetic ingredients which have detonation pressure exceeding that of the explosive used in current reactive armor, and create new melt cast ingredients and formulations with performance exceeding that of Composition B. Will use non-traditional physics-based approaches to synthesize, explore stabilization routes and characterize performance of disruptive-type materials and energetic reaction processes, including extended solids, structural reactive materials and enhanced yield energetics. Will determine response of newly developed ingredients to dynamic compression and correlate findings with numerical simulations for validation and verification. Will conduct numerical simulations to aide in understanding the kinetic rates of newly developed propellants and propulsion technologies (ramjet). ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H43 Research In Ballistics in FY 2019.	-	-	3.583
Title: Theory in atmospheric characterization, sensing, and modeling.	-	-	4.055

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: New algorithms and methods are developed to account for a variety of complex-terrain physical processes in microscale models. Novel instrumentation and observational methods are developed to advance the understanding of physical processes in the atmosphere. Employ optical techniques to advance detection methods for chemical/biological agents mixed in with atmospheric constituents. Data from high-resolution instrumentation arrays are used to advance and verify evolving atmospheric characterization theory focused on complex terrain and dense urban areas. ***FY 2020 Plans:*** Will understand urban land surface energy budget and radiative transfer processes at the Dense Urban Area Meteorological Sensor Array (MSA) testbed and couple radiative transfer module to Atmospheric Boundary Layer Environment (ABLE) model for high resolution urban modeling. Will understand thermal and momentum flux of sloping surfaces under stratification to better treat physical processes in complex and urban terrain; will implement new approaches for quantifying uncertainty in forecast model output, and adequately expressing the uncertainty for decision support tools; will implement machine learning techniques as a method to increase the performance of low-resource forecast models in the presence of increasing volumes of sensor data; will examine new methodologies for predicting environmental impacts on acoustic vector sensing; will quantify the effects of variations in humidity, ozone, and ultraviolet radiation on the transport and chemical evolution of ambient aerosols with an emphasis on processes occurring in dense-urban environments. Will create physics algorithms for atmospheric optical communication link budget models that simulate optical turbulence effects upon link quality and maximum data rate among ground terminals, airborne platforms, and low earth orbit (LEO) platforms. Will utilize instrumented Unmanned Air Systems multi-rotors for microscale model initialization in data sparse environments; will implement Machine Learning techniques to accurately and efficiently identify the atmospheric state from large datasets. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 53A Battlefield Env & Sig in FY 2019.			
Title: Multiscale Modeling for Novel Materials	-	-	3.489
Description: Explore and develop multi-scale modeling techniques to support fundamental studies of electronic and structural material properties from the atomistic to the continuum. Resulting models will be used to design and develop materials for more efficient, longer lifetime sensors and power and energy devices, and lighter materials for vehicle and soldier protection. This effort includes coupled research with two 5-year Collaborative Research Alliances (CRAs): the Materials in Extreme Dynamic Environments CRA and the Multi-scale/Multidisciplinary Modeling of Electronic Materials CRA. These CRAs are funded under PE 0601104A (University and Industry Research Centers) / Project AB7 (Army Collaborative Research and Tech Alliances). ***FY 2020 Plans:*** Will create numerical methods and algorithms to enable new high-fidelity computer models of materials, with uncertainty of model predictions and incorporating some non-deterministic aspects of microstructure characterization, capable of taking advantage			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
of large-scale computing environments; will create new and extend existing computational methodologies to advance the state-of-the-art of at-scale models of materials, from the electronic scale through atomistic- and meso-scale to macro-scale, to take full advantage of state-of-the-art large-scale computing environments in order to expedite design of new materials for Army applications. Will implement models that describe transport in electronic materials for improved design of electronic and electrochemical interfaces in materials and devices. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H44 Adv Sensors Research in FY 2019. Funding increase will expand research to include non-deterministic aspects of microstructure characterization and transport phenomena in electronic materials for improved design of electronic and electrochemical interfaces in materials and devices.			
Title: Environmental Quality ***Description:*** This effort conducts research on innovative environmentally-friendly technologies that support the warfighter focusing on pollution prevention technologies. ***FY 2020 Plans:*** Will synthesize and characterize a possible new class of layered coatings as a possible replacement to chrome. Will understand the bio-optics of light scattering pigmentary nanoparticles that provide visible and infrared coloration for improved Green Coatings. Will create materials and coatings to protect and reduce maintenance of military clothing and textile items. Will create the underlying science base for making energetics with a reduction of hazardous materials in the processing of energetics. Will perform basic research on the possible clean synthesis of energetic polymers for the reduction of hazardous chemicals in processing. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H67 Environmental Research in FY 2019.	-	-	1.085
Title: Surface Science Research ***Description:*** The activities in this program are related to performing basic research in chemistry, biology, and physics on fundamental problems related to surfaces, interfacial dynamics, thin film materials, chemical-biological catalysis and opto-electronic/sensory technologies. ***FY 2020 Plans:*** Will understand and characterize chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces, to include the effects of binding energy, reactions, transport and deposition; will understand the interactions between chemical reactions and transport processes on surfaces; will develop the theory and conduct modeling of processes at complex	-	-	2.383

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA7 / *Mechanics and Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
surfaces; and will conduct experiments focused on the systematic understanding of surface structure, morphology and surface group properties. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project VR9 Surface Science Research in FY 2019.			
Accomplishments/Planned Programs Subtotals	-	-	35.306

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA8 / *Sensing and Electromagnetics*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
AA8: *Sensing and Electromagnetics*	-	0.000	0.000	8.875	-	8.875	9.075	9.576	9.768	9.877	0.000	47.171

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element 0601102A Defense Research Sciences
* Project 31B Infrared Optics Rsch
* Project H44 Adv Sensors Research
* Project H47 Applied Physics Rsch
* Project H52 Equip For The Soldier

A. Mission Description and Budget Item Justification

This Project conducts basic research on semiconductor materials, layered structures, and novel devices for optical sources, detectors, integrated optoelectronic circuits, and energy generation and storage devices. Efforts include multiscale modeling, material and structure growth and characterization, and novel device design and fabrication. The research has application to Soldier power, sensors, lower power communications, and quantum networks; unattended sensor networks, including distributed sensor fusion; ground vehicle sensors and auxiliary power systems; alternative position, navigation, and timing (PNT) systems for Global Positioning System (GPS)-denied environments; and sensors and power for small unattended ground and air vehicles. This work addresses Army Modernization Priorities in Soldier Lethality, Next Generation Combat Vehicle, Long-Range Precision Fires, and Assured Position, Navigation, and Timing.

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Photonic Materials and Device Research	-	-	1.000
Description: Conduct research into novel material and device structures operable throughout the electromagnetic spectrum from long wave infra-red (LWIR) to ultraviolet (UV) including sources, detectors, and integrated photonic devices to increase situational awareness in open and complex terrains; allow assured communication, improve target detection, identification, and discrimination; and create new device functionalities while reducing size, weight, and power requirements.			
FY 2020 Plans: Will understand the growth and properties of semi-polar and non-polar aluminum gallium nitride alloys including the polarization of light emission, n-type and p-type doping of the alloys, and the generation of defects associated with heteroepitaxial (one kind of crystal is grown upon the surface of a different type) growth techniques; and will perform fundamental studies on chip-scale			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
integrated photonic sub-wavelength structures with the goal of identifying critical features for optical phase delay radio frequency (RF) beamforming and enhancement of surface interactions electromagnetic field for possible on-chip sensing. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 31B Infrared Optics Rsch in FY 2019.			
Title: Advanced Materials Research ***Description:*** This effort conducts research in modeling, fabrication, and characterization of semiconductor materials and structures that leads to revolutionary device functionality in sensing, low power electronics, quantum networks, and power generation. This effort investigates novel complex crystal structures that can lead to devices with performance beyond normal semiconductor transistors, including neuromorphic computing structures and topological insulator based heterostructure with low operating voltage. ***FY 2020 Plans:*** Will create topological insulators applicable for ultra-low power devices for Army electronics; will identify complex crystal structures for new device concepts beyond traditional semiconductor transistors for high performance electronics including neuromorphic computing structures with low operating voltage; will understand the fundamental physics of electron transport along and across material interfaces to achieve new electronic/optoelectronic device functionalities; will identify the performance of semiconductor materials specifically designed to reduce leakage currents in infrared sensors; will identify the proximity superconductor effect in semiconductors; and will validate modeling of charge carrier dynamics at a semiconductor-electrolyte interface of energy generating materials. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 31B Infrared Optics Rsch in FY 2019.	-	-	2.752
Title: Distributed Sensor Research ***Description:*** This effort creates more survivable and secure sensors and displays, investigates new acoustic, seismic, magnetic- and electric-field sensor technologies for personnel, activity, vehicle, and weapon-fire, and develops means to correlate, fuse, and interpret data from diverse sensors. This effort develops novel algorithms and electromagnetic models to investigate RF propagation and exploitation in complex clutter environments for improved RF and radar sensing. ***FY 2020 Plans:*** Will create robust machine learning tools and agile inference in resource constrained environment; will create full-wave electromagnetic scalar and vector Helmholtz solvers for extremely large (up to a trillion elements) quasistatic magnetic- and electric-field sensing problems; will establish wideband direction-of-arrival methods for multiple acoustic targets with reflectors and reconstruct individual waveforms using a single acoustic particle velocity sensor; and will understand and create new radar data-	-	-	1.657

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
driven approaches for forming three-dimensional high-frequency millimeter wave synthetic aperture radar (SAR) imagery using limited positional information. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H44 Adv Sensors Research in FY 2019.			
Title: Materials Science for Army Power and Communications ***Description:*** This research includes modeling of advanced battery materials and structures, and modeling of electromagnetic fields interacting with catalytic materials. High bandgap materials including silicon carbide and gallium nitride with modified composition will be used to fabricate diodes for improved performance as optical communications sources, sensors, and high power components. Materials, designs, and fabrication techniques will be developed for Micro-Electro-Mechanical Systems (MEMS) for RF devices and sensors. ***FY 2020 Plans:*** Will develop models that investigate ion transport in 3D electrode structures; will identify the interactions of electromagnetic fields with plasmonic electrocatalytic materials; will vary the density of carbon vacancies in silicon carbide and characterize changes to signal and leakage currents; and will advance three-dimensional fabrication techniques for piezoelectric materials and integration strategies for thin film piezoelectrics to enable tunable, adaptable RF MEMS devices and inertial sensors to address challenges with spectrum management and operation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H47 Applied Physics Rsch in FY 2019.	-	-	1.613
Title: Fundamentals for Precision Measurement for Contested Environments ***Description:*** This effort develops new materials, novel device architectures, and unique processing techniques to successfully maintain communication and information sharing protocols in GPS-denied, actively jammed, or austere environments. ***FY 2020 Plans:*** Will design, simulate and establish fabrication process to investigate environmentally stable electro-optic air-ring resonator using specialized metamaterial approach as a component for GPS-denied timing applications. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H47 Applied Physics Rsch in FY 2019.	-	-	0.649
Title: Functional Materials	-	-	1.204

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA8 / *Sensing and Electromagnetics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: This Project supports basic research in polymer science and textile technology, nano and biotechnology, and multifunctional materials to achieve technologies that support the Soldier of the future through multi-functional materials with clothing/protective equipment functionality that also embody electronic functionality. ***FY 2020 Plans:*** Will design and synthesize homogenous multilayer composites of carbon nanotubes using layer-by-layer assembly to systematically elucidate the effect of carbon nanotube dimensions on their function as electromagnetic radiation absorbers and broaden the frequency range of carbon nanotube microwave absorption. Will utilize full wave electromagnetic simulations to predict geometric and periodic design patterns for printed hybrid nanocomposites of magnetic nanoparticles and graphene to enhance electromagnetic absorption and inform the design of lightweight Soldier protective platforms. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H52 Equip For The Soldier in FY 2019.			
Accomplishments/Planned Programs Subtotals	-	-	8.875

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army												Date: March 2019
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) AA9 / *Information and Networking*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
AA9: *Information and Networking*	-	0.000	0.000	40.449	-	40.449	41.075	41.491	42.322	42.793	0.000	208.130

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601102A Defense Research Sciences
* Project 305 ATR Research
* Project H47 Applied Physics Rsch
* Project H48 Battlespace Info & Comm Rsc

A. Mission Description and Budget Item Justification

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

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

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Communications in Complex Dynamic Networks	-	-	5.677
Description: Perform research to provide communications capability for a fully-mobile, fully-communicating, and situationally-aware force operating in a highly dynamic, wireless, mobile networking environment populated by hundreds to thousands of			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
networked nodes. This research includes techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldiers' information needs, modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber-attacks. Also to be considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information. ***FY 2020 Plans:*** Will create models for the structure and processes associated with social, information, and communication networks, and composite networks thereof, with the communication networks potentially comprising unconventional communication channels (e.g., incoherent optical communications and low-radio-frequency channels) with features that can be exploited to enable operation in complex dynamic environments. Will utilize simulated and experimentally collected data to identify adaptive methods to control the evolution of these networks and to optimize network performance. Will create methods for the simulated and experimental assessment of the novel communications and networking modeling and control approaches by exploiting, e.g., low-complexity approximations or high-performance computing resources, and will apply such methods to the evaluation of the proposed approaches. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in portions of PE 0601102A Defense Research Sciences / H48 Battlespace Info & Comm Rsc in FY 2019.			
Title: Data to Knowledge to Support Decision Making (Information Mediation)	-	-	5.161
Description: Design and implement a laboratory-scale common information processing infrastructure, inclusive of cloud computing, for networking processes that aids the transformation of data into actionable intelligence to support decision-making under uncertainty. Perform research to utilize real-time, tactical, Soldier-centric information for improved decision-making and situational awareness. Perform research in support of rapidly enhancing long-duration, complex, dynamic decision-making capabilities of individual Warfighters and units through the integration of cognitive augmentation and course of action recommender technologies. ***FY 2020 Plans:*** Will understand the characteristics of complex systems behavior and reasoning given heterogeneous exascale networked sensing and actuating information-sources and ensemble machine-learning models; will identify methods to estimate Soldier state through use of wearable sensors and personal devices; will quantify and understand the propagation of uncertainty given intelligent predictive representations and will create theoretical models that enable machine learnable risk quantification for decision making. ***FY 2019 to FY 2020 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / H48 Battlespace Info & Comm Rsc in FY 2019.			
Title: Information Protection in Mobile Dynamic Networks ***Description:*** Perform research on protecting information in highly mobile, wireless tactical environments, where networks must operate under severe bandwidth, energy, and processing constraints, and without reliance on centralized security services. ***FY 2020 Plans:*** Will create communications and networking models and methodologies that provide physics-based security guarantees through the exploitation of fundamental characteristics of entanglement. Will identify algorithms that provide information-theoretic guarantees on security for conventional networks and develop associated theoretical performance characterizations. Will establish ultraviolet networking protocols that optimize network performance while satisfying bounded probability of adversarial detection by exploiting atmospheric absorption effects. Will create methodologies and algorithms for non-invertible intrusion detection systems in resource constrained environments. Will understand cyber deception methods for contested tactical networks to effectively mask current and future operations by exploiting machine learning and game-theoretic approaches. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / H48 Battlespace Info & Comm Rsc in FY 2019. Funding increase will expand research into quantum entanglement and secure communications using non-traditional portions of the electromagnetic spectrum.	-	-	4.922
Title: Naturalistic Behavior for Shared Understanding and Explanation with Intelligent Systems ***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of-the-art techniques in machine translation and natural language processing. ***FY 2020 Plans:*** Will identify or create natural language processing (NLP), social terrain modeling, multimodal data analytics, and soldier-centric informatics to support human-agent interaction, situational awareness, and decision-making. Will leverage machine learning, ontological, morphological, rule-based, and other evolutionary approaches to using human language technologies (HLT), computational linguistics, social theory, and informatics for naturalistic communication and shared understanding between Soldiers and systems. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / H48 Battlespace Info & Comm Rsc in FY 2019.	-	-	1.202
Title: Advanced Computing Architectures and Algorithms	-	-	3.815

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Investigate advanced computing and high performance computing (HPC) networking architectures, memory/storage architectures, algorithms and visualization techniques to support advanced battle command applications for C4I systems. ***FY 2020 Plans:*** Will identify memory and processor architecture needed to simulate and characterize performance characteristics of advanced computer systems; will establish methods to use neuromorphic processors and heterogeneous architectures using innovative programming techniques beyond machine learning; will advance mathematical algorithms and models devoted to scalable and temporal data analytics for machine learning, real-time detection, increased, and predictive analytics to increase Soldier effectiveness, situational awareness, and decision-making. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / H48 Battlespace Info & Comm Rsc in FY 2019.			
Title: Assured Operations in the Physical, Social and Cyber Domain	-	-	6.066
Description: Conduct research that will enhance the survivability of information by radically dispersing and continuously moving data across a multitude of inter-networked devices. This effort seeks to address the growing demands on information assurance, reliability and transmission in resource constrained environments. Theories and methods will be developed for securing information across heterogeneous devices/sources and networks, detecting and creating information obfuscation and deception techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. ***FY 2020 Plans:*** Will establish networking approaches and algorithms that configure physical and cyber network properties to leverage multiple communication modalities and obscure the location and nature of information on the network while providing enhanced network adaptiveness. Will create the framework for integrating conventional radio-frequency communications with unconventional spectrum usage to enhance network adaptability and provide resilience to adversarial jamming and detection. Will identify methodologies and algorithms for automated resilience for tactical cyber physical systems. Will understand both signature-based intrusion detection and anomaly detection methods for cyber physical systems. Will identify methods of assigning dynamic risk scores for tactical systems based on mission and phase of mission to enhance the overall resilience of the entire tactical system. Will formulate methods for augmenting situational awareness by leveraging and navigating the social terrain in complex environments. Will establish the principles of distributed and hybrid approaches for combining model-based and data-driven approaches, to detect anomalies in the environment, devices, and systems in a manner that is aware of and helpful to learning operating parameters, security considerations, and mission goals. ***FY 2019 to FY 2020 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / H48 Battlespace Info & Comm Rsc in FY 2019. Funding increase will expand research to include creating the framework for integrating conventional radio-frequency communications with unconventional spectrum usage to enhance network adaptability and resilience to adversarial jamming and detection and methods for assigning dynamic risk scores for tactical systems based on mission and phase of mission to enhance the overall resilience of the entire tactical system.			
Title: Machine Learning for Intelligent Agent and Human Decision Making ***Description:*** This effort will research methodologies and algorithms for machine learning with incomplete, unstructured, potentially deceptive and heterogeneous information, enabling joint decision making for Intelligent Agent-Human teams which adapt to unknown environments and missions. Research will include methods for learning and decision making that occur under short time frames and constrained resources (computation, power, spectrum and networks). ***FY 2020 Plans:*** Will understand the implications of training deep networks from sparsely labeled data under time constraints; will identify learning approaches with statistically mismatched data. Will create the framework for enhanced natural, intuitive, multimodal, and bi-directional communication between Soldiers, agents, and systems. Will improve computational methods for capturing knowledge and intent from information in military environments. Will create methods for online discovery and adaptation of semantic models in dynamic environments. Will use human input to improve learning algorithms that provide improved decision-making with less data and in less time. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / H48 Battlespace Info & Comm Rsc in FY 2019. Funding increase will expand research to include creating methods for online discovery and adaptation of semantic models in dynamic environments	-	-	3.912
Title: Image Analytics and understanding ***Description:*** This effort investigates new methodologies and techniques for improved scene and situational understanding using multi-modal imaging sensors from heterogeneous air and ground platforms. This work explores novel machine learning approaches for applications in resource constrained environments. ***FY 2020 Plans:*** Will create machine learning approaches to obtain real-time scene understanding and situational awareness from multimodal visible and infrared imaging sensors distributed on multiple heterogeneous aerial and ground platforms to support Next Generation Combat Vehicle engagement scenarios; will identify point-of-need at the edge image data exploitation methods	-	-	2.186

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
in the absence of remote, back-end networking support; and will refine computational vision approaches for enhanced scene understanding in visually degraded environments. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project 305 ATR Research in FY 2019.			
Title: Fundamentals for Energy Efficient Electronic & Photonic Components ***Description:*** This program addresses the power draw (demand) of radio frequency (RF) front ends for communication and electronic materials for the digital back-end, as well as efficient materials for delivery of power (supply) for electronics on energy constrained platforms. The work explores new materials with inherently higher energy efficiencies in conjunction with advances in circuits and systems to provide improvements in power efficiencies, linearity and noise at the subsystem level for unique Army requirements for demand and supply electronics. ***FY 2020 Plans:*** Will identify innovative electronic device structures based on surface conduction phenomena in diamond; will understand the utility of ferromagnetic material for developing conformal low frequency antennas by exploring host materials with high permeability, embedded with meta-material cells that enhance the permeability for efficient operation at desired frequencies; will create the growth techniques for chalcogenide-based topological insulator and topological crystalline insulator materials to understand the structural, electronic and unique transport properties of these specialized materials; and will create pyroelectric materials with multiple compositions to enable stacking of materials and efficiently extract energy from a pulsed thermal source for both wireless power and data transfer. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project H47 Applied Physics Rsch in FY 2019.	-	-	1.947
Title: Quantum Information Sciences ***Description:*** This effort investigates interactions between light and quantum systems, including atoms, ions, and solid-state materials, for developing the fundamental building blocks of distributed quantum systems. A particular emphasis is efficient light matter interfaces, including optical cavities, nanophotonics, and high density atomic systems. This effort also develops quantum algorithms for entanglement distribution. ***FY 2020 Plans:*** Will understand atomic systems confined to optical cavities for strengthened light-matter interactions; will create an understanding of Rydberg atomic systems for high-sensitivity electrometry and deterministic quantum memories; will understand the interactions	-	-	5.561

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AA9 / *Information and Networking*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
between optical nanofibers and atomic systems; and will identify techniques for quantum frequency conversion from ultraviolet to telecommunications wavelengths, solid-state qubit candidates, and quantum algorithms. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / H48 Battlespace Info & Comm Rsc in FY 2019.			
Accomplishments/Planned Programs Subtotals	-	-	40.449

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
AB1: *Basic Res in infect Dis, Oper Med and Combat Care*	-	0.000	0.000	33.224	-	33.224	33.085	33.956	35.048	35.441	0.000	170.754

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601102A Defense Research Sciences
* Project ET6 BASIC RESCH IN CLINICAL & REHABILITATIVE MED
* Project S13 Sci BS/Med Rsh Inf Dis
* Project S14 Sci BS/Cbt Cas Care Rs
* Project S15 Sci BS/Army Op Med Rsh
* Project T64 Sci BS/System Biology And Network Science

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Damage Control Resuscitation	-	-	1.760
Description: This effort conducts studies to define and identify cellular processes and metabolic (biochemical activity) mechanisms associated with blood clotting to understand the relationships between the human immune processes and bleeding in trauma.			
FY 2020 Plans: Will identify candidate key additives for improving platelet storage that delay or inhibit the biochemical processes that lead to platelet death during storage. Will investigate correlations between biochemical changes in blood clotting system to clinical markers of acute traumatic coagulopathy. Will perform studies of stem cells to determine the growth / environmental conditions			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
which minimize their ability to create lethal blood clots when administered into the bloodstream. Will continue use of cell culture screening of drugs that protect cells from the effects of blood loss and oxygen deprivation. Will characterize the response of tissue capillaries to hemorrhagic shock. Will understand the utility of stem cells and the proteins they secrete for possible application as treatments for traumatic hemorrhage. Will initiate mathematical modeling for predicting success of resuscitation strategies for traumatic injuries. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project S14 Sci BS/Cbt Cas Care Rs in FY 2019.			
Title: Combat Trauma Therapies ***Description:*** This effort conducts studies of trauma to tissues and organs, including dental (facial and oral) injuries, extremity wounds and fractures, and burns, and ways to mitigate and/or repair this damage. ***FY 2020 Plans:*** Will characterize composite cell/tissue scaffolds and stem cells as potential candidates for a viable skin substitute. Will elucidate the mechanisms of impaired extremity wound healing caused by bone-muscle composite injury in a rodent model. Will identify wound healing agents that limit injury progression by stabilize necrotic tissue and/or resolving dysregulated inflammation in wounds. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed inPE 0601102A Defense Research Sciences / Project S14 Sci BS/Cbt Cas Care Rs in FY 2019	-	-	1.586
Title: Pre-hospital tactical Combat Casualty Care ***Description:*** This effort conducts basic science studies to determine physiological responses to trauma and aid in development of life-saving interventions. ***FY 2020 Plans:*** Will perform conceptual studies to guide development of animal models to assess novel agents that protect the kidney during hemorrhage with and without resuscitation, and to assess effects of blast injury on the ability to survive hemorrhage as well as the effect of hemorrhage on neural damage induced by blast injury. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	0.993

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project S14 Sci BS/Cbt Cas Care Rs in FY 2019.			
Title: Traumatic Brain Injury ***Description:*** This effort conducts basic research in poly-trauma (multiple injuries)/Traumatic Brain Injury (TBI) model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI ***FY 2020 Plans:*** Will establish framework to guide animal model development for assessment of novel treatments for severe traumatic brain injury that may be administered by combat medical personnel at the point of injury. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project S14 Sci BS/Cbt Cas Care Rs in FY 2019.	-	-	1.468
Title: Prolonged Field Care ***Description:*** This effort performs basic research to study the physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties. ***FY 2020 Plans:*** Will define changes that occur within the capillaries when perfused with oxygen-carrying blood substitutes. Will characterize stem cell ability to mitigate organ failure following traumatic injury in rodent models. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project S14 Sci BS/Cbt Cas Care Rs in FY 2019.	-	-	1.131
Title: Injury Prevention and Reduction ***Description:*** This effort identifies biological patterns of change in Warfighters during states of physical exertion, identifies physiological (human physical and biochemical functions) mechanisms of physical injury and exertion that will predict musculoskeletal (muscle, bone, tendons, and ligaments) injury. Also includes the characterization of ocular injury pathways resulting from blast exposure in small animal models. ***FY 2020 Plans:*** Will characterize cellular and vital organ bioeffects from exposures to various sources of directed energy to include: acoustic/sonic waves, lasers, microwaves and other relevant radiofrequency threats. Will identify and characterize risk factors that contribute to	-	-	2.796

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
increased risk for musculoskeletal injury during Basic Combat Training (BCT). Will create whole body blast animal models that can inform blast injury criteria for next generation bomb suit and blast exposure health hazard assessment criteria. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project S15 Sci BS/Army Op Med Rsh in FY 2019.			
Title: Physiological Health ***Description:*** This effort conducts fundamental research on the physiological mechanisms of sleep, fatigue, and nutrition on Soldier health, readiness and performance. In addition, this effort discovers basic understanding of physiological and genetic processes leading to biomedical performance enhancement in in the physical, cognitive and psychological domains. ***FY 2020 Plans:*** Will understand the role of nutrition support for metabolic recovery. Will understand regulation of mineral transport by inflammation. Will discover Central Nervous System (CNS) correlates of chronic sleep restriction and recovery. Will define field-based impact of sleep on operational performance. Will investigate non-invasive brain stimulation for enhancing operational performance. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project S15 Sci BS/Army Op Med Rsh in FY 2019.	-	-	3.810
Title: Environmental Health ***Description:*** This effort involves the understanding of physiological (human physical and biochemical functions) mechanisms of exposure to extreme heat, cold, altitude, and other environmental stressors. This effort establishes scientific evidence for specific and sensitive diagnostics of exertional heat illness to optimize Warfighter performance in austere environments. ***FY 2020 Plans:*** Will establish animal models for basic mechanisms of injuries from exposure to heat that degrade health and performance and those factors that accelerate improved recovery. Will identify physiological and host response signatures for performance degradation following toxic chemical exposures. Will identify small molecule biomarkers for accurate assessment of exposures to toxic chemicals or hazardous environmental materials. Will identify microbiome perturbations after exposure to environmental chemicals which can modulate adverse health effects of the host. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	1.184

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project S15 Sci BS/Army Op Med Rsh in FY 2019.			
Title: Physiological Health and Resilience ***Description:*** This effort conducts research into the basic mechanisms of the ability to overcome traumatic events including determination of underlying neurobiological mechanisms (nervous system control of cellular and molecular processes) related to Post-Traumatic Stress Disorder (PTSD) and depression. ***FY 2020 Plans:*** Will advance, refine, and maintain animal models for PTSD. Will facilitate rapid through-put evaluation of candidate compounds for prevention/ treatment of PTSD. Will facilitate development of new analytic techniques to be used in Systems Biology research for obtaining an understanding of the underlying biological processes for both PTSD onset and maintenance and combat stress resolution for those exposed to trauma in which resolution of symptoms occurred without intervention. Will continue identify neuro-biomarkers to optimize recovery from adverse performance-limiting outcomes of traumatic stress. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project S15 Sci BS/Army Op Med Rsh in FY 2019.	-	-	2.163
Title: Basic Research on drugs and vaccines against parasitic diseases ***Description:*** Discover and identify new chemical compounds for further characterization and optimization as potential drug leads against malaria. Discover and identify new antigens, virulence factors and adjuvants that will lead to the development of effective malaria vaccines, develop approaches for multivalent vaccines that achieve protective efficacy across genetically diverse malaria parasites and identify correlates of protection in animal models and in humans. ***FY 2020 Plans:*** Will formulate and analyze triazine class compounds intended for oral administration in humans. Will create analysis methods for projected pyrimidinylguanidine class of compounds (a newly discovered family of similar chemical compounds that are active against malaria parasites in animal models). Will determine mode of action of primaquine-like compounds used to prevent or treat malaria. Will create methods for projected clinical trials and to assess drug distribution and efficacy in experimental animals and humans. Will identify and assess new lead candidates from additional chemical classes for treatment and prevention of malaria. Will fabricate newly discovered malaria proteins (artificially produced via genetic engineering) to characterize their ability to prevent malaria in experimental animals. Will identify new formulations or delivery methods of malaria proteins for inclusion into malaria vaccines. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	6.564

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project S13 Sci BS/Med Rsh Inf Dis in FY 2019.			
Title: Bacterial Disease Threats ***Description:*** Discover and identify new antigens, virulence factors and adjuvants that will lead to the development of effective diarrheal vaccines against Enterotoxigenic Escherichia Coli (ETEC), Shigella and Campylobacter. Identify approaches to develop multivalent vaccines that achieve protective efficacy across several bacterial serotypes and species, as well as identify correlates of protection from bacterial diarrheal disease in animal models and in humans. ***FY 2020 Plans:*** Will characterize previously identified antigens (substances derived from the agent which stimulate immune systems to produce antibodies) from ETEC, Shigella and Campylobacter which together are responsible for most of the cases of diarrhea in deployed Warfighters. Will characterize various types of ETEC, Shigella and Campylobacter to inform vaccine development efforts. Will understand previously identified indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea to predict protection from disease. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project S13 Sci BS/Med Rsh Inf Dis in FY 2019.	-	-	1.710
Title: Viral Threats Research ***Description:*** Discover and identify new antigens, virulence factors and adjuvants that will lead to the development of effective vaccines against hemorrhagic fever viruses (e.g. dengue and Hantaviruses). Identify approaches to develop multivalent vaccines that achieve protective efficacy across all dengue serotypes, and discover and identify correlates of protection from viral diseases in animal models and in humans. ***FY 2020 Plans:*** Will formulate new attenuated (weakened) dengue viruses for use in dengue human challenge trials as part of vaccine testing and studying virus induced host damage and immune cell mediated protection. Will characterize immune cells and antibodies in samples from humans in novel inactivated virus/ live attenuated virus vaccinations against dengue. Will conduct computer based assessments of human immune responses to dengue vaccination and dengue infection. Will identify and characterize vaccine technologies to produce antibody products that might be used to prevent or treat disease by lethal viruses such as Hantaviruses, South American and African Hemorrhagic viruses. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	1.820

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601102A Defense Research Sciences / Project S13 Sci BS/Med Rsh Inf Dis in FY 2019.			
Title: Insect Vector Basic Research ***Description:*** Identify and characterize specific populations of vectors that may carry and transmit infectious disease, inform vector control countermeasures, and develop detection assays for vectors and vector-borne pathogens. ***FY 2020 Plans:*** Will identify unique biological markers (e.g., proteins, genes) and technology that can be used to produce improved detection tools that can identify multiple pathogens in a vector population and help to inform vector control countermeasures and risk assessment tools. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project S13 Sci BS/Med Rsh Inf Dis in FY 2019.	-	-	1.711
Title: Clinical and Rehabilitative Medicine ***Description:*** This effort conducts basic studies of mechanisms of tissue growth and traumatic injury to gain an understanding that will assist or facilitate the healing or transplantation process. The focus is placed on severe blast trauma to the limbs, head, face (including eye), genitalia (organs of reproduction), and abdomen. ***FY 2020 Plans:*** Will create candidate products to treat severe burn injury for skin regeneration and reduced scarring. Will create animal pain models, discover novel pain treatment targets and identify biomarkers that predict pain phenotype and analgesic efficacy. Will understand and characterize the pattern of molecules that impact immune response in the eye after injury to understand the timing of clinical impacts. Will characterize cellular mechanisms leading to vision dysfunction. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project ET6 BASIC RESCH IN CLINICAL & REHABILITATIVE MED in FY 2019.	-	-	1.334
Title: Network Sciences Initiative ***Description:*** This effort uses mathematical models and algorithms to extract medical information from large-scale datasets (generated from the study of cellular genetic makeup, protein structures and function, wearables, and whole organism responses) to improve understanding, prevention, diagnostics, and treatments of those injuries and diseases that pose a threat to Warfighter	-	-	3.194

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB1 / *Basic Res in infect Dis, Oper Med and Combat Care*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
readiness: e.g., musculoskeletal injury, PTSD, uncontrolled bleeding, infectious diseases, hard-to-diagnose pulmonary disease, and exposure to environmental stressors and hazards. ***FY 2020 Plans:*** Will refine and test computational models to understand blood-clotting processes and assess the effects of changes in clot formation, blood flow, and injury severity on trauma-induced coagulopathy (when the blood's clotting ability is impaired); will refine and test algorithms to predict the risk of musculoskeletal stress-fracture injury in Warfighters during basic combat training; will refine computational algorithms to improve the understanding of vaccine-induced immune responses during viral infection, to provide insight into molecular mechanisms of protection; will improve and extend algorithms to predict biomarkers indicative of toxic chemical exposure and organ damage; will create algorithms to understand the mechanisms involved in hearing loss; will utilize new deep-learning algorithms to extract knowledge from big datasets, in order to identify brain activity during sleep that may be indicative of PTSD, and more efficiently assess pharmacological properties of drug candidates. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project T64 Sci BS/System Biology And Network Science in FY 2019.			
Accomplishments/Planned Programs Subtotals	-	-	33.224

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
AB2: *Protection, Maneuver, Geospatial, Natural Sciences*	-	0.000	0.000	17.420	-	17.420	17.755	18.587	19.186	19.400	0.000	92.348

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601102A Defense Research Sciences
* Project 52C Mapping & Remote Sens
* Project T22 Soil & Rock Mech
* Project T23 Basic Res Mil Const
* Project T24 Signature Physics And Terrain State Basic Research
* Project T25 Environmental Science Basic Research

A. Mission Description and Budget Item Justification

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

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Mapping, remote sensing, signature physics and terrain state	-	-	3.892
Description: Investigates compact mathematical representations of terrain data, explores automated learning of built elemental features unique to location, formulates new techniques for automatically retrieving Earth surface features, properties and patterns, explores sensing phenomenology and surface state as affected by terrain and weather, studies optimizing and adapting decision making based on changing geospatial conditions.			
FY 2020 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Will explore new analytical approaches of automated learning to a wide class of spatially-enabled data to discover hidden but important patterns. Fundamental research in this effort will also investigate emergent properties of multimodal observations and novel collection strategies. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed inPE 0601102A Defense Research Sciences / Project 52C Mapping & Remote Sens and PE 0601102A Defense Research Sciences / Project T24 Signature Physics And Terrain State Basic Research in FY 2019.			
Title: Fundamental Adaptive Protection and Projection Research ***Description:*** Conduct fundamental studies on the theory and modeling of future revolutionary geological, structural, and signature reducing materials; and examine, investigate and model complex geophysical, littoral, and other environments that fill critical Army knowledge gaps in adaptive protection and projection. ***FY 2020 Plans:*** Will determine the fundamental mechanisms for material concealment; develop novel damage theories for protective materials; will investigate fundamental responses of snow, ice, and soil to dynamic loads; and will investigate acoustic and infrasound to enhance geophysical environment predictions. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project T22 Soil & Rock Mech in FY 2019.	-	-	4.738
Title: Infrastructure and artificial intelligence science ***Description:*** Explores fundamental theory of artificial intelligence, robotics, autonomous construction, three-dimensional (3D) printing materials, self-assembly and advanced or innovative material science as related to advancing military construction and Engineer operations. ***FY 2020 Plans:*** Will identify and quantify fundamental scientific principles that support complex autonomous/semi-autonomous Engineer operations and 3-dimensional (3D) printing, maximize infrastructure resilience and adaptability through new, innovative infrastructure materials. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project T23 Basic Res Mil Const in FY 2019.	-	-	1.850
Title: Biological, chemical and physical sciences	-	-	6.940

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** AB2 / *Protection, Maneuver, Geospatial, Natural Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Explore novel approaches of innovative data analytics, bio-inspired materials, and chemical experimentation to understand basic principles of biological and chemical mechanisms, organisms, and natural processes of the environment. ***FY 2020 Plans:*** Will explore and inform the effects of permafrost thaw on biogeochemical processes of the microbiome using state-of-the-art metabolite analysis to relate measured processes to landscape scale effects and impacts on future Army operations. Will investigate the fundamental divergence of chemical signaling in isolated populations of slender glass lizards to increase basic understanding of chemical signal evolution, and determine if chemical signaling can inform future Army applications in communications. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601102A Defense Research Sciences / Project T25 Environmental Science Basic Research in FY 2019.			
Accomplishments/Planned Programs Subtotals	-	-	17.420

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
ET6: *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*	-	4.589	4.860	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.449

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB1 Basic Res in Infect Dis, Oper Med and Combat Care

A. Mission Description and Budget Item Justification

This Project supports basic research on experimental models that are developed to support in-depth trauma research studies. This Project includes studies to understand the healing of burned or traumatically injured tissues including eye, bone, nerve, skin, muscle, organs and composite tissues. Such efforts will minimize lost duty time and provide military medical capabilities for post-evacuation restorative and rehabilitative care.

Work in this Project complements and is fully coordinated with PE 0602787A (Medical 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.

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

Work in this project is performed by the United States Army Medical Research Materiel Command (USAMRMC), Fort Detrick, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Clinical and Rehabilitative Medicine	4.589	4.690	-
Description: This effort conducts basic studies of mechanisms of tissue growth and traumatic injury to gain an understanding that will assist or facilitate the healing or transplantation process. The focus is placed on severe blast trauma to the limbs, head, face (including eye), genitalia (organs of reproduction), and abdomen.			
FY 2019 Plans: Investigate the ability of a magnetic field to pull specialized therapeutic cells with metallic beads into the correct location to optimize the healing of key cellular layers necessary to restore vision. Further investigate and characterize the pattern of molecules that impact immune response in the eye after injury to understand the timing of clinical impacts. Further characterize			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** ET6 / *BASIC RESCH IN CLINICAL & REHABILITATIVE MED*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
cellular mechanisms leading to vision dysfunction. Advance studies of cellular mechanisms that encourage growth of microvasculature (part of the circulatory system made up of the smallest vessels) for multiple tissue types muscle or bone. Continue exploring innovative biologics (potential pharmaceuticals made from biological sources) to encourage improved regeneration of craniofacial tissues. Define biological markers for prognosis (predicting the likely outcome) of wound healing and scarring. Continue analysis of immunomodulatory (modification of the immune response/immune system functioning) technologies that reduce the need for long term immune suppression following transplantation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in Infect Dis, Oper Med and Combat Care in FY 2020.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.170	-
Accomplishments/Planned Programs Subtotals	4.589	4.860	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) F20 / *Adv Propulsion Rsch*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
F20: *Adv Propulsion Rsch*	-	3.443	3.544	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.987

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA6 Robotics and Mobile Energy

A. Mission Description and Budget Item Justification

This Project fosters research to increase the performance of small air-breathing engines and power-trains to support improved system mobility, reliability, and survivability for air and/or ground vehicles; and ultimately serves to reduce the logistics cost burden for the future force. Problems addressed include the need for greater fuel efficiency and reduced weight in these propulsion systems. Technical barriers to advanced propulsion systems are the inadequacy of existing materials to safely withstand higher temperature demands, the lack of capability to accurately simulate the flow physics and the mechanical behavior of these systems, including the engine and drive train. The Army is the lead Service in these technology areas and performs basic research in propulsion, as applicable to rotorcraft as well as tracked and wheeled vehicles. Technical solutions are being pursued through analysis, code generation, and evaluations to improve engine and drive train components and investigate advanced materials. Component level investigations include compressors, combustors, turbines, energy sources and conversion, injectors, pistons, cylinder liners, piston rings, gears, seals, bearings, shafts, and controls.

Work in this Project provides the technical underpinnings for PE 0602211A (Aviation Technology).

FY 2020 realignments are due to financial restructuring in support of Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Vehicle Propulsion & Power Research	3.443	3.544	-
Description: Basic research investigating engine and drivetrain technologies for Army manned-and-unmanned vehicles. Research investigates concepts and theories to provide enhanced tools, methods, and innovative concepts to enable improvements in propulsion power density, energy efficiency, reliability, and lifecycle cost for increased performance and capabilities in future Army systems.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F20 / *Adv Propulsion Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Investigate propulsion engine and drivetrain technologies that will enable multi-fuel tolerant combustion in extreme environments, with improved debris tolerance, and thermal management/energy recovery of highly-loaded mechanical interfaces. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY 2020.			
Accomplishments/Planned Programs Subtotals	3.443	3.544	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) F22 / *Rsch In Veh Mobility*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
F22: *Rsch In Veh Mobility*	-	0.720	0.749	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	1.469

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA6 Robotics and Mobile Energy

A. Mission Description and Budget Item Justification

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

Work in this Project provides the theoretical underpinnings for PE 0602601A (Combat Vehicle and Automotive Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Advanced Mathematical Algorithms for Improved Vehicle Efficiency	0.720	0.749	-
Description: Research in support of advanced military mobility technologies with emphasis on Terramechanics (vehicle-terrain interaction), and complex vehicle dynamics and simulation. Research is directed at understanding advanced mathematical and computational methodologies using state-of-the-art analytical and empirical procedures.			
FY 2019 Plans: Identify multi-scale computational algorithms that can model a large ground vehicle traversing over fine soil particles to their true size and geometry in one integrated mobility simulation robustly and hyper efficiently; investigate Deep Learning to supplement high fidelity simulations in generating a Go/No-Go Mobility Map for a large geographic region; develop human cognitive models to represent behavioral dynamics to work side-by-side with control algorithms in a semi-autonomous robotic system engaged in extreme mobility scenarios, thereby replacing the need for ?real human?-in-the-loop assessments; assess how ?shared control? and ?control authority? will work, and how to benchmark full algorithmic control against human operators. The mobility			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** F22 / *Rsch In Veh Mobility*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
performance is affected by the computational challenges faced by the autonomous algorithm; address the computationally intensive autonomy algorithms and extreme mobility scenarios that demand exceptional performance from the on-board computer such as accurate solutions in real time. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Project F22 is moved to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY 2020.			
Accomplishments/Planned Programs Subtotals	0.720	0.749	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H42 / *Materials & Mechanics*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H42: *Materials & Mechanics*	-	9.480	12.200	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	21.680

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA7 Mechanics and Ballistics

A. Mission Description and Budget Item Justification

This Project conducts basic research in materials science, which includes research into key phenomena enabling the creation and production of revolutionary materials that will provide higher performance, lighter weight, lower cost, improved reliability, and environmental compatibility for Army unique applications. The current methodology of using materials to gain added functionality for Army systems is to use a layered approach, whereby each layer provides added capability (e.g., ballistic, chemical/biological, signature, etc.), but ultimately makes the system too heavy and too expensive. Technical solutions are being pursued through understanding the fundamental aspects of chemistry and microstructure that influence the performance and failure mechanisms of ceramics, advanced polymer composites, and advanced metals, with the goal of creating hierarchically organized materials systems that possess multifunctional attributes at greatly reduced weight and cost. These advanced materials will enable revolutionary lethality and survivability technologies for the future.

Work in this Project supports key Army needs and provides the technical underpinnings for several PEs to include PE 0602105A (Materials Technology) / Project H84 (Materials) and PE 0602786A (Warfighter Technology) / H98 (Clothing & Equipment Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Microscopic/Nanostructural Materials	2.988	3.050	-
Description: Devise new materials and design capabilities based upon fundamental concepts derived at the microscopic and nanostructural levels for the future force.			
FY 2019 Plans: Synthesize nanostructured alloy systems to validate model predictions of grain size and grain boundary effects on mechanical response; and investigate if nanostructured metal coatings can provide a 10-fold increase in corrosion protection with other tailorable properties using electrochemical processing from ionic liquids.			
FY 2019 to FY 2020 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H42 / *Materials & Mechanics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY 2020.			
Title: High Deformation Rate Materials ***Description:*** Develop the fundamental understanding necessary to design, process, and characterize materials specifically intended for high loading-rate applications, as in armor and armaments. ***FY 2019 Plans:*** Investigate martensitic transformations in novel strain glass alloys for unique deformation mechanisms and identify a strategy for formulation of novel compositions; demonstrate novel modeling strategies that link molecular dynamics simulations to continuum models of microfibril structure within single fibers of ultrahigh molecular weight polyethylene (UHMWPE). ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY 2020.	3.123	3.164	-
Title: Materials Research and Processing at Small Scale ***Description:*** Elucidate and exploit unique structure, processing, and property relationships that occur in materials at small length scales and develop methods to tailor the physical, chemical and mechanical response of these materials to enable unprecedented performance improvements in materials properties.	1.079	-	-
Title: Materiel Research and Processing Using High Energy Fields ***Description:*** Explore interactions between materials and intense energy fields (magnetic, electric, pressure, etc.) to discover new pathways and mechanisms for controlling and altering material structure, enabling the development of new materials with unique property combinations and abilities to respond adaptively to battlefield conditions. ***FY 2019 Plans:*** Validate models using novel experiments to demonstrate enhanced fracture resistance in two-phase ceramic materials under electromagnetic fields; develop new models to simulate the manipulation of intermolecular interactions with electromagnetic fields. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY 2020.	2.290	2.365	-
Title: 1D and 2D Materials and Processing Research ***Description:*** Discover novel building block materials that provide disruptive protection mechanisms. Research includes synthesis, processing, characterization, and modeling to discover new 1-dimensional (1D) and 2-dimensional (2D) building block materials and associated assembly into protective membranes, smart fibers and films, and other molecular composite architectures.	-	1.597	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H42 / *Materials & Mechanics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: Identify synthesis methods for novel 2D polymer molecules assembled with intermolecular hydrogen bonding to create graphene-like materials with enhanced toughness relative to graphene. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY 2020. Funding decrease will focus research from 1D and 2D material systems to 2D polymer molecules.			
Title: Precision Materials Synthesis and Assembly ***Description:*** Explore new biology-based methods for controlled synthesis and assembly to create materials with precise chemistries, microstructures, properties, and responsive functionalities through controlled molecular placement, spatial architectures, and interfacial structures. This research utilizes biological platforms that can act as micro-environments to control thermodynamics and govern reactions, thereby providing completely new pathways for materials discovery. ***FY 2019 Plans:*** Explore scalable cell-free synthesis of enzymes and subsequent site-specific synthesis of rudimentary polymers that will serve as a foundation for dictating morphology in defense-relevant polymer fibers and membranes. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY 2020.	-	1.675	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.349	-
Accomplishments/Planned Programs Subtotals	9.480	12.200	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H42 / *Materials & Mechanics*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H43 / *Research In Ballistics*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H43: *Research In Ballistics*	-	11.035	11.714	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.749

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA7 Mechanics and Ballistics

A. Mission Description and Budget Item Justification

This Project seeks to improve the understanding of the chemistry and physics controlling the propulsion, launch, and flight of gun-launched projectiles and missiles, and to understand the interaction of these weapons with armored targets. This research results in basic new knowledge, which allows the formulation of more energetic propellants, more accurate and non-lethal (NL)/lethal projectiles and missiles, and advanced armors for increased survivability of Army combat systems. This Project supports the Office of the Secretary of Defense Advanced Energetics Initiative to mature the fundamental technologies required to transition the next generation of energetic materials into field use.

Work in this Project supports key Army needs and provides the theoretical underpinnings for PE 0602618A (Ballistics Technology) / Project H80 (Survivability and Lethality Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Advanced Energetics Initiative	3.476	3.475	-
Description: Expand and confirm physics based models and validation techniques to enable design of novel insensitive propellants/explosives with tailored energy release for revolutionary future force survivability and weapons effectiveness.			
FY 2019 Plans: Apply ultrafast laser based techniques to a variety of energetics in order to obtain a more fundamental understanding of detonation event. Investigate the complexity of deflagration or combustion reactions using ballistic imaging. Assess experimental characterization methods to measure detonation properties from a minimal amount of material and validate them with large scale measurements. Explore novel systems as candidates for disruptive-type energetic/propellant materials to increase the power of explosives and range/velocities of projectiles.			
FY 2019 to FY 2020 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H43 / *Research In Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY20.			
Title: Launch and Flight of Gun Launched Projectiles as well as Missiles ***Description:*** Improve the fundamental understanding of the mechanisms controlling the launch and flight of gun-launched projectiles and missiles, and understand the interaction of these weapons with armored targets. ***FY 2019 Plans:*** Obtain fundamental understanding of flow mechanisms necessary to mitigate undesired vortex interactions or flow separation to ultimately enhance vehicle maneuver control; establish theory for distributed estimation of multi-agent, high-speed systems with union of heterogeneous sensor signals. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY20.	2.819	2.900	-
Title: Armor Research ***Description:*** Develop fundamental knowledge of mechanisms that can be exploited to ensure the next generation of lightweight and efficient armor technologies. ***FY 2019 Plans:*** Create new anisotropic/asymmetric model for flow and localization, and implement into three-dimensional multi-physics numerical simulation software. Perform ballistic model experiments on lightweight metals variants to probe range of flow behaviors exhibited. Conduct additional experiments at the Dynamic Compression Sector. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY20.	3.618	3.688	-
Title: Humans in Extreme Ballistic Environments Research ***Description:*** Provide physics-based discovery of novel protection mechanisms through increased understanding of wave propagation through tissue, and the resulting deformation and damage of tissue during ballistic and blast events. ***FY 2019 Plans:*** Develop a computational framework to study the effects of mechanical loading on voltage sensitive ion channels of the brain. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY20.	1.122	1.358	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer	-	0.293	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H43 / *Research In Ballistics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer			
Accomplishments/Planned Programs Subtotals	11.035	11.714	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H44 / *Adv Sensors Research*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
H44: *Adv Sensors Research*	-	8.711	9.908	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	18.619

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA5 Biotechnology and Systems Biology
* Project AA7 Mechanics and Ballistics
* Project AA8 Sensing and Electromagnetics

A. Mission Description and Budget Item Justification

This Project supports basic research to produce future generations of sensors with capabilities beyond those currently being employed. Technical barriers include the fundamental speed and bandwidth limitations of current materials and devices, the efficiency of current algorithms, current computing architectures, organic material lifetimes, the understanding of the fundamental concepts of quantum cryptography, and the spatial resolution of current radio frequency (RF) sensors. The technical approach is to exploit large-scale electromagnetic (EM) models to predict and explain target and clutter scattering behavior, and research new digital and image processing modules and algorithms, beam propagation and material models of nonlinear optical effects, remote sensing and intelligent system distributive interactive simulations, and battlefield acoustic signal processing algorithms for improved, hazardous material detection and sensor data feature and information fusion under, unique sensor development, and survivable sensor systems. This Project also funds research in the development of biologically inspired materials for use as sensors as well as for power generation and storage; and physics-based multi-scale models for electronic, optical, mechanical, and chemical materials. Payoffs include high-data-rate military communications, improved radar signal processing techniques that will allow existing systems to improve spatial resolution, improved ultra-wideband radar technology for detection of explosives including mine detection, through-the-wall sensing and improved robotics perception, improved sensor approaches and signal processing techniques for enhanced acoustic/seismic sensing systems in noisy environments, distributed sensor data fusion in ad hoc networks, improved cryptography techniques, improved understanding of the physics and atomic properties of materials, and improved capabilities in hazardous material and event sensing.

Work in this Project supports key Army needs and provides the theoretical underpinnings to PE 0602786A (Warfighter Technology) / Project H98 (Clothing & Equipment Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Improving Sensor Research (previously Improving Sensor and Photonics Research (Nano))	1.514	1.559	-
Description: Create more survivable and secure sensors and displays, and investigate new magnetic- and electric-field sensor technologies for personnel, activity, and improvised explosive device (IED) detection. Develop novel algorithms and			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
electromagnetic models to investigate RF propagation and exploitation in complex clutter environments for improved RF and radar sensing. ***FY 2019 Plans:*** Investigate the development of new methods to efficiently solve extremely complex quasi-static electric/magnetic-field boundary-element problems on Department of Defense supercomputers for wide-area power lines; research joint estimation and fusion of human generated measurements for crowd sourcing applications; research distributed deep learning fusion with low cost, low energy electro-optic sensors for robust target classification; research decentralized quickest change detection algorithms and performance metrics; and develop fundamental electro-magnetic models and signal processing algorithms to support airborne sensing of ground-based concealed targets using networked based distributed sensing concepts. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA8 Sensing and Electromagnetics in FY20.			
Title: Multi-scale Modeling for Novel Materials ***Description:*** Explore and develop multi-scale modeling techniques to support fundamental studies of electronic and structural materials properties from the atomistic to the continuum. Resulting models will be used to design and develop materials for more efficient, longer lifetime sensors and power and energy devices, and lighter materials for vehicle and soldier protection. This effort includes research that leverages two 5-year Collaborative Research Alliances (CRAs): the Materials in Extreme Dynamic Environments CRA and the Multi-scale/Multidisciplinary Modeling of Electronic Materials CRA. These CRAs are funded under PE 0601104A/Project VS2 (Multi-scale Materials Modeling Centers). ***FY 2019 Plans:*** Explore uncertainty of model predictions; explore approaches to employing state-of-the-art computing architectures, which enable large-scale numerical processing; and advance the bridging of at-scale models, across the electronic- to atomic- to meso- to macro-scales. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY20.	2.838	2.867	-
Title: Biological and Bio-inspired Materials and Devices Research ***Description:*** Create synthetic biological materials for devices and sensors that can be used by the Army to improve force protection and reduce logistical burden. ***FY 2019 Plans:***	4.359	2.026	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Investigate computational and experimental routes to functional, stable microbial interactions for biologically enabled devices and processes; and explore mechanistic and evolutionary responses of engineered bacteria to environmental factors for improved bio-hybrid materials, sensors, and electronic devices. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA5 Biotechnology and Systems Biology in FY20.			
Title: Living Materials ***Description:*** Research the concept of responsive materials imparting living functions for operation in Army relevant environments thus enabling disruptive capabilities, such as self-healing, adaptation, protection, and situational awareness. Perform research to enable design and synthesis of materials both enabled by and including biological entities to provide these living functions. ***FY 2019 Plans:*** Perform innovative synthetic biology research in novel hosts to move technology into Army relevant environments; and investigate pioneering tools for dynamic control of biological / abiological hybrid assemblies. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA5 Biotechnology and Systems Biology in FY20.	-	3.229	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.227	-
Accomplishments/Planned Programs Subtotals	8.711	9.908	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H44 / *Adv Sensors Research*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H45 / *Air Mobility*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H45: *Air Mobility*	-	2.354	2.456	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.810

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102 Defense Research Sciences
* Project AA6 Robotics and Mobile Energy

A. Mission Description and Budget Item Justification

This Project supports basic research in aerodynamics for manned and unmanned rotary wing aircraft. The goal of this effort is to develop improved tools and methods to analyze, evaluate, and assess rotorcraft-unique aerodynamic properties in conventional helicopter and tilt-rotor aircraft. The efforts in this Project will result in a better understanding of rotorcraft aeromechanics and will result in improved performance, safety and, ultimately, improved combat effectiveness of the manned and unmanned rotorcraft in the future force. This Project supports the future force by providing research into technologies that can improve tactical mobility, reduce logistics footprint, and increase survivability for rotary wing aircraft.

Work in this Project provides the theoretical underpinnings for PE 0602211A (Aviation Technologies).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Rotary Wing Aerodynamics	2.354	2.410	-
Description: Create robust experimental and computational approaches for understanding, modeling, and predicting the complex fluid flow and aerodynamics of next generation rotorcraft concepts. This research includes innovative numerical methods for capturing the details of steady state and non-steady state aerodynamics and acoustics occurring with multi-rotor, rotor-propeller, and rotor hub configurations; and associated experimental techniques needed to verify modeling results.			
FY 2019 Plans: Conduct experimental research in acoustics and interactional aerodynamics of multi-rotor and rotor-propeller configurations; explore the possibility of active flow control for adverse force reduction on rotorcraft empennage structure; conduct computational sciences research on higher-order accuracy in time for improved flow computations of maneuvering rotorcraft; leverage high performance computing tools for fundamental studies of unsteady aerodynamics and rotor flow fields in hover and forward flight.			
FY 2019 to FY 2020 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H45 / *Air Mobility*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Project H45 will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.046	-
Accomplishments/Planned Programs Subtotals	2.354	2.456	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H47 / *Applied Physics Rsch*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H47: *Applied Physics Rsch*	-	5.549	5.843	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.392

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA6 Robotics and Mobile Energy
* Project AA8 Sensing and Electromagnetics
* Project AA9 Information and Networking

A. Mission Description and Budget Item Justification

This Project performs basic research on electronic materials and structures as well as technologies in energy harvesting and energetic materials, batteries and fuel cells to enable higher performance and more efficient electronic systems. This includes nanoelectronic devices for low-power and high-frequency applications; sensors, emissive nonlinear and nanophase electrodes, and electronic materials; advanced battery materials, thermoelectric devices, photovoltaic devices, as well as more efficient fuel cells for hybrid power; and the manipulation of cold atoms on a chip for improved gyroscopes and accelerometers for inertial navigation units in global positioning system (GPS)-denied environments, very sensitive gravitational sensors for detecting underground facilities, low-phase noise precision oscillators for low-velocity Doppler radar, and ultra-stable atomic clocks for GPS-denied environments, as well as for future space-based timing applications. These investigations will also impact the development of power sources and specialty electronic materials for the Army's future force, including improved wide band gap semiconductor performance for more electric platforms, nanomaterials for batteries and fuel cells, quantum dots for increased photovoltaic efficiency and advanced radar systems. Technical barriers affecting performance, weight, cost, and power consumption will be addressed.

Work in this Project supports key Army needs and provides the technical underpinnings to PE 0602705A (Electronics and Electronic Devices) / Project H94 (Electronics & Electronic Devices).

Funding has been realigned to reflect the FY20 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Nanoelectronic Devices and Sensors	1.453	1.513	-
Description: Conduct research on advanced battery materials; fuel cells and reformers for Soldier and vehicle power; electronic materials structures and defects in high-temperature, wide-bandgap semiconductors for high-power electronic and photonic applications; materials for advanced nano- and micro-devices; and integration of nano-energetics and Micro-Electro-Mechanical Systems (MEMS) for fusing and micro-robotic applications.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: Initiate improvements in charge trapping dielectrics models to cover a broader range of wide band gap materials; evaluate characterization results of the gallium nitride (GaN) power devices and develop improved understanding of the dielectric/ semiconductor interaction under high field, high temperature condition; develop an approach to couple variational thermodynamic theory with stochastic models; apply this approach to heterogeneous materials systems with distributed structure & properties; develop modeling approaches for simulations of concentrated aqueous electrolytes for energy storage applications; apply developed approaches and quantum chemistry methods to guide development of safe lithium-ion and zinc-based batteries; develop, verify, and validate modeling and simulation methodologies to enable research of advanced energy harvesting and (photo)electrochemical energy storage/conversion technologies; explore theory to directly bridge scales (e.g., molecular to continuum); analyze two dimensional (2D) and three-dimensional (3D) fabrication techniques for achieving both piezoelectric materials properties and integration strategies to enable tunable, adaptable radio frequency (RF) MEMS devices, inertial sensors, and position/navigation aiding sensors; and will investigate processes and structures for improving the near ultraviolet and deep ultraviolet quantum efficiency of silicon carbide (SiC) detectors to enable low-cost and compact chemical and biological agent detection and identification. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA8 Sensing and Electromagnetics in FY20.			
Title: Fundamentals for Energy Efficient Electronic Components (previously Advanced Energy Efficient Science Research)	1.834	1.860	-
Description: This program addresses the power draw of RF front ends for communication and the digital back-end from electronic materials. This work explores new materials with inherently higher energy efficiencies, while improving upon the current state-of-the-art. These materials will be used in conjunction with advances in circuits and systems to provide improvements in power efficiencies, linearity and noise at the subsystem level which are unique needs of the military. Conduct materials, components, and multi-scale modeling research that will lead to advances in energy storage, harvesting, conversion, and efficiency for a wide range of Army applications such as Soldier and vehicle power, microgrids, communications, radar and electronic warfare. ***FY 2019 Plans:*** Will integrate front-side optical filter and backside scattering reflector into a photovoltaic (PV) cell to fully match the emission spectrum of the microburner/selective emitter; will experimentally investigate the dramatic power density improvement at reduced temperatures via near-field coupling between the emitter and PV cells having separations less than the peak blackbody wavelength; will investigate non-linear energy conversion in metal oxide conformal thin-film coatings to boost areal power density; will investigate new ferroelectric materials and composites and evaluate properties for greatly enhanced pyroelectric energy conversion; will explore micro-compression effects on the dislocation density motion in GaN materials; will develop phase change			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
and surface enhanced semiconductor-based RF switches with superior power handling, lifetime, and insertion loss; and will investigate magneto-dielectric material research for ultra-thin (<1mm) multiband antennas. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.			
Title: Fundamentals for Precision Measurement for Contested Environments ***Description:*** Develop new materials, novel device architectures, and unique processing techniques to successfully maintain communication and information sharing protocols in GPS-denied, actively jammed, or austere environments. ***FY 2019 Plans:*** Will explore new materials and novel device architectures to realize compact field-capable oscillators that are environmentally insensitive; and will identify issues associated with propagation of the timing pulses. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA8 Sensing and Electromagnetics in FY20.	0.526	0.576	-
Title: Fundamentals for Alternative Energy ***Description:*** Explore novel concepts in energy generation and capture, and in technologies for efficient conversion of ambient energy to electrical energy for use and storage. Design novel structures to include microscale power devices for multimodal harvesting and efficient distributed power conversion. Focus areas include: energy storage and release from atomic nuclei, new materials for topological insulators for energy conversion, and new designs for solar cells. ***FY 2019 Plans:*** Will demonstrate a 1-microwatt per square centimeter 3D etched nuclear-to-electric direct energy converter using a tritium-loaded carrier as the energy source; will determine the efficiency limits for 3D nano-pillared gallium nitride direct energy conversion using promethium-147 isotope; will design a 1-microwatt, 10 cubic centimeter, 10 gram isomer power source using indirect energy conversion; will explore ion solvation, ion-ion interaction and new liquid structure in the new aqueous electrolytes; will establish relation between electrochemical properties and the liquid structure at super-concentrations; will explore light-matter interactions at plasmonically-enhanced electrocatalytic interfaces tailored for carbon-carbon oxidation; will initiate development of light initiated surface chemical reactions and measure scattering and/or absorption spectra of select photo-electrodes to evaluate efficiency; will explore chip level integration of active devices made using 2D and surface conduction electron transport for high conductivity channels that enable more efficient RF performance; will develop underlying principles for vertical gallium nitride (GaN) device/ material issues (more efficient vs lateral); will test high electron mobility transistor devices in multiple geometries; will model and demonstrate acoustic (ultrasonic) power transfer and design enhanced acoustic coupled with inductive transfer of approximately 1W; will develop the technology to co-fabricate piezo-transformers with matching networks at -40 dBm of power; and will quantify	1.736	1.751	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H47 / *Applied Physics Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
cell performance improvements resulting from a new ?greenhouse? solar cell design which captures recombination luminescence that is lost in traditional cells. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.143	-
Accomplishments/Planned Programs Subtotals	5.549	5.843	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H48 / *Battlespace Info & Comm Rsc*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H48: *Battlespace Info & Comm Rsc*	-	30.490	32.263	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	62.753

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA9 Information and Networking

A. Mission Description and Budget Item Justification

This Project supports basic research to enable intelligent and survivable command and control, communication, computing, and intelligence (C4I) systems for the future force. As the combat force structure decreases and operates in more dispersed formations, information systems must be more robust, intelligent, interoperable, and survivable if the Army is to retain both information and maneuver dominance. This research supports the Army's Network Science initiative and addresses the areas of information assurance, signal processing for wireless battlefield communications, document and speech machine translation, and intelligent systems for C4I. Major barriers to achieving the goals are the inherent vulnerabilities associated with using standardized protocols and commercial technologies while addressing survivability in a unique hostile military environment that includes highly mobile nodes and infrastructure, bandwidth-constrained communications at lower echelons, resource-constrained sensor networks, diverse networks with dynamic topologies, high-level multi-path interference and fading, jamming and multi-access interference, levels of noise in speech signals and document images, new low-density languages, and information warfare threats. These C4I technologies must accommodate heterogeneous security infrastructures and information exchange/security mechanisms between multiple levels of security. The intelligent systems for C4I research focuses on providing the agent technology capabilities that will produce highly relevant tactical events for mounted or dismounted commanders, leaders and Soldiers; improve the timeliness, quality and effectiveness of actions; and speed the decision-making process of small teams operating in complex natural or urban terrain.

Work in this Project supports key Army needs and provides the technical underpinnings to PE 0602783A (Computer and Software Technology) / Project Y10 (Computer/ Information Science Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Communications in Complex Dynamic Networks	1.078	1.066	-
Description: Perform research to provide communications capability for a fully-mobile, fully-communicating, and situationally-aware force operating in a highly dynamic, wireless, mobile networking environment populated by hundreds to thousands of networked nodes.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: Investigate and create adaptive networking and algorithms that extends previous research in joint physical, media access control (MAC) and network layer optimization to consider higher layer performance requirements. Develop directional networking algorithms that consider radio frequency (RF) & non-RF channels. Extend energy efficient methods to operate more effectively in an adversarial (contested) and congested operating environments; extend software defined networking control plane algorithms to work across contested hybrid channels. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.			
Title: Data-to-Knowledge to Support Decision-Making ***Description:*** Design and implement a laboratory-scale common information processing infrastructure, inclusive of cloud computing, for networking processes that aids the transformation of data into actionable intelligence to support decision-making under uncertainty. Perform research to utilize real-time, tactical, soldier-centric information for improved decision-making and situational awareness. Perform research in support of rapidly enhancing long-duration, complex, dynamic decision-making capabilities of individual Warfighters and units through the integration of cognitive augmentation and course of action recommender technologies. ***FY 2019 Plans:*** Investigate methods for incorporating online and continuous learning of decision-relevant feedback and preferences stemming from interactions with multi-sourced, multi-media information and knowledge representations; investigate methods for developing belief-state models of intelligence, surveillance, and reconnaissance tasks which teams of agents can use to autonomously select actions such as observations, motions, and interactions. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.	4.909	4.960	-
Title: Information Protection for Mobile Dynamic Networks ***Description:*** Perform research on protecting information in highly mobile, wireless tactical environments, where networks must operate under severe bandwidth, energy, and processing constraints, and without reliance on centralized security services. . ***FY 2019 Plans:*** Enhance distributed energy efficient techniques that minimize the RF signatures and are resilient to coordinated attacks on both the physical layer and network layer; identify techniques for the distributed composition, positioning, and adapting of information services based on user context and state & device processing capabilities that is resilient in the presence of adversary disruption of portions of the information layer; develop provably secure networking techniques that enable authenticated, private & reliable	4.569	3.810	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
networks. Explore and develop metrics for characterizing risk, and cyber-attack effects on mission performance; investigate techniques for cyber-physical systems security; research generation-after-next cyber tools for intrusion detection and active defense of Army systems; investigate behaviors of attackers and defenders for possible attribution and anomaly detection. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.			
Title: Naturalistic Behavior for Shared Understanding and Explanation with Intelligent Systems ***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of- the-art techniques in machine translation and natural language processing. ***FY 2019 Plans:*** Research semantic meaning, object recognition, and information extraction; understand natural language approaches to support tactical communication in human-intelligent agent interaction. Develop algorithmic approaches to derive tactical meaning from heterogeneous data sources. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.	1.125	1.144	-
Title: Advanced Computing Architectures and Algorithms ***Description:*** Investigate advanced computing and high performance computing (HPC) networking architectures, memory/storage architectures, algorithms and visualization techniques to support advanced battle command applications for C4I systems. ***FY 2019 Plans:*** Pioneer compiler techniques for re-using non-parallel software and porting / compiling for new low-power high-core density architectures; perform fundamental research on memory and processor architecture to simulate and estimate performance characteristics of next-gen computer systems; investigate expanding usability for neuromorphic processors thru use of innovative programming techniques beyond machine learning; create interdisciplinary mathematical algorithms and models devoted to scalable and temporal data analytics for machine learning, real-time detection, increased, and predictive analytics to increase Soldier effectiveness, situational awareness, and decision-making. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.	4.065	4.118	-
Title: Quantum Information Sciences ***Description:*** Perform research to enable quantum networks, which necessitates research in efficient light / matter interfaces and long-lived, robust quantum memories. Additionally, the study of quantum techniques for sensing and ultra-precise navigation,	5.246	5.304	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
timing, and communications will be undertaken. Conventional techniques for sensing magnetic fields, gravity, and timing have reached a plateau in their performance, and will be severely impacted in future contested-battlefield environments. This research brings new insights regarding the use of quantum science to enhance Warfighter effectiveness. ***FY 2019 Plans:*** Investigate experimentally and theoretically nanophotonic interactions with quantum systems and cold atoms in exotic electronic states strongly coupled to laser beams; investigate experimentally and theoretically highly-efficient light-matter interactions in four physical platforms for quantum memories and coherent manipulations, including rare-earth materials, ion traps, and solid-state defects; investigate experimental and theoretical methods for coupling different quantum systems using frequency conversion and multiplexed interactions using higher-order light modes; and investigate advantages and limitations of distributed quantum systems through theoretical modeling. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.			
Title: Experimental Methods in Network Science ***Description:*** Supports in-house Network Science studies in conjunction with the Network Sciences Collaborative Technology Alliance and Distributed Analytics and Information Science for United States / United Kingdom (U.S. / U.K.) Coalition Operations Information (PE 0601104A). ***FY 2019 Plans:*** Investigate models, techniques and fundamental limits for dynamically adapting analytics processing (code and data) in a tactical coalition environment as missions and coalitions change to support distributed analytics in coalitions; develop models, theories and algorithms for dynamically adapting information and network configurations in multi-genre networks to support mission based information quality requirements and enable improved distributed decision-making; identify methods and techniques for simulating and emulating large scale software defined wireless networks; develop techniques, algorithms for discovering hidden network processes in multilayer time-evolving networks under incomplete information; investigate deep learning based algorithms for pattern discovery, classification and prediction in multi-genre networks. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.	4.315	2.173	-
Title: Assured Operations in the Physical, Social and Cyber Domain ***Description:*** Conduct research that will enhance the survivability of information by radically dispersing and continuously moving data across a multitude of inter-networked devices. This effort seeks to address the growing demands on information assurance, reliability and transmission in resource constrained environments. Theories and methods will be developed for securing information across heterogeneous devices/sources and networks, detecting and creating information obfuscation and	4.160	4.594	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
deception techniques, managing risk of information quality and trust, and fusing and regenerating needs-relevant information from highly fragmented and dispersed data. ***FY 2019 Plans:*** Investigate the impact of computational reasoning over machine learning outputs inherent in notions of quality and value of information; formulate characteristics for integrating formal models to prevent/detect information tampering while enabling deception detection and adaptive hardening against adversarial machine learning techniques; develop formal models, theories and methods for information obfuscation and deception across the network of tactical edge devices that adapt to adversarial activity in the network; develop models and theories for characterizing the impact of information dispersal on trust & information quality; investigate machine learning based approaches for information dispersion that optimizes the tradeoff between security and timely re-gathering of mission relevant information; identify context aware algorithms for the timely aggregation and presentation of radically dispersed information. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.			
Title: Mobile Network Modeling ***Description:*** This research focuses on techniques that enable predictions of performance and stability of large, complex communications networks. It takes into account the impact of Soldiers' information needs, modalities of access and use of communication networks in complex adversarial environments, high mobility, and adversarial effects such as jamming or cyber-attacks. Also to be considered are computational modeling approaches that capture dynamics of information that flows through the network and/or is stored within the network, and undergoes continual changes as new information arrives and other information ages or is refuted/superseded by newly arrived information. ***FY 2019 Plans:*** Demonstrate high fidelity simulations for communications in unconventional frequency bands with specific focus on high frequency (HF) and very high frequency (VHF) bands; develop key enablers for multi-wavelength uninterrupted communications and networking capability in infrastructure-poor austere environments with novel localization techniques; demonstrate concepts for low power systems for autonomous networking and control. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.	1.023	1.039	-
Title: Machine Learning for Intelligent Agent and Human Decision Making ***Description:*** This effort will research methodologies and algorithms for machine learning with incomplete, unstructured, potentially deceptive and heterogeneous information, enabling joint decision making for Intelligent Agent-Human teams which	-	3.155	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H48 / *Battlespace Info & Comm Rsc*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
adapt to unknown environments and missions. Research will include methods for learning and decision making that occur under short time frames and constrained resources (computation, power, spectrum and networks). ***FY 2019 Plans:*** Develop novel methods for joint human / intelligent agent learning and decision making to capitalize on individual strengths of humans and intelligent agents to improve emergent group performance; identify approaches for rapid, cooperative decision making and learning utilizing machine learning approaches; investigate the training of deep networks from sparsely labeled data under time constraints; investigate learning approaches with statistically mismatched data. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.900	-
Accomplishments/Planned Programs Subtotals	30.490	32.263	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H52 / *Equip For The Soldier*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H52: *Equip For The Soldier*	-	1.130	1.177	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	2.307

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA8 Sensing and Electromagnetics

A. Mission Description and Budget Item Justification

This Project supports basic research to achieve technologies for the Soldier of the future. This research is focused on core technology areas which include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat ration research. Research efforts are targeted at enhancing the mission performance, survivability, and sustainability of the Soldier by advancing the state-of-the-art in the sciences underlying human performance, clothing, and protective equipment to defend against battlefield threats and hazards such as ballistics, chemical agents, lasers, environmental extremes, and ration shortfalls.

Work in this Project provides theoretical underpinnings for PE 0602786A (Warfighter Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Equipment for the Soldier	1.130	1.177	-
Description: This Project supports basic research to achieve technologies that support the Soldier of the future. Research areas include mathematical modeling, physical and cognitive performance, polymer science/textile technology, nanotechnology, biotechnology, and combat rations.			
FY 2019 Plans: Begin to understand the role of surface patterning, structure and surface area on functional performance of seemingly incompatible functionalities (e.g. water repellency and catalysis) with a long term goal of developing orthogonal multifunctional systems for Soldier protection. Explore fundamental phenomena that influence diffusion and surface segregation of metal oxide nanoparticles within polymer matrices. Create a three-dimensional (3D) dynamic knee OpenSim model informed by biomechanics			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H52 / *Equip For The Soldier*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
load carriage and magnetic resonance imaging data to enable prediction of the effects of equipment load and augmentation on Soldier performance. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Project H52 will move to PE 0601102A Defense Research Sciences / Project AA8 Sensing and Electromagnetics in FY20.			
Accomplishments/Planned Programs Subtotals	1.130	1.177	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) H57 / *Single Investigator Basic Research*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H57: *Single Investigator Basic Research*	-	92.806	101.319	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	194.125

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA3 Single Investigator Basic Research

A. Mission Description and Budget Item Justification

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

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Basic Research in Life Sciences	5.414	5.865	-
Description: Pursues fundamental discoveries in life sciences with the ultimate goal of facilitating the development of novel biomaterials to greatly enhance Soldier protection and performance. More specifically, i) molecular genetics research pursues fundamental studies in molecular and systems biology, and genetics, ii) neurosciences research investigating the physiology underlying perception, neuro-motor output, and potential methods of monitoring cognitive states during activity, iii) biochemistry research focuses on studies in structural and cell biology, metabolic processes, and biophysics, iv) research in microbiology pursues studies in microbial physiology, ecology, and evolution, v) social science research aims to elucidate the social, cultural, and other influences to human actions, and vi) auditory and signal processing research to map the cognitive implications of multisensory information integration.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Use digital polymerase chain reaction to quantify copy numbers of barcoding markers and single-copy nuclear genes in pollen samples of known counts, thereby allowing estimates of both isolation and copy number biases, ultimately enabling the genetic mapping and identification of various pollen species, that if successful, will enable new forensic capabilities for personnel and materiel. Genetically integrate a protein switch isolated from cephalopod reflectin protein that can reversibly switch between assembled and disassembled states into a related protein that is naturally unable to disassemble once assembled, that if successful, may enable a wide range of future electro-optical applications relevant to the Army and the Department of Defense (DoD), including systems that are more energy-efficient, lightweight, or exhibit adaptive concealment capabilities. Understand a multiple-target visual search experimental system and test results versus traditional laboratory assessments to evaluate and validate the effectiveness of laboratory-based searches as compared to real-world searches, that if successful, will lead to new designs and validation methods for new standard operating procedures to improve accuracy in visual search tasks (e.g., to identify contraband) known to be susceptible to dangerously high miss rates. Within a biofilm of the bacterium P. aeruginosa, which produces redox-active electron shuttles called phenazines, explore how biofilm of the bacterium P. aeruginosa is affected by the presence of non-phenazine producing species, that if successful, in the long term may lead to the creation of precisely balanced microbial communities for the control of energy generation within electrode-laden biofilms in microbial fuel cells. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.			
Title: Basic Research in Environmental Sciences	0.563	0.300	-
Description: Environmental Sciences research explores the properties of Earth materials and chemical species to discover how they interact with their environments and respond to external forces. Knowledge of the fundamental properties of these materials, from the atomistic to the landscape scale, and their interactions with the atmosphere, hydrosphere, and biosphere are relevant to Army operations, infrastructure, and stewardship. Fundamental research lays the foundation to provide future new Army capabilities, including the remote characterization of land surfaces, trafficability of ground vehicles, and new methods for waste management and remediation. ***FY 2019 Plans:*** Investigate the fundamental surface photo-reactivity of organic compounds during reaction with gaseous and bulk aqueous phases of environmental relevance, that if successful, will provide new methods for protecting the Soldier and other first-responders from exposure to toxic chemicals. Develop a city-scale model of how heat is stored by urban typical urban surfaces, transferred by runoff and dissipated by evaporation following a rainfall event, allowing better prediction of how unmanned aerial vehicles will be affected by updrafts caused by spatial variations in ground temperature and how environmental conditions affect sensor performance. ***FY 2019 to FY 2020 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.			
Title: Basic Research in Chemical Sciences ***Description:*** Basic research to achieve advanced energy control, improved threat detection, and novel responsive materials for Soldier protection. Research efforts will lead to: light-weight, reliable, compact power sources, more effective, lower vulnerability propellants and explosives for tailored precision strikes with minimum collateral damage, new approaches for shielding the Soldier and Army platforms from ballistic, chemical, and biological threats, and reducing signatures for identification by the enemy, and advance warning of explosive, chemical, and biological weapons and dangerous industrial chemicals. ***FY 2019 Plans:*** Develop mechanistic descriptions of catalysis by metal nanostructures when excited with photons, electrons and ions, that if successful, will provide an improved understanding of photoelectrocatalysis that is essential to reducing soldier-borne weight associated with power storage and generation. Use new high-resolution methods to image dissociation of designated compounds to directly observe and characterize roaming mechanisms for the first time, that if successful may enable improved control and development of next-generation propellants and explosives. Design and synthesize polymer-protein hybrid materials and ascertain the design rules necessary for achieving hybrid materials with optimal protein stabilization in non-natural environments, that if successful, may lead to methods for sensing, energy conversion, and optical nonlinearity. Devise a versatile method to immobilize enzymes to abiological substrates while preserving biological structure and function, that if successful will provide new methods for detecting and neutralizing harmful chemicals. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.	13.291	13.573	-
Title: Basic Research in Physics ***Description:*** Focuses on research in many subfields of physics, including condensed matter physics, optical physics, atomic and molecular physics and quantum information, with an emphasis on discovering new realms of quantum and optical phenomena. Pursuit of fundamental physics in these subfields provides new opportunities for future developments in superior optics, ultra-sensitive sensors, and novel electronic architectures for classical and quantum computing. ***FY 2019 Plans:*** Modify graphene to induce an optical nonlinearity (e.g., emitting light at a different frequency than was introduced) that in the long term may enable the creation of new materials with greatly enhanced functionalities. Create theoretical models of the quantum phases and dynamics of periodically driven ultra-cold atomic gases that, if successfully validated, may provide a method for predicting and measuring defects in materials and enable the rapid development of new materials with desired properties. Explore the quantum limits of spectroscopy and control of single molecular ions using atomic ions as qubit probes, that if successful may enable capabilities beyond those possible with classical systems in the application areas of resource optimization, efficient	17.252	18.650	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance), and maximal logistical support. Utilize optical laser beams to discover energy-release channels for several nuclear isomers, that if successful may reveal new methods for long-lived energy source sources, such as batteries. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.			
Title: Basic Research in Electronics and Photonics ***Description:*** Pursues discoveries in electronic sensing, optoelectronics, solid state and high frequency science, electromagnetics, microwaves, and power electronics for situational awareness, communications, information processing, electro-magnetic warfare, and power efficiency. ***FY 2019 Plans:*** Exploit exotic electromagnetic phenomena in solid-state structures which require theoretical formulations beyond Maxwell? s equations (such as axion electrodynamics, chiral anomaly, and spontaneous symmetry breaking) and interfacial proximity effects in quantum heterostructures. Establish the nano-specific functionality of electrical currents and fields unique to the interior of a single cell for stimulation, sensing, and manipulation of the critical functions within and surrounding individual biological cell structures. Incorporate materials, microcavity, and metamaterial design advances to exceed the mobility and resistive loss limitations of electron transport for enhanced computational processing and data communications. Elucidate the transition between notably different forms of energy (such as magnetic, phononic, as well as hybrid physical regimes involving magnons, polarons, and surface plasmon polaritons) to develop novel devices manifesting these phenomena. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.	8.340	7.095	-
Title: Basic Research in Materials Sciences ***Description:*** Research that provides innovations in materials design and process through the elucidation of fundamental relationships linking composition, microstructure, defect structure, processing and properties of materials. Revolutionary materials provide support for the Army in firepower, mobility, communications, personnel protection, infrastructure and installations, and will directly affect virtually all mission areas. ***FY 2019 Plans:*** Design and synthesize selective quantum grade quality novel host materials with desired color centers exhibiting unique quantum properties and elucidate the physical mechanisms responsible for the observed novel quantum properties (e.g. spin coherence) and governing composition- processing- defect- property relationships. Employ theory and integrated modeling/simulations to guide experimental efforts and explore new quantum science opportunities such as collective states. Develop spectroscopic and other applicable characterization methods for direct observation of plasma/material interactions and the dynamics of the	7.613	8.453	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
consolidation process. Refine or modify plasma and materials processing tools to achieve bulk manipulation and scalable consolidation of first-of-their-kind three-dimensional macrostructures. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.			
Title: Basic Research in Computing Sciences ***Description:*** Provides the backbone for performing complex, multi-system analysis, modeling and simulation for understanding information systems. Advancements in computer sciences have a direct impact on enhancing the Warfighters' decision-making, situation awareness, command and control, as well as on the overall performance of weapon, intelligence, transportation and logistics systems. ***FY 2019 Plans:*** Create computational methods to ensure that critical timing constraints are met for real-time mixed-criticality workloads on multicore platforms augmented with graphics processing units (GPUs) for acceleration. Establish a framework for robust, decentralized processing of sensing data that leads to enhanced performance under dynamic and constrained environments to support processing algorithms that exploit geographically distributed and contaminated big data for near optimal inference and decision making. Explore new cyber deception approaches that rely on both obfuscation and decoy techniques that can confuse adversaries and divert cyber attacks to the wrong targets. The particular workloads of interest are emerging safety-critical embedded Army systems where autonomous functionality is required such as in unmanned airplanes and helicopters, battlefield robots, unmanned ground vehicles, and various autonomous weapon systems. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.	6.531	6.720	-
Title: Basic Research In Network Sciences ***Description:*** Focuses on gaining an understanding of the fundamental aspects of how networks develop, function, and adapt to the environment and the rate of information flow in man-made and naturally occurring networks. This understanding will have a direct impact on net-centric force operations, such as better communication system design and operations, and more efficient logistics or communications support. ***FY 2019 Plans:*** Develop state-of-the-art modeling for opinion dynamics over multiple, coupled networks focused on the role of human interactions for shaping people's opinions, beliefs, and actions. Research the adaptation of information theoretical free energy minimization principles in brain theory into the formation of natural and man-made networks. Investigate algorithms, routing methodologies, and software defined network derivatives resulting from free energy related approaches for maximizing information delivered in networks. Investigate applications of network analysis and control to study the organization and functional principles of the human	11.179	12.344	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
brain. Existing analytical methods based on graph theory and statistics fail to take system dynamics into account; research will focus on investigating new theories of network evolution describing interactions in population dynamics, especially using Lotka-Volterra dynamical system models to elucidate high-level properties of community structure. Investigate the impact of network structure on Mean Field Games, as well as hybrid games that combine discrete and continuous games with application to opinion dynamics. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.			
Title: Basic Research in Mechanical Sciences ***Description:*** Focuses on improved understanding of propulsion and combustion for improved efficiency and fuel flexibility, energetics initiation for insensitive munitions, fluid dynamics for rotorcraft, complex dynamic systems for novel sensors, energy generation and multi-dimensional systems, and solid mechanics especially at high strain rates in composite materials for novel armor and protection systems. ***FY 2019 Plans:*** Investigate underlying fluid-structure interaction mechanisms governing vortex-induced galloping of rectangular prisms, which may lead to controlled stability for suspension lines in precision airdrop systems. Develop and demonstrate the fundamentals of a predictive, computational method for modeling damage due to propagating localized bands of plastic deformation in metals, in particular shear bands, under both high temperature and room temperature conditions which will lead to enhanced structures. Develop and validate a new theoretical foundation for describing multi-modal combustion under autoignition conditions achieving a new general, computationally efficient combustion model for Large Eddy Simulation (LES) models that can account for all three modes of combustion (premixed, non-premixed and autoignition) involved in turbulent lifted flame stabilization which will lead to broad fuel flexibility for vehicles. Develop a predictive framework for minimum energy legged locomotion pathways in heterogeneous and cluttered terrain using methods from nonequilibrium statistical mechanics and scattering to enable fast, efficient, and robust autonomous vehicle maneuverability in environments complicated by complex topographies, dense vegetation, or significant debris. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.	6.332	6.620	-
Title: Basic Research in Mathematical Sciences ***Description:*** Pursue the creation of new mathematical tools and methods for performing complex, multi-system analysis and modeling to enhance soldier and weapon-system performance. More specifically, the focus is on creating mathematical principles and practical algorithms for stochastic analysis and control, analysis and control of biological systems, numerical computation of infinite-dimensional systems, and modeling of irregular geometric and social phenomena.	5.550	5.695	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: Initiate and conduct basic research efforts to develop the stochastic mathematics that underlie and enable the analysis of mean field games, and continue to investigate interdisciplinary approaches to reduce the order of the huge systems of equations generated for modeling the control of open quantum systems. Development of these new mathematical areas is expected to provide new mathematical tools to social scientists for modeling strategic decisions in reasoning about cultural norms and emergence of non-state adversarial groups among large populations and enable the design of more efficient quantum computation algorithms. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.			
Title: Basic Research in Simulation and Training ***Description:*** Advances in simulation and training require basic research to understand neuronal changes that occur in the brain during successful and unsuccessful simulations and training. An interdisciplinary approach involving chemistry, computer science, engineering, mathematics, physics, and network science will be required to understand the molecular, cellular, developmental, structural, functional, and computational aspects of the brain during learning, simulation, and training. It will be necessary to determine how neural circuits develop and are arranged physiologically in individuals to produce cognitive computations during simulation and training. This research will also include extensive studies to discover and map the neural circuitry that enables cognitive adaptation, and the dynamic mechanisms of neural network modification need to be established. ***FY 2019 Plans:*** Identify numerous candidate genes found to have increased expression in key sleep-promoting nuclei that if successful, may reveal new methods to reduce sleep deficit and requirements for Soldiers who operate in conditions that are not conducive to restful sleep, that in term would have a positive impact on the maintenance of operational tempo and cognitive resilience. Identify points of divergence between human behavior, task model behavior, and technological systems requirements through the development of computational models that scale to large-scale complex systems that integrate a number of different discrete technologies, that if successful, may enable more effective design methods for user interfaces in Army equipment, training paradigms, and methods to mitigate operator error. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.	1.963	2.060	-
Title: Expeditionary Materials Processing Science ***Description:*** Basic research coupling materials, innovative design, and manufacturing science to enable conversion of resources for meeting an expeditionary Army?s requirements. This research will enable predictive material-to-materiel models for high-	4.942	5.212	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
confidence, certifiable article production, high-fidelity expeditionary and versatile material-to-materiel processing capabilities, and a new generation of materials responsive to applied field for shape shifting and phase transformation. ***FY 2019 Plans:*** Establish the fundamental relations between morphology and composition of single-function nanostructures that can be seamlessly integrated into hierarchical multifunctional systems and incorporate dynamic components capable of inducing actuation of the material across a wide range of length scales; create materials that incorporate sensory elements, propagate waves of information through coupled reaction-diffusion and mechanical processes, and integrate feedback loops and energy transduction mechanisms. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.			
Title: Basic Research in Social Sciences ***Description:*** Social science research focuses on generating fundamental understanding of how social dynamics unfold, taking into account individual-level biophysiological factors contributing to social interaction (e.g., genetics, health, cognition, perception), group processes (e.g., interpersonal forces that determine influence, power, conformity), and the impacts of social institutions (e.g., economic processes, legal/governance structures, religious/belief systems, kin networks), with attention to the interconnections among these levels of analyses, and to the physical and natural environments in which human social dynamics are situated. This scientific understanding will improve situational awareness for Warfighters and analysts, improving efficacy of decision-making to achieve mission objectives. ***FY 2019 Plans:*** Establish methods to validate and measure social dynamics by demonstrating the relationship between vocal patterns in the nonverbal acoustic band and status, dominance, and prestige dynamics and develop models capturing these relationships, that in the long term may enable the rapid detection of the most influential members in a social network, to measure the degree of group cohesiveness, and therefore could provide new capabilities in detecting and improving group performance in Army units. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20.	3.836	5.463	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:***	-	3.269	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H57 / *Single Investigator Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 SBIR / STTR Transfer			
FY 2019 to FY 2020 Increase/Decrease Statement: FY 2019 SBIR / STTR Transfer			
Accomplishments/Planned Programs Subtotals	92.806	101.319	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H66 / *Adv Structures Rsch*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
H66: *Adv Structures Rsch*	-	3.065	3.152	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.217

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA6 Robotics and Mobile Energy

A. Mission Description and Budget Item Justification

This Project funds basic research for improved tools and methods to advance structural health monitoring capabilities and enable condition-based maintenance for sustainment of rotorcraft and ground vehicles. This research also enables the design and use of composite structures that can better address the cost, weight, performance, and dynamic interaction requirements of future platforms identified by the Army Modernization Strategy. Ultimately, these technologies result in safer, more affordable vehicles with a greatly reduced logistics footprint. This Project is a collaborative Army and National Aeronautics and Space Administration (NASA) effort that includes structures technology research into: structural integrity analyses; failure criteria; inspection methods which address fundamental technology deficiencies in both metallic and composite Army rotorcraft structures; use of composite materials in the design and control of structures through structural tailoring techniques; rotorcraft aeroelastic modeling and simulation; helicopter vibration (rotating and fixed systems); and the design and analyses of composite structures with crashworthiness as a goal. The problems in structural modeling are inaccurate structural analysis and validation methods to predict durability and damage tolerance of composite and metallic rotorcraft structures and inadequate structural dynamics modeling methods for both the rotating and fixed system components to address reliability issues for future aircraft. The technical barriers include a lack of understanding of failure mechanisms, damage progression, residual strength, high-cycle fatigue, the transfer of aerodynamic loads on the rotor to the fixed system, and impact of these unknown loads on aircraft components. Technical solutions are focused on: advanced fatigue methodologies for metallic structures, improved composites technology throughout the vehicle, long-term investigation of integrated stress-strength-inspection, advanced methods for rotor system vehicle vibratory loads prediction, improved methods to predict vehicle stability, and improved analyses to address Army Aviation requirements. These advancements will extend service life, reduce maintenance costs, enhance durability, and reduce the logistics footprint of existing and future Army vehicles. This is the only basic research Project supporting investigations for rotorcraft and ground vehicle structures within the Department of Defense.

Work in this Project supports key Army needs and provides the technical underpinnings to PE 0602211A (Aviation Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Air Vehicle Structures & Dynamics Research	2.075	2.128	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H66 / *Adv Structures Rsch*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Conduct basic research in advanced analytical methodologies and techniques for understanding and predicting the health and performance of rotorcraft structures. Develop and experimentally validate technologies, models, and approaches to increase the reliability, useful life, or performance of components in vertical takeoff and landing systems. ***FY 2019 Plans:*** Develop novel methods using concepts such as material self-awareness for the detection and identification of precursors to damage under different types of loading conditions. Investigate the capability to manufacture mission-specific multifunctional and tailored materials/components. Explore complex systems, which will enable the prediction of complex dynamics behavior in real-life conditions and increase rotor performance through better understanding of rotor system aeromechanics processes. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20.			
Title: Reconfigurable Platform Mechanics & Propulsion ***Description:*** Conduct basic research in reconfigurable platform mechanics and propulsion science technologies to enable high-speed Vertical Take-off and Landing (VTOL). Investigate reconfigurable technologies for improved performance, stability and handling qualities across different flight regimes in all operational environments. ***FY 2019 Plans:*** Investigate wide-operability propulsion for future vehicles, including multi-fuel-responsive combustion, tailoring of magnetic properties of materials for aviation electric motors, and extended temperature range smart materials. Explore propulsion theories associated with achieving the dynamic response of flight stability and maneuverability, in addition to fundamental research on the effect of interfacial interaction on mechanical response which would enable reconfigurable platform sub-systems. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20.	0.990	0.988	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.036	-
Accomplishments/Planned Programs Subtotals	3.065	3.152	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H66 / *Adv Structures Rsch*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) H67 / *Environmental Research*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
H67: *Environmental Research*	-	1.036	1.065	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	2.101

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA7 Mechanics and Ballistics

A. Mission Description and Budget Item Justification

This Project focuses basic research on innovative technologies for industrial pollution prevention (P2) that directly supports the Army production base and weapon systems and also addresses non-stockpile chemical warfare (CW) site remediation. Work in pollution prevention invests in next generation manufacturing, maintenance, and disposal methods that will result in significantly reducing the usage of hazardous and toxic substances and their associated costs. The goal is to decrease the overall life-cycle costs of Army systems by 15-30% through the application of advanced pollution prevention technologies. Non-stockpile CW efforts include establishing the ecotoxicity of CW compounds, environmental fate and effect of CW compounds in soils and biodegradation of CW compounds. Pollution prevention thrusts include: environmentally acceptable, advanced, non-toxic processes to manufacture lightweight alternative structural materials to enhance weapon system survivability; clean synthesis of more powerful and improved energetic compounds to eliminate the use of hazardous materials and minimize the generation of wastes; and surface protection alternatives to hazardous paints, cadmium, chromium, and chromate conversion metal and composite surfaces.

Work in this Project complements and is fully coordinated with the Army Environmental Requirements Technology Assessment (AERTA) requirements and contains no duplication with any effort within the Military Departments.

The cited work provides the technical underpinnings for PE 0602618A (Ballistics Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Industrial Pollution Prevention	1.036	1.065	-
Description: This effort conducts research on innovative environmentally-friendly technologies that support the warfighter (focusing on pollution prevention technologies).			
FY 2019 Plans: Investigate and perform basic research to formulate new environmentally friendly propellants, pyrotechnics, and explosives, which reduce the generation of hazardous materials during processing. The focus areas are the replacement of high explosives			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** H67 / *Environmental Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
including RDX, trinitrotoluene (TNT), and hazardous binders and plasticizers. Investigate novel materials to minimize human health, environmental, and long-term sustainable risks from Army weapon systems. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Project H67 will move to PE 0601102A / Project AA7 in FY 2020			
Accomplishments/Planned Programs Subtotals	1.036	1.065	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S13 / *Sci BS/Med Rsh Inf Dis*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
S13: *Sci BS/Med Rsh Inf Dis*	-	10.807	11.263	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.070

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB1 Basic Res in infect Dis Oper Med and Combat Care

A. Mission Description and Budget Item Justification

This Project fosters basic research leading to medical countermeasures for naturally occurring diseases impacting military operations. Basic research for this Project provides an understanding of the mechanisms that make organisms infectious and mechanisms that render the human body's response effective, preventing diseases caused by infectious agents. Understanding the biological characteristics of infectious organisms also enables the development of point-of-care and laboratory-based diagnostic tools (used to identify the nature and cause of a particular disease). Understanding of disease transmission by insects and other organisms helps in developing new interventions to prevent transmission of such diseases. Infectious disease threats from malaria, diarrhea, and dengue (a severe debilitating disease transmitted by mosquitoes), common where Warfighters are stationed across all Unified Combatant Commands, are the highest priorities for basic research.

Research conducted in this project focuses on military-relevant infectious diseases in the following four areas:

(1) Prevention/Treatment of Parasitic (organism living in or on another organism) Disease Threats
(2) Bacterial Disease Threats
(3) Viral Disease Threats
(4) Vector Identification and Control

Work in this Project complements and is fully coordinated with PE 0602787A (Medical Technology).

Funding has been realigned to reflect the FY20 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Basic Research on drugs and vaccines against parasitic diseases	6.130	6.191	-
Description: Malaria, which can cause fatal and chronic disease, is the most significant military infectious disease threat. This effort seeks to better understand the biology of malaria and leishmaniasis (a skin-based disease transmitted by sand flies predominantly exhibited as skin sores) parasites and to gain the necessary foundation for discovering medical countermeasures			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
to protect military personnel from infection. Because the malaria parasite becomes resistant to drugs over time, it is necessary to continually search for parasite weaknesses that can be exploited by different drugs and vaccines. This effort seeks to better understand small molecule therapeutics and prophylactics, to overcome drug resistant organisms and identify new proteins in the design of candidate vaccines for various types of malaria including the severe form (caused by Plasmodium falciparum) and the less severe but relapsing form (caused by Plasmodium vivax). In FY17 the Prevention/Treatment of Parasitic Diseases research area and the Vaccines for Prevention of Malaria research area were merged into one task area titled Parasitic Diseases ? Drugs and Vaccines. ***FY 2019 Plans:*** Formulate and analyze triazine class compounds intended for oral administration in humans. Develop analysis methods for projected pyrimidinylguanidine class of compounds (a newly discovered family of similar chemical compounds that are active against malaria parasites in animal models) and primaquine-like compounds used to prevent or treat malaria. Develop methods for projected clinical trials and to assess drug distribution and efficacy in experimental animals and humans. Continue to identify and assess new lead candidates from additional chemical classes for treatment and prevention of malaria. Continue to monitor for emergence of drug resistant malaria in Asia, Africa and South America. Fabricate newly discovered malaria proteins (artificially produced via genetic engineering) to characterize their ability to prevent malaria in experimental animals. Continue to identify new formulations or delivery methods of malaria proteins for inclusion into malaria vaccines. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.			
Title: Bacterial Disease Threats ***Description:*** This effort is to better understand the biology of bacterial organisms and their effects on humans, how to prevent wound infections, prevent/treat diarrhea (a significant threat during initial deployments), and scrub typhus (a debilitating mite-borne disease that has in recent history been the leading rickettsial disease to impact US military operations and is developing resistance to currently available antibiotics). ***FY 2019 Plans:*** Characterize previously identified antigens (substances derived from the agent which stimulate immune systems to produce antibodies) from Campylobacter, Shigella, and enterotoxigenic E. coli. (ETEC) which together are responsible for most of the cases of diarrhea in deployed Warfighters. Continue to characterize various types of Shigella, ETEC and Campylobacter to inform vaccine development efforts. Further investigate previously identified indicators of vaccine effectiveness (correlates of protection) in animal models of bacterial diarrhea for protection from disease. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	1.524	1.564	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.			
Title: Viral Threats Research ***Description:*** This effort is to better understand highly lethal or incapacitating viruses, including those that cause hemorrhagic diseases (viral infection that causes severe internal bleeding) such as dengue hemorrhagic fever (life-threatening form if disease caused by the Dengue virus, transmitted by mosquitoes) and Hantaviral pulmonary syndrome (caused by hantavirus infection resulting in internal bleeding; can be transmitted by exposure to rodents or their droppings). Basic research includes understanding risk to the Warfighter of contracting a viral disease based on its prevalence in the respective area of operations, viral biology (structure, function, life cycle of the virus and its ecological factors), the disease process, and disease interaction (symptomology) with the human body. ***FY 2019 Plans:*** Continue to formulate new attenuated (weakened) dengue viruses for use in dengue human challenge trials as part of vaccine testing and studying virus induced host damage and immune cell mediated protection. Characterize immune cells and antibodies in samples from humans in novel inactivated virus/ live attenuated virus vaccinations against dengue. Continue computer based assessments of human immune responses to dengue vaccination and dengue infection. Continue to identify and characterize vaccine technologies to produce antibody products that might be used to prevent or treat disease by lethal viruses such as Hantavirus, South American and African Hemorrhagic viruses. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.	1.630	1.669	-
Title: Vector Identification and Control ***Description:*** This effort conducts research to investigate the biology of biting arthropods (i.e. mosquitoes and sand flies) and other vectors (organisms that transmit disease) and their control. This effort also expands identification of infectious disease pathogens in vectors and disease surveillance capabilities in the field. This research will help to direct new interventions into preventing disease transmission. ***FY 2019 Plans:*** Continue to develop knowledge keys to identify and characterize new species of vectors. Continue to explore integrated vector control strategies to include new insecticides or unique formulations, application equipment, and non-chemical control methods. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	1.523	1.565	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S13 / *Sci BS/Med Rsh Inf Dis*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.274	-
Accomplishments/Planned Programs Subtotals	10.807	11.263	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S14 / *Sci BS/Cbt Cas Care Rs*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
S14: *Sci BS/Cbt Cas Care Rs*	-	5.121	5.604	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	10.725

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB1 Basic Res in Infect Dis, Oper Med & Combat Care

A. Mission Description and Budget Item Justification

This Project supports basic research to understand the fundamental mechanisms of severe trauma to advance treatment and surgical procedures to save lives and improve medical outcomes for the Warfighter. Experimental models are being developed to support in-depth trauma research studies. This project includes basic research studies of new concepts for control of severe bleeding, studies of predictive indicators and decision aids for life-support systems; studies to identify potential new therapeutics to heal and repair burned or traumatically injured hard and soft tissues of the eye, face, mouth, and extremities; and studies to elucidate the physiological basis of combat-related traumatic brain injury (TBI). Such efforts will minimize lost duty time and provide military medical capabilities for far- forward medical/surgical care of injuries.

Research conducted in this Project focuses on combat casualty care in the following five areas:
(1) Damage Control Resuscitation
(2) Combat Trauma Therapies
(3) Combat Critical Care Engineering
(4) Traumatic Brain Injury
(5) Prolonged Field Care

Work in this Project complements and is fully coordinated with PE 0602787A (Medical Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Damage Control Resuscitation	1.625	1.594	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: This effort conducts studies to define and identify cellular processes and metabolic (biochemical activity) mechanisms associated with blood clotting to understand the relationships between the human immune processes and bleeding in trauma. ***FY 2019 Plans:*** Study effects of hypotensive (lower than normal blood pressure) resuscitation on human physiology. Identify candidate key additives for improving platelet storage. Study changes in the blood clotting system that occur after traumatic injury. Study biomechanical aspects of blood vessels relevant to bleeding control. As a following on to the FY 2018 effort, use cell culture techniques to better understand stem cell safety and effects of stem cells on blood-clotting and inflammation. Continue use of cell culture methods to screen candidate small-volume drugs for ability to protect blood- and oxygen-deprived cells from further damage and restore normal function. Continue characterization of response of tissue capillaries to traumatic bleeding. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.			
Title: Combat Trauma Therapies ***Description:*** This effort conducts studies of trauma to tissues and organs, including dental (facial and oral) injuries, extremity wounds and fractures, and burns, and ways to mitigate and/or repair this damage. ***FY 2019 Plans:*** Perform studies to determine factors associated with composite bone-muscle injury that lead to impaired healing. Characterize cell /tissue scaffolds and stem cells as potential candidates for skin substitute. Continue work to identify wound healing agents and means to reduce injury progression and mitigate eschar (dead skin tissue formed as result of burn injury)-induced inflammation when early debridement (surgical removal of dead tissue) is not possible. Study burn wound fluid to identify potential biomarkers that signal adequacy of wound healing. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20..	1.389	1.432	-
Title: Combat Critical Care Engineering ***Description:*** This effort conducts basic science studies of vital sign (e.g. heart rate, blood pressure, blood oxygen concentration) responses to trauma as predictors of medical outcomes and as a basis for developing life-saving interventions. This effort also conducts basic science studies to support development of technologies to preserve function of vital organs following traumatic injury.	0.824	0.863	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: Characterize new coating materials for Extracorporeal Life Support circuits that will prevent blood clotting within the system. Study stem cells to identify potential therapeutic capabilities. Study biology of airway stem cells. Conduct studies to characterize effects of partial aortic occlusion on vital organs. Determine the correlation between blood pressure and renal oxygenation/function, the threshold of hypotension (low blood pressure) for ischemia (lack of blood flow) or reperfusion (resumed blood flow)-induced kidney injury, and correlated ischemia tolerance time of the kidneys. Assess feasibility of new approaches to enable combat medics to provide basic critical care in austere, out-of-hospital settings. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.			
Title: Traumatic Brain Injury ***Description:*** This effort conducts basic research in poly-trauma (multiple injuries)/TBI model, mechanisms of cell death, and the discovery of novel drugs and medical procedures to mitigate the effects of TBI. ***FY 2019 Plans:*** Identify proteins in blood that may be of benefit in diagnosing TBI. Explore the basic biology underlying how and why the brain continues to degenerate in the weeks and months following severe TBI. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.	1.283	1.319	-
Title: Prolonged Field Care ***Description:*** This effort performs basic research to study the physiological implications of delayed medical evacuation and limited access to definitive surgical care in severely injured casualties. ***FY 2019 Plans:*** Study physiological effects of reintroducing circulation to a limb after long-term administration of oxygen-carrying blood substitutes. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.	-	0.208	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer	-	0.188	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S14 / *Sci BS/Cbt Cas Care Rs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer			
Accomplishments/Planned Programs Subtotals	5.121	5.604	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) S15 / *Sci BS/Army Op Med Rsh*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
S15: *Sci BS/Army Op Med Rsh*	-	7.002	6.439	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	13.441

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB1 Basic Res in Infect Dis, Oper Med & Combat Care

A. Mission Description and Budget Item Justification

This Project fosters basic research on physiological and psychological factors that limit Warfighter effectiveness and on characterization of health hazards generated by military systems that result as a consequence of military operations; includes research on the neurobehavioral aspects of post-traumatic stress; develops concepts for medical countermeasures to prevent or mitigate the effects of muscle and bone injury to include reducing the effects of sleep loss and other stressors on Warfighter performance. The hazards of exposure to directed energy, repetitive use, fatigue, heat, cold, and altitude are also investigated under this Project.

Research conducted in this Project focuses on military operational medicine in the following four areas:

(1) Injury Prevention and Reduction
(2) Physiological Health
(3) Environmental Health and Protection
(4) Psychological Health and Resilience

Work in this Project complements and is fully coordinated with PE 0602787A (Medical Technology).

Funding has been realigned to reflect the FY20 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Injury Prevention and Reduction	1.201	2.180	-
Description: This effort identifies biological patterns of change in Warfighters during states of physical exertion, identifies physiological (human physical and biochemical functions) mechanisms of physical injury and exertion that will predict musculoskeletal (muscle, bone, tendons, and ligaments) injury. Also includes the characterization of ocular injury pathways resulting from blast exposure in small animal models.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: Continue to identify risk factors for musculoskeletal injury in Department of Defense personnel and identify leading candidates of biomarkers that can diagnose injury from overuse. Continue to determine injury mechanisms and scaling laws from repeated blast in animal models to refine pre-clinical models of low level blast induced mild Traumatic Brain Injury (mTBI). ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.			
Title: Physiological Health ***Description:*** This effort conducts research on the physiological mechanisms of sleep, fatigue, and nutrition on Soldier performance, readiness and well-being. Also, efforts will contribute to human health and performance optimization and enhancement. ***FY 2019 Plans:*** Characterize the impact of sleep on operational performance by designing field-based methodologies to assess sleep, fatigue and performance. Investigate nutritional support for metabolic recovery and immune function. Define inflammatory regulation of nutrient absorption and metabolism. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.	3.554	1.988	-
Title: Environmental Health and Protection ***Description:*** This effort involves the understanding of physiological (human physical and biochemical functions) mechanisms of exposure to extreme heat, cold, altitude, and other environmental stressors. This effort establishes scientific evidence for specific and sensitive diagnostics of exertional heat illness to optimize Warfighter performance in austere environments. ***FY 2019 Plans:*** Establish criteria to down-select biomarkers of multi-organ injury to improve diagnosis of exertional heat injury severity in male and female rats at 1, 2, 3 and 7 days of recovery as a model for human health effects. Investigate dose response modeling for identifying latent hepatic, renal, and cardiac injury after toxic metal and/or toxic industrial chemical exposure during training and operations, including emerging megacities and other multi-domain battle scenarios. Identify novel circulating biomarkers of organ damage in military working dogs following heat injury for improved medical readiness and recovery assessment. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	1.025	1.102	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.			
Title: Psychological Health and Resilience ***Description:*** This effort conducts research into the basic mechanisms of the ability to overcome traumatic events including determination of underlying neurobiological mechanisms (nervous system control of cellular and molecular processes) related to Post-Traumatic Stress Disorder (PTSD) and depression. ***FY 2019 Plans:*** Screen for additional compounds for the treatment of PTSD in an animal model, including investigating the ability of the compounds to inhibit adverse memory formation and related disorders. Complete specific refinements to animal model behavioral test procedures and expand capacity for bench pharmacological assays for PTSD. Use an established animal model of mTBI with or without the addition of stress to identify dietary supplements for improved resolution or resilience to brain trauma. Characterize markers and time course of nervous and endocrine systems response and recovery following trauma exposure in rats. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.	1.222	1.036	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.133	-
Accomplishments/Planned Programs Subtotals	7.002	6.439	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** S15 / *Sci BS/Army Op Med Rsh*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T14 / *BASIC RESEARCH INITIATIVES - AMC (CA)*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
T14: *BASIC RESEARCH INITIATIVES - AMC (CA)*	-	18.000	39.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	57.000

Note

Congressional Interest Item funding provided for Defense Research Sciences.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Defense Research Sciences.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Open Campus Pilot Program	8.000	-
FY 2018 Accomplishments: Open Campus Pilot Program		
Congressional Add: Collaborative Research in the Human Dimension	10.000	-
FY 2018 Accomplishments: Collaborative Research in the Human Dimension		
Congressional Add: Basic Research Program Increase	-	35.000
FY 2019 Plans: Basic Research Program Increase		
Congressional Add: Counter UAS Technology	-	3.000
FY 2019 Plans: Counter UAS Technology		
Congressional Add: UAV fuel systems enhancements	-	1.000
FY 2019 Plans: UAV fuel systems enhancements		
Congressional Adds Subtotals	18.000	39.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T14 / *BASIC RESEARCH INITIATIVES - AMC (CA)*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T22 / *Soil & Rock Mech*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
T22: *Soil & Rock Mech*	-	4.489	4.691	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.180

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB2 Protection, Maneuver, Geospatial, Natural Sciences

A. Mission Description and Budget Item Justification

This Project fosters basic research to correlate the effects of the nano- and micro-scale behavior on the macroscale performance of geological and structural materials to provide a foundation for the creation of future revolutionary materials and to revolutionize the understanding of sensor data within heterogeneous geological systems. This research encompasses geologic and structural material behavior, structural systems, and the interaction with dynamic and static loadings. Research includes underlying physics and chemistry that control the mechanics and electromagnetic behavior of geological and structural materials, new techniques that provide measurements at the fundamental scale, and fundamental theories for relating nano- and micro-scale phenomena to macro-scale performance.

Work in this Project provides the basis for applied research in PE 0602784A (Military Engineering Technology), Project T40 (Mobility/Weapons Effects Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Military Engineering Basic Research	2.156	2.195	-
Description: Conduct fundamental research to determine how physical and chemical characteristics of materials affect their interactions with environment.			
FY 2019 Plans: Reduce non-physical oscillations from high-order nonlinear finite element models of environmental flows by devising entropy viscosity numerical methods for hydrodynamics and numerical methods for a new class of continuum formulations that will be the foundation for new models for mass and energy transfer across land-atmosphere boundary; devise a capability for the creation, synthesis, and evaluation of lattice dislocations and surface functionalization for graphene, Carbon Nanotube-metal composites with significantly improved dynamic strength and durability.			
FY 2019 to FY 2020 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T22 / *Soil & Rock Mech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This effort will move to PE 0601102A Defense Research Sciences / Project AB2 Protection, Maneuver, Geospatial, Natural Sciences in FY20.			
Title: Materials Modeling for Force Protection ***Description:*** Conduct fundamental research on material interactions at the micro- and nano-scales to determine how they affect macroscale properties ***FY 2019 Plans:*** Create scalable fuzzy logic tools combined with Geographic Information System multi-criteria decision analysis for geospatial data fusion that will enhance knowledge of environmental parameters with reduced uncertainty in limited knowledge conditions. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB2 Protection, Maneuver, Geospatial, Natural Sciences in FY20.	2.333	2.366	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.130	-
Accomplishments/Planned Programs Subtotals	4.489	4.691	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T23 / *Basic Res Mil Const*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
T23: *Basic Res Mil Const*	-	1.742	1.814	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.556

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB2 Protection, Maneuver, Geospatial, Natural Sciences

A. Mission Description and Budget Item Justification

Work in the Project fosters basic research and supports facilities research initiatives. The objective of Army installations basic research is to investigate, identify, and quantify the fundamental scientific principles that can be used to predict or influence the development of high performance facilities and sustainable installations, both fixed and contingency. Such basic research provides the requisite long term cost effective training and sustainment platforms for Army mission accomplishment. These efforts provide basic research leading to improved design in a range of facilities to optimize facility mission performance, enhance facility security, reduce design and construction errors and omissions, reduce resource requirements, and reduce the environmental burdens over the facility's life. This Project provides leap-ahead technologies to solve military-unique problems in the planning, programming, design, construction, and sustainment of deployed facilities, and energy and utility infrastructure.

Work in this Project provides the basic research basis for applied research in PE 0602784A (Military Engineering Technology) / Projects T41 (Military Facilities Engineering Technology) and T45 (Energy Technology Applied to Military Facilities).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Facilities Research	1.742	1.777	-
Description: Conduct fundamental research on innovative infrastructure technologies to optimize facility mission performance, through enhanced security and reduction in resource requirements, design errors and omissions, and environmental burdens.			
FY 2019 Plans: Determine the aspects of geopolymer chemistry that affect metal bonding and adhesion, and examine martensite formation in dual phase stainless steels and the impact of this formation on material durability in corrosive environments.			
FY 2019 to FY 2020 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T23 / *Basic Res Mil Const*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This effort is moved to PE 0601102A Defense Research Sciences / Project AB2 Protection, Maneuver, Geospatial, Natural Sciences in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.037	-
Accomplishments/Planned Programs Subtotals	1.742	1.814	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T24 / *Signature Physics And Terrain State Basic Research*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
T24: *Signature Physics And Terrain State Basic Research*	-	1.684	1.719	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.403

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB2 Protection, Maneuver, Geospatial, Natural Sciences

A. Mission Description and Budget Item Justification

This Project supports basic research to increase knowledge in the areas of terrain state and signature physics. It investigates the knowledge base for understanding and assessing environmental impacts critical to battlespace awareness. Projects include fundamental material characterization, investigation of physical and chemical processes, and examination of energy and mass transfer applicable to predicting state of the terrain, which control the effects of the environment on targets and target background signatures and mobility, in support of the materiel development community. The terrain state area of terrestrial sciences investigates weather-driven terrain material changes and the sensing and inferring of subsurface properties. The signature physics area of terrestrial sciences focuses on understanding the dynamic changes to electromagnetic, acoustic, and seismic signatures, and energy propagation in response to changing terrain state and near surface atmosphere.

Work in this Project provides a foundation for applied research in PE 0602784A (Military Engineering Technology) / Project 855 (Topographical, Image Intel and Space) and T42 (Terrestrial Science Applied Research).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Analysis for Signal and Signature Phenomenology (Previously titled - Terrain State and Signature Physics)	1.684	1.719	-
Description: Conduct fundamental research to examine the effects of environmental parameters on electromagnetic, acoustic, and seismic signatures as well as energy propagation with regard to terrain state and near surface atmosphere. ***FY 2019 Plans:*** Conduct full-scale field measurements of multimodal wave transmission across a land/water boundary to identify the waves reflected, transmitted, and converted to different types at a land-water interface. Advance the understanding of military relevant urban radiofrequency (RF) propagation by investigating urban structures both as materially heterogeneous and geometrically			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T24 / *Signature Physics And Terrain State Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
rough, considering both the surface and interior characteristics of urban structures, and explicitly considering multipath effects (fading) by performing wideband channel sounding measurements inside and outside buildings, alleys, and narrow streets. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort is moved to PE 0601102A Defense Research Sciences / Project AB2 Protection, Maneuver, Geospatial, Natural Sciences in FY20.			
Accomplishments/Planned Programs Subtotals	1.684	1.719	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T25 / *Environmental Science Basic Research*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
T25: *Environmental Science Basic Research*	-	6.493	6.838	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	13.331

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB2 Protection, Maneuver, Geospatial, Natural Sciences

A. Mission Description and Budget Item Justification

This Project supports basic research to investigate fundamental scientific principles and phenomena necessary to ensure efficient development of the technologies needed to address Army sustainment issues in the restoration, compliance, conservation, and non-industrial pollution prevention areas. These efforts include: investigating and monitoring contaminated sites, including chemical contamination and unexploded ordnance (UXO) detection and discrimination; better characterization of contaminants through improved risk-based assessment; destruction, containment, or neutralization of organics resulting from military activities in water, soil, and sediments; adhering to applicable federal, state, and local environmental laws and regulations; monitoring and controlling noise generation and transport; protecting and enhancing natural and cultural resources; reducing pollution associated with military activities; and the study of ecosystem genomics and proteomics in support of the Army's Network Science initiative.

Work in this Project provides a fundamental basis for applied research in PE 0602720A (Environmental Quality Technology) / Project 048 (Industrial Operations Pollution Control Technology), Project 835 (Military Medical Environmental Criteria), and Project 896 (Base Facilities Environmental Quality).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Environmental and Ecological Fate of Explosives, Energetics, and Other Contaminants	3.338	3.403	-
Description: Conduct fundamental research to examine the effects of Army relevant compounds on the environment			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Determine if sub-lethal exposures to an environmental toxicant can negatively impact an animal?s ability to thrive in the ecosystem; assess interactive feedbacks on individual stamina and cognition after exposure to sublethal concentrations; and evaluate spatial scaling effects on individual level cognition after exposure to sublethal concentrations. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort is moved to PE 0601102A Defense Research Sciences / Project AB2 Protection, Maneuver, Geospatial, Natural Sciences in FY20.			
Title: Fundamental Understanding of Explosives, Energetics and UXO in the Environment ***Description:*** Conduct fundamental research to increase the understanding of the physical and chemical characteristics of insensitive munitions ***FY 2019 Plans:*** Identify biogeochemical parameters that stimulate horizontal gene transfer that will increase the understanding of degradation processes; identify the sources and mechanisms of photo-activated insensitive munitions toxicity; and determine the environmental relevance of photo-activated insensitive munitions toxicity. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort is moved to PE 0601102A Defense Research Sciences / Project AB2 Protection, Maneuver, Geospatial, Natural Sciences in FY20.	1.031	1.053	-
Title: Training Land Natural Resources ***Description:*** Conduct fundamental research on the molecular interactions of plants and animals with environmental stimuli. ***FY 2019 Plans:*** Explore the interrelationships between surface affinity and photocatalytic degradation, including orientation, kinetics, selectivity, and mechanistic pathway; and determine the feasibility, mechanisms, photonic efficiency and fundamental processes of a novel, indirect excitation of photocatalyst using evanescent waves. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort is moved to PE 0601102A Defense Research Sciences / Project AB2 Protection, Maneuver, Geospatial, Natural Sciences in FY20.	1.209	1.234	-
Title: Network Science ***Description:*** Conduct fundamental research to examine the behavior of environmental networks to inform data models and algorithms	0.915	0.931	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T25 / *Environmental Science Basic Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: Compare nectar defense in generalist and specialist plants that are in pollination networks, and model crowd confusion and evacuation in complex networks. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort is moved to PE 0601102A Defense Research Sciences / Project AB2 Protection, Maneuver, Geospatial, Natural Sciences in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.217	-
Accomplishments/Planned Programs Subtotals	6.493	6.838	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
T63: *Robotics Autonomy, Manipulation, & Portability Rsh*	-	8.554	9.536	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	18.090

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AA6 Robotics and Mobile Energy

A. Mission Description and Budget Item Justification

This Project supports basic research in areas that expands the autonomous capabilities, utility, and portability of small robotic systems for military applications, with a focus on enhanced intelligence, biomimetic functionality, and robust mobility, to permit these systems to serve as productive tools for dismounted Soldiers. It enables future systems to support and unburden Soldiers by integrating technologies with an understanding of cognitive and physical needs, and the missions of the humans and (non-human) agents operating on the battlefield. The ability of the Warfighter to command a suite of small unmanned systems (e.g., air, ground, and hybrid vehicles) reduces exposure of the Soldier to harm and improves the efficiency by which a dismounted unit achieves tactical objectives such as securing a targeted zone. Example missions requiring enhanced autonomy, manipulation, and man-portability include rapid room clearing and interior structure mapping; detection of human presence, chemical/biological/nuclear/radiological/explosive (CBNRE), and booby-traps; surveillance; and subterranean passage detection and exploration. Because of their relatively small size, light weight, and service in dismounted environments, small unmanned systems have unique challenges in perception, autonomous processing, mobility mechanics, propulsive power, and multi-functional packaging that transcend similar challenges associated with large unmanned systems. The Army Futures Command conducts research in related disciplines, including machine perception, intelligent control, biomimetic robotics, manipulator mechanics, and propulsive power and drives to foster the development of technologies for lightweight, small-volume, robotics applications for harsh environments. Machine perception research includes the exploration of lightweight ultra-compact sensor phenomenology and the maturation of basic machine vision algorithms that enable small unmanned systems to more fully understand their local environment. Intelligent control research includes the maturation of autonomous processing capabilities and the advancement of artificial intelligence techniques that lead to reliable autonomous behavior in a large-displacement, highly-dynamic environment and permit unmonitored task performance. Research in biomimetic robotics and manipulator mechanics includes the advancement of mechatronic and biomimetic appendages to enable agile high-speed locomotion, dexterous task-performance, and environmental-manipulation; and the maturing of nonlinear control algorithms to support robust, stable mobility. Propulsion power research includes investigations of engine cycles and alternative hybrid energy conversion techniques to provide compact, lightweight, quiet, low-emission, high-density power sources that support highly-portable unmanned systems capable of performing long-endurance missions.

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Robotics Autonomy and Human Robotic Interface Research ***Description:*** In-house research with a focus on enabling robust autonomous mobility for small robotic systems, including autonomous operations in Global Positioning System (GPS) denied areas, planning, behaviors, intelligent control, and the interface of perception technologies to accomplish Army missions in the area of unmanned systems. ***FY 2019 Plans:*** Research methods to improve the ability of robots to have a deeper understanding of the world, increasing their capability to learn from limited, dirty, dynamic, and complex data. This includes the development of a shared-world model with a single probabilistic framework and a unified probabilistic knowledge base for robotic data. Cognitive approaches to perceptions are also explored. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20.	1.836	1.869	-
Title: Intelligent Systems ***Description:*** Pursue in-house research that supports and unburdens Soldiers in a flexible, robust, survivable and comprehensive manner. This work will address the cognitive requirements of humans and (non-human) agents, both hardware and software based, operating individually or in collaboration, on the battlefield. Emphasis will be placed on perception, reasoning, and collaboration techniques that can apply to and transfer between a broad range of systems (such as: adaptive communication and data collection networks; cyber defense, crowd-sourcing and information retrieval software agents; and predictive and explanatory decision support systems). ***FY 2019 Plans:*** Investigate methods to enable the teaming of intelligent systems with Soldiers by developing techniques for online semantic learning from sparse datasets and for intelligent exploration of complex environments. Explore using sparse representations to map high-dimensional physical problems into low-dimensional ones that can be solved using existing techniques. Investigate perceptual and intelligence methods to enable an autonomous system to participate in squad level missions. Explore semantic vector spaces to bridge symbolic and metric representations to develop common representations between humans and intelligent agents. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20.	5.169	5.827	-
Title: Unmanned Air Vehicle Research ***Description:*** Conduct basic research focused on topics that contribute to the body of knowledge required to create future intelligent unmanned aerial vehicles that can effectively team with manned aircraft. Emphasis will be placed upon topics of control	1.549	1.550	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T63 / *Robotics Autonomy, Manipulation, & Portability Rsh*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
and aeromechanics that will expand the flight envelope for unmanned systems, manipulation of objects, and specialized topics relating to perception, reasoning, and creation of a common model of the surrounding environment and planning for behaviors in adversarial environments at high tempo.. ***FY 2019 Plans:*** Develop and explore methods and architectures that enable unmanned air vehicles to interact with the environment while airborne, including perception models for manipulation and flight control methods for robust performance in extreme environments and kinetic/kinematic simulations of unmanned air system (UAS) swarm behavior to enable human-agent teaming. Develop algorithms for real-time control system adaptation due to conditions such as platform reconfiguration, exploring probabilistic methods to access material state awareness to enable risk-informed maneuver. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.290	-
Accomplishments/Planned Programs Subtotals	8.554	9.536	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*	Project (Number/Name) T64 / *Sci BS/System Biology And Network Science*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
T64: *Sci BS/System Biology And Network Science*	-	2.904	3.076	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.980

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102A Defense Research Sciences
* Project AB1 Basic Res in infect Dis Oper Med and Combat Care

A. Mission Description and Budget Item Justification

This Project fosters research investigations through a systematic approach using iterative computer simulation with mathematical modeling and biological information to analyze and refine biological studies. Information gained from these studies has the potential to provide a better understanding of the overall biological system and its molecular network of interactions, leading to improved early strategic decision-making in the development of preventive and treatment solutions to diseases. This approach establishes a model for application of computational biology processes and knowledge of biological networks to discover medical products that prevent and/or treat diseases or medical conditions.

The cited work provides theoretical underpinnings for PE 0602787A (Medical Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Network Sciences Initiative	2.904	2.994	-
Description: This basic research effort involves the use of mathematical models and algorithms to extract medical information from large-scale datasets (generated from the study of cellular genetic makeup, protein structures and function, and whole organism responses) to improve understanding, prevention, diagnostics, and treatments of post-traumatic stress disorder (PTSD), uncontrolled bleeding, infectious diseases, hard-to-diagnose pulmonary disease, and exposure to environmental stressors and hazards.			
FY 2019 Plans: Design algorithms to identify the impact of bone size, structure and function on the risk of stress-related bone fracture in Warfighters during basic combat training; improve and refine computational algorithms to investigate the association of genetic			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** T64 / *Sci BS/System Biology And Network Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
factors with psychiatric disorders such as PTSD; refine models to understand how antibody responses may lead to neutralization or enhancement of viral infection; improve algorithms to predict biomarkers indicative of toxic chemical exposure and organ damage; extend capabilities to understand blood clotting processes under coagulopathic conditions and assess the effects of shape changes in blood vessels, biochemical pathways, and pharmacological (drug) interventions on trauma-induced coagulopathy (blood?s ability to form clot is impaired); develop mathematical models of upper respiratory airflow patterns for the non-invasive diagnosis of pulmonary (lung) diseases. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort will move to PE 0601102A Defense Research Sciences / Project AB1 Basic Res in infect Dis Oper Med and Combat Care in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.082	-
Accomplishments/Planned Programs Subtotals	2.904	3.076	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army										Date: March 2019		
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601102A / *Defense Research Sciences*				Project (Number/Name) VR9 / *Surface Science Research*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
VR9: *Surface Science Research*	-	2.201	2.334	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	4.535

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601102 Defense Research Sciences
* Project AA7 Mechanics and Ballistics

A. Mission Description and Budget Item Justification

This Project fosters basic research to establish and maintain a core capability to enable a molecular level understanding of properties and behaviors of materials relevant to the Army; by developing understanding and ability to manipulate nanostructured materials as a means to tune properties which meet desired performance requirements; by advancing the scientific understanding of surface properties and interfacial dynamics of complex materials; and by providing scalable processes grounded in a molecular understanding of materials. This Project funds basic research in the characterization of chemical and biochemical phenomena occurring at or near solid surfaces and interfaces; the interactions between chemical reactions and transport processes on surfaces; theory and modeling of processes at complex surfaces; and the synthesis and characterization of catalysts that function at the nanoscale. Investment in basic research centered on the surface science disciplines will enable growth of a knowledge base that will result in improved understanding of the interactions of complex materials in real world environments.

The cited work provides the theoretical underpinnings for PE 0602622A (Chemical, Smoke and Equipment Defeating Technology).

Funding has been realigned to reflect the FY 2020 financial restructure and Army Modernization Priorities.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Surface Science Research	2.201	2.259	-
Description: The activities in this program are related to performing basic research in chemistry, biology, and physics on fundamental problems related to surfaces, interfacial dynamics, thin film materials, chemical-biological catalysis and opto-electronic/sensory technologies.			
FY 2019 Plans: Further fundamental research on chemical and biochemical phenomena occurring at or near solid surfaces and material interfaces; probe the connection between low frequency vibrational modes and macroscopic behavior of metal organic frameworks; investigate the effects of binding energy, reactions, transport and deposition, theory and modeling of processes at			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601102A / *Defense Research Sciences*	**Project (Number/Name)** VR9 / *Surface Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
complex surfaces, and experimental work focused on the systematic understanding of surface structure, morphology and surface group properties. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Project VR9 will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.075	-
Accomplishments/Planned Programs Subtotals	2.201	2.334	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601103A *I University Research Initiatives*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	-	74.349	65.202	65.858	-	65.858	67.214	68.552	69.923	70.704	0.000	481.802
AB3: *MURI/PECASE/DURIP*	-	0.000	0.000	65.858	-	65.858	67.214	68.552	69.923	70.704	0.000	342.251
D55: *University Research Initiative*	-	63.556	65.202	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	128.758
D58: *URI ACTIVITIES (CA)*	-	10.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	10.000
V72: *Minerva*	-	0.793	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	0.793

A. Mission Description and Budget Item Justification

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

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army	Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	67.027	65.283	65.858	-	65.858
Current President's Budget	74.349	65.202	65.858	-	65.858
Total Adjustments	7.322	-0.081	0.000	-	0.000
• Congressional General Reductions	-0.055	-0.081			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	10.000	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.623	-			

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: D58: *URI ACTIVITIES (CA)*		
Congressional Add: *Congressional Add*	10.000	-
Congressional Add Subtotals for Project: D58	10.000	-
Congressional Add Totals for all Projects	10.000	-

Change Summary Explanation

FY18 increase related to Congressional Adds totaling $10 million.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) AB3 / *MURI/PECASE/DURIP*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
AB3: *MURI/PECASE/DURIP*	-	0.000	0.000	65.858	-	65.858	67.214	68.552	69.923	70.704	0.000	342.251

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601103A University Research Initiatives
* Project D55 University Research Initiative.

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Multidisciplinary University Research Initiative (MURI)	-	-	53.555
Description: MURI programs are typically 5 years in length at a cost of $1.25 million each per year. ***FY 2020 Plans:*** Will provide continued support for MURI awards made in prior years and will initiate six to eight new FY20 MURI efforts that will enable advances in select interdisciplinary basic science and/or engineering research areas determined to be of critical importance to national defense. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601103A University Research Initiatives/ Project D55 University Research Initiative.			
Title: Presidential Early Career Awards for Scientists and Engineers (PECASE)	-	-	2.500

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** AB3 / *MURI/PECASE/DURIP*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Supports PECASE investigators started in prior years as well as new award recipients. ***FY 2020 Plans:*** Will support 12 existing PECASE awardees. FY20 plans assume there are no new PECASE awards made during FY18 through FY20. Funding for new awards is moved to DURIP. If new PECASE awards are made during FY19 through FY20, funding to support the new PECASE awards will come from DURIP. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601103A University Research Initiatives/ Project D55 University Research Initiative. Since there have been no new PECASE awards, funding remains to support existing awards and the funding for new awards is moved to DURIP.			
Title: Defense University Research Instrumentation Program (DURIP) ***Description:*** Supports basic research through competitive grants for research instrumentation. ***FY 2020 Plans:*** Will evaluate and award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research and enhance educational capabilities critical to Army transformation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601103A University Research Initiatives/ Project D55 University Research Initiative. Funding for new PECASE awards has been moved to DURIP since there have been no new PECASE awards. If new PECASE awards do occur during FY 2018 through FY 2020, funding for the awardees will come from DURIP funds.	-	-	9.803
Accomplishments/Planned Programs Subtotals	-	-	65.858

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) D55 / *University Research Initiative*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
D55: *University Research Initiative*	-	63.556	65.202	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	128.758

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601103A University Research Initiatives
* Project AB3 MURI/PECASE/DURIP

A. Mission Description and Budget Item Justification

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

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Multidisciplinary University Research Initiative (MURI)	51.032	51.093	-
Description: MURI programs are typically 5 years in length at a cost of $1.25 million per year.			
FY 2019 Plans: Provide support for MURI awards made in prior years and will identify six to eight new FY19 MURI awards to enable advances in select interdisciplinary basic science and/or engineering research areas determined to be of critical importance to national defense.			
FY 2019 to FY 2020 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** D55 / *University Research Initiative*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This Project will move to PE 0601103A / Project AB3 MURI/PECASE/DURIP in FY20.			
Title: Presidential Early Career Awards for Scientists and Engineers (PECASE) ***Description:*** Supports PECASE investigators started in prior years as well as new awards initiated in current year. ***FY 2019 Plans:*** Support prior year awardees and will select four new PECASE candidates. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This Project will move to PE 0601103A / Project AB3 MURI/PECASE/DURIP in FY20.	4.390	4.408	-
Title: Defense University Research Instrumentation Program (DURIP) ***Description:*** Supports basic research through competitive grants for research instrumentation. ***FY 2019 Plans:*** Evaluate and award competitive grants for research instrumentation to enhance universities' capabilities to conduct world class research and enhance educational capabilities critical to Army transformation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This Project will move to PE 0601103A / Project AB3 MURI/PECASE/DURIP in FY20	8.134	7.312	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	2.389	-
Accomplishments/Planned Programs Subtotals	63.556	65.202	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** D55 / *University Research Initiative*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) D58 / *URI ACTIVITIES (CA)*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
D58: *URI ACTIVITIES (CA)*	-	10.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	10.000

Note

Congressional Interest Item

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for University Research Initiatives.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Congressional Add	10.000	-
FY 2018 Accomplishments: Congressional Add		
Congressional Adds Subtotals	10.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601103A / *University Research Initiatives*	Project (Number/Name) V72 / *Minerva*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
V72: *Minerva*	-	0.793	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	0.793

Note

This Project ended in Fiscal Year (FY) 2018.

A. Mission Description and Budget Item Justification

This Project supports the Minerva Research Initiative (MRI), a university-based social science research program initiated by the Secretary of Defense in FY09. It focuses on areas in the social sciences that are of strategic importance to national security policy which have not been substantially pursued in the past. The Minerva research effort will be performed to understand the internal military-political dynamics of repressive regimes, the vulnerabilities of regimes and institutions to various kinds of disruption and instability, the nature of crowd dynamics, group violence, community belief structures, the potential to influence public opinion and attitudes in diverse cultures, cultural effects on network security and military operations, the influence of technology on military capabilities of potential adversaries and allies, and other intersections of social-cultural issues with military activities and national security. Predictive models and other analysis tools will be developed. Leveraging the expertise in the social sciences within the academic community is needed to provide understanding of the roots of terrorist organizations and the challenges and opportunities for military operations in a culturally diverse environment. Better understanding at a fundamental level and new computational tools will provide a beneficial impact on war fighting capabilities at the national policy, military strategy, operational, and tactical levels, and will enhance the capabilities of intelligence activities at all levels. All research results are open source.

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 2018	FY 2019	FY 2020
Title: The Minerva Research Initiative (MRI)	0.793	-	-
Description: The MRI is a university-based social science research program initiated by the Secretary of Defense. It focuses on areas in the social sciences of strategic importance to national security policy. It seeks to increase the Department's intellectual capital in the social sciences and improve its ability to address future challenges and build bridges between the Department and the social science community. Minerva will bring together universities, research institutions, and individual scholars and support multidisciplinary and cross-institutional projects addressing specific topic areas determined by the Department.			
Accomplishments/Planned Programs Subtotals	0.793	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601103A / *University Research Initiatives*	**Project (Number/Name)** V72 / *Minerva*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	-	103.957	114.003	86.164	-	86.164	87.621	89.301	91.116	93.058	0.000	665.220
AB4: *Army Research Centers*	-	0.000	0.000	26.150	-	26.150	26.452	26.973	27.513	27.818	0.000	134.906
AB7: *Army Collaborative Research and Tech Alliances*	-	0.000	0.000	42.863	-	42.863	43.482	44.295	45.122	45.564	0.000	221.326
AB8: *Army Educational Outreach Program*	-	0.000	0.000	10.466	-	10.466	10.675	10.893	11.111	12.225	0.000	55.370
AC6: *International Science and Technology*	-	0.000	0.000	6.685	-	6.685	7.012	7.140	7.370	7.451	0.000	35.658
EA6: *Cyber Collaborative Research Alliance*	-	3.204	4.880	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.084
F17: *Neuroergonomics Collaborative Technology Alliance*	-	4.725	4.714	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.439
FF5: *Distributed Collaborative Intelligent Systems CTA*	-	4.012	5.813	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.825
FF7: *Internet of Battlefield Things CTA*	-	2.946	4.174	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.120
H04: *HBCU/MI Programs*	-	1.475	1.589	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.064
H05: *Institute For Collaborative Biotechnologies*	-	5.759	5.992	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.751
H09: *Robotics CTA*	-	3.971	4.235	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.206
H50: *Network Sciences Cta*	-	6.208	5.821	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	12.029
H59: *International Tech Centers*	-	6.459	6.549	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	13.008
H73: *Automotive Research Center (ARC)*	-	3.113	3.292	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.405
J08: *Institute For Creative Technologies (ICT)*	-	6.057	6.432	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	12.489

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army													Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*								
J12: *Institute For Soldier Nanotechnology (ISN)*	-	5.759	5.992	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.751
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	20.000	22.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	42.000
J14: *Army Educational Outreach Program*	-	9.646	10.259	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	19.905
J15: *Network Sciences ITA*	-	3.919	4.106	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.025
J17: *Vertical Lift Research Center Of Excellence*	-	3.005	3.182	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.187
VS2: *Multi-Scale Materials Modeling Centers*	-	8.686	8.743	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	17.429
VS3: *Center For Quantum Science Research*	-	5.013	6.230	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.243

Note

In Fiscal Year (FY) 2020 this Program Element (PE) was previously funded with continuity of effort realigned to several new Projects in the following PEs:
* 0601104A University and Industry Research Centers
* 0601121A Cyber Collaborative Research Alliance

A. Mission Description and Budget Item Justification

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army	Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*

training and simulation. Examples of specific research of mutual interest to the entertainment industry and the Army are technologies for realistic immersion in synthetic environments, networked simulation, standards for interoperability, and tools for creating simulated environments. This PE also includes the Historically Black Colleges and Universities and Minority Institution (HBCU/MI) Centers of Excellence that address critical research areas for Army Transformation.

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

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

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	87.395	92.115	88.203	-	88.203
Current President's Budget	103.957	114.003	86.164	-	86.164
Total Adjustments	16.562	21.888	-2.039	-	-2.039
• Congressional General Reductions	-0.068	-0.112			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	20.000	22.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.001	-			
• SBIR/STTR Transfer	-3.369	-			
• Adjustments to Budget Years	-	-	-2.039	-	-2.039

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*		
Congressional Add: *Congressional Program Increase - University and Industry Research Centers*	15.000	10.000
Congressional Add: *Congressional Program increase - Materials in Extreme Dynamic Environments*	5.000	10.000
Congressional Add: *Congressional Program Increase - university assisted hypervelocity testing*	-	2.000
Congressional Add Subtotals for Project: J13	20.000	22.000
Congressional Add Totals for all Projects	20.000	22.000

Change Summary Explanation

FY18 increase related to Congressional Adds totaling $20 million.
FY19 increase related to Congressional Adds totaling $22 million.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*				Project (Number/Name) AB4 / *Army Research Centers*			
COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
AB4: *Army Research Centers*	-	0.000	0.000	26.150	-	26.150	26.452	26.973	27.513	27.818	0.000	134.906

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601104A University and Industry Research Centers
* Project H04 HBCU/MI Programs
* Project H05 Institute For Collaborative Biotechnologies
* Project H73 Automotive Research Center
* Project J08 Institute For Creative Technologies
* Project J12 Institute For Soldier Nanotechnology
* Project J17 Vertical Lift Research Center of Excellence

A. Mission Description and Budget Item Justification

This Project encompasses The Partnered Research Initiative (PRI) which supports Army's research partnerships with Historically Black Colleges and Universities and Minority Institutions (HBCU/MI), University Affiliated Research Centers (UARCs), and Army Centers of Excellence (COEs). The PRI Program was established as the next phase of what was previously known as Partnership in Research Transition (PIRT) Program that ended in FY16. The focus of the PRI Program is to advance innovative basic research leading to potential technology development in areas of strategic importance to the Army by bringing competitively selected HBCUs and Minority-Serving Institutions (MIs) research teams into existing Army Futures Command Collaborative Research Alliances (CRAs) and Collaborative Technology Alliances (CTAs). The CTAs and CRAs are large collaborative centers focused on developing and transitioning research in Army critical areas. Army UARCs have been created to exploit opportunities to advance new capabilities through a sustained long- term multidisciplinary effort. The Institute for Soldier Nanotechnologies focuses on Soldier protection by emphasizing revolutionary materials research for advanced Soldier protection and survivability. The Institute for Collaborative Biotechnologies focuses on enabling network centric-technologies, and broadening the Army's use of biotechnology for the development of bio-inspired materials, sensors, and information processing. The Institute for Creative Technologies is a partnership with academia and the entertainment and gaming industries to leverage innovative research and concepts for training and simulation. Examples of specific research of mutual interest to the entertainment industry and the Army are technologies for realistic immersion in synthetic environments, networked simulation, standards for interoperability, and tools for creating simulated environments. The COEs focus on expanding the frontiers of knowledge in research areas where the Army has enduring needs, and couples state-of-the-art research programs at academic institutions with broad-based graduate education programs to increase the supply of scientists and engineers in automotive and rotary wing technology.

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Centers of Excellence for Battlefield Capability Enhancements (BCE) ***Description:*** The PRI Program was established as the next phase of what was previously known as PIRT Program that ended in FY16. The focus of the PRI Program is to advance innovative basic research leading to potential technology development in areas of strategic importance to the Army by bringing competitively selected HBCUs and MIs research teams into existing Army Futures Command CRAs and CTAs. The CTAs and CRAs are large collaborative centers focused on developing and transitioning research in Army critical areas. ***FY 2020 Plans:*** New Mexico Institute of Mining and Technology will collaborate with Multiscale Modeling of Electronic Materials (MSME) CRA by investigating how Uncertainty Quantification techniques and Optimization algorithms can be used to complete the pipeline for robust design of nanoparticles; City College of New York will contribute to Cognition and Neuroergonomics (CaN) CTA by focusing on measuring the relevance of peripheral stimuli to neural reliability via experiments in combined electroencephalogram and eye-tracking during passive free viewing of films; University of Texas at El Paso will collaborate with Cyber Security CRA by designing and running behavioral game theory experiments on group decision making; and North Carolina Agricultural & Technical State University will contribute to Materials in Extreme Dynamic Environments (MEDE) CRA with experiments to understand the effects of loading conditions such as temperature (from ambient to 773 Kelvin) and strain rate (from quasi-static to ultra-high) and their coupled effects on the mechanical properties and microstructure evolution of magnesium alloys. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601104A University and Industry Research Centers/ Project H04 HBCU/MI Programs.	-	-	1.629
Title: Institute for Collaborative Biotechnologies ***Description:*** This effort performs sustained multidisciplinary basic research supporting technology to provide the Army with bio-inspired materials and biomolecular sensor platforms. ***FY 2020 Plans:*** Will continue to support projects and seedlings started in FY19 in systems and synthetic biology and bio-enabled materials. These efforts will include synthetic biology tools for novel thermal bioswitches, field-programmable molecular circuits, biological thermoelectric gels, and novel photochromic materials for load bearing. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE0601104A University and Industry Research Centers / Project H05 Institute For Collaborative Biotechnologies	-	-	5.344
Title: Institute for Creative Technologies	-	-	6.569

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: This effort focuses on the basic research of Immersive Environments and spans a number of key areas to include virtual humans, three-dimensional (3D) sound and visual media to achieve more efficient and affordable training, modeling, simulation and application solutions and tools. Research includes: investigation of techniques and methods to address the rapid development of synthetic environments and the study of perception and cognition to help direct the development of new technologies and techniques that evoke more realistic responses from users; auditory aspects of immersion to provide the sound stimulus for increasing the realism for military training and simulation devices; new computational techniques in graphics for achieving real-time photo-realistic rendering of physical and synthetic environments for training and simulations; innovative methods for automatically generating animations and gestures for virtual humans based on what is being communicated; new technologies for scanning real people and rapidly generating virtual humans which look like these people significantly reducing the time, expense and effort required to develop virtual humans and virtual environments; methods and techniques for creating virtual human computer-generated characters that look, communicate and behave like real people that are autonomous, use verbal and non-verbal communication, exhibit emotions, model their own beliefs, desires and intentions as well as those of others, and reason using advanced artificial intelligence; and methods and techniques for improving the perception, communication, understanding, and responsiveness of virtual humans when interacting with live humans and explore how people relate to virtual humans. ***FY 2020 Plans:*** Will use learning science and social simulations to understand and develop the human dimension of immersive environments and its complement to the physical dimensions of synthetic immersive environments, as well as the mixed reality live-synthetic training environment. Will define accurate articulation and behavior of virtual entities that will include the use of machine learning and artificial intelligence. Will use social simulations and cognitive network techniques to understand the critical human interactions that are necessary for effective virtual humans to replicate accurate training scenarios. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE0601104A University and Industry Research Centers/ Project J08 Institute For Creative Technologies (ICT)			
Title: Institute for Soldier Nanotechnologies ***Description:*** This effort investigates Nanomaterials and Nanotechnologies for Soldier Application focused on light-weight, multifunctional nanostructured fibers and materials. ***FY 2020 Plans:*** Will advance high-fidelity 3D dynamical modeling for simulation of durability, fracture, and failure of materials under blast to create resilient structural materials. Will advance the use of nanooptoelectronics and novel light-matter interactions for optical	-	-	5.998

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
sensing and energy. Through nanoscience, will advance next generation electronics including two-dimensional systems, photonic integrated circuits for ultra-low power electrons, and electromagnetic pulse-resistant circuits. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE0601104A University and Industry Research Centers / Project J12 Institute For Soldier Nanotechnology (ISN)			
Title: Vertical Lift Research Center of Excellence (VLRCOE) ***Description:*** VLRCOE agreements with Penn State University, University of Maryland, and Georgia Institute of Technology to supplement a robust experimental and analytic basic research program in rotorcraft technologies including: Aeromechanics, Structures, Flight Dynamics and Control, Rotorcraft Design and Concepts, Vibration and Noise Control, Propulsion, Affordability, Safety and Survivability, and Naval Operations. ***FY 2020 Plans:*** Will implement year four of VLRCOE agreements with Penn State University, University of Maryland, and Georgia Institute of Technology to conduct a robust experimental and analytic basic research program in broad rotorcraft technologies areas relevant to future vertical lift to include high-performing composite materials to enable extremely light-weight rotor and airframe structures, aeromechanics of high-speed compound rotors and multi-rotor interactions, enhanced damping for high-speed rigid rotors. Following the annual review at the three rotorcraft Centers, will adjust technical directions of the research tasks as necessary to ensure that the research remains relevant to the Army's Science and Technology goals. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE0601104A University and Industry Research Centers/ Project J17 Neuroergonomics Collaborative Technology Alliance	-	-	3.249
Title: Automotive Research Center (ARC) ***Description:*** The ARC is an U.S. Army Center of Excellence for Modeling and Simulation of ground vehicles. The Center relies on the collaboration of researchers from multiple universities and disciplines to bridge fundamental technology gaps in five research thrust areas of strategic importance to the Army; mobility, human factors and man-machine integration, lightweight structure and materials, power and energy, and design integration. A major integrative focus of these five areas are autonomy and manned-unmanned teaming. ***FY 2020 Plans:*** Will conduct advanced modeling and simulation research on autonomy and mobility problems for ground vehicles. Topics will include teleoperated, semi-, fully-, and multiple autonomous vehicle operation and control, high fidelity operational evaluations of autonomy related technologies, high performance terramechanics models, machine learning, robotic trust, etc. Will research	-	-	3.361

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB4 / *Army Research Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
optimal power generation storage and distribution for autonomous vehicles expanding in application for drone and electric vehicles in support of the third offset strategy. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE0601104A University and Industry Research Centers/ Project H73 Automotive Research Center (ARC)			
Accomplishments/Planned Programs Subtotals	-	-	26.150

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) AB7 / *Army Collaborative Research and Tech Alliances*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
AB7: *Army Collaborative Research and Tech Alliances*	-	0.000	0.000	42.863	-	42.863	43.482	44.295	45.122	45.564	0.000	221.326

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601104A University and Industry Research Centers
* Project EA6 Cyber Collaborative Research Alliance
* Project F17 Neuroergonomics Collaborative Technology Alliance
* Project FF5 Distributed Collaborative Intelligent Systems CTA
* Project FF7 Internet of Battlefield Things CTA
* Project H05 Institute For Collaborative Biotechnologies
* Project J15 Network Sciences ITA
* Project VS2 Multi-Scale Materials Modeling Centers
* Project VS3 Center For Quantum Science Research

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Internet of Battlefield Things CTA (IoBT CTA)	-	-	6.020
Description: The IoBT CTA seeks to gain fundamental understanding of Internet of Things (IoT) phenomena and its performance in tactical environments, ranging from sparse, remote settings to complex, dense urban environments. Research will address			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB7 / *Army Collaborative Research and Tech Alliances*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
intelligent resourcing and influence in complex, constrained and uncertain networks (demand from massive numbers of dynamically connected devices, limited and unpredictable connectivity, shared civilian networks, computation at or near the device), heterogeneous sensing and actuation devices (efficient, smart devices with self-organizing/ preservation/directing capabilities), and variable, and unreliable provenance and dynamisms of information and device signals. ***FY 2020 Plans:*** Will establish theories and insights leading to scalable composition and management of heterogeneous networks of small sensing and/or actuation devices to enable secure information-driven awareness; will build the theoretical foundations, models, and methods for autonomic complex systems that deliver adaptive cyber-physical capabilities and services; will create scientific principles, theories, and methods for predictive processing, analytics, and anomaly detection given heterogeneous and varied autonomic, sensing, and actuation data that may be sparse and voluminous. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601104A University and Industry Research Centers/ Project FF7 Internet of Battlefield Things CTA. Increase will fully fund the university consortium to extend research beyond initial exploratory studies.			
Title: Distributed Analytics and Information Science International Technology Alliance (ITA) ***Description:*** This research will address the fundamental science underpinning the complex information network issues that are vital to future United States (US) / United Kingdom (UK) coalition military operations and to fully exploit the joint development of emerging technologies necessary to enable coalition operations. These efforts provide enhanced ability to perform adaptive, goal-driven, semantically-aware, distributed analytics for situational understanding in coalition operations. ***FY 2020 Plans:*** Will model distributed, dynamic, secure coalition communication/information infrastructures that support distributed analytics to derive situational understanding; will create techniques for dynamic self-configuring services "on demand" based on mission needs, context and resource constraints; will model underlying distributed analytics and situational understanding that supports dynamic coalition operations involving complex multi-actor situations. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601104A University and Industry Research Centers/ Project J15 Network Sciences ITA.	-	-	4.151
Title: Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Material CRA ***Description:*** Research will focus on two-way multiscale modeling for predicting performance and designing materials; investigating analytical and theoretical analyses to effectively define the interface physics across length scales; advancing experimental capabilities for verification and validation of multiscale physics; and modeling and strategies for the synthesis of	-	-	8.739

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB7 / *Army Collaborative Research and Tech Alliances*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
high loading rate tolerant materials. The multiscale modeling capability will be applied across multiple disciplines to facilitate revolutionary advances in materials for coupled environments (electromagnetic, high rate, high pressure and other extreme environments). ***FY 2020 Plans:*** Will implement and integrate basic science tools into a proof-of-concept multiphysics, multiscale capability for Materials by Design that crosses the three electronic materials classes and applications that 1) works across a variety of computational platforms from the desktop to large-scale distributed computing as the problem dictates; 2) allows for uncertainty quantification at scale and moving up and down the scales; and 3) allows assessment of reliability of simulation-predicted outcomes. Will initiate a predictive framework that demonstrates a materials-by-design paradigm suitable for Army applications. Will establish a process that rigorously limits the path in the multiscale space that must be understood for multiscale materials design. Will create newly designed metal, ceramic and composite systems for critical armor applications. Will validate and transition integrated codes for multiscale materials design in each of our chosen material systems, coupling aspects of processing, experiments and modeling with respect to the application space. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601104A University and Industry Research Centers / Project VS2 Multi-Scale Materials Modeling Centers.			
Title: Distributed Collaborative Intelligent Systems Technology CTA ***Description:*** Establish the underpinning science to extend the reach, situational awareness, and operational effectiveness of intelligent system and soldier teams against dynamic threats in complex and contested environments and provide technical and operational superiority through fast, intelligent, resilient, and collaborative behaviors. Research efforts will enable distributed systems to engage in complex, time-varying, and contested environments to accomplish Army missions by leveraging a mix of online adaptation and system-wide resilience. ***FY 2020 Plans:*** Will establish the fundamental underpinnings of hierarchical, composable, and adaptable learning for collaborative multi-agent networks; distributed learning, inference and planning; resource aware perception-action-communication loops; autonomous and heterogeneous team formation and tasking; robotic team interaction with human teammates; adaptive and on-line learning for robust behaviors in complex and contested environments; scalable control for distributed heterogeneous multi-agent manned-unmanned teams; resilient situational awareness, communications, and autonomous behaviors in the face of failure and adversarial actions. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	6.131

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB7 / *Army Collaborative Research and Tech Alliances*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work was previously performed in PE 0601104A University and Industry Research Centers/ Project FF5 Distributed Collaborative Intelligent Systems CTA.			
Title: Neurosciences CRA ***Description:*** This effort performs multidisciplinary basic research in the area of neuroscience through collaboration with the University of California at Santa Barbara. ***FY 2020 Plans:*** Will establish an understanding of the effect of fatigue and stress on cognition and on decision making and will identify neural indicators/biomarkers for optimal decision making; will create neuro-engineering techniques to make inferences about human?s cognitive and attentional states that are particularly relevant to challenges faced by the Soldier. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in a portion of PE 0601104A University and Industry Research Centers/ Project H05 Institute For Collaborative Biotechnologies.	-	-	0.654
Title: Army Artificial Intelligence Innovation Institute (A2I2) ***Description:*** This effort investigates, designs and matures Artificial Intelligence (AI) and Machine Learning (ML) to address the Army problem of Fully Autonomous Maneuver in a Multi-Domain Battlespace. General AI capabilities are critical to the integration of operations in the contested environment including human-agent teaming for faster and more informed decisions, multi-domain Command, Control, Communications, and Computers (C4) that is resilient to Cyber Electromagnetic Activities (CEMA), and AI-enabled cyber security that is robust to enemy deception. This effort will provide key aspects of Army counter-AI against near-peer adversaries. Army futures command will leverage its existing High Performance Computing (HPC) and network infrastructure, along with its regional laboratory extensions to enable basic research on AI that is open, with top-tier universities, small & large commercial businesses, and established Department of Defense industrial partners. ***FY 2020 Plans:*** Will establish challenge problems on autonomous ground maneuver in complex off-road terrain as well as intelligent perception in complex urban terrain; will progressively increase problem complexity (from simple to complex terrain and from single to multiple agents), and will steadily increase generality of the AI deceptive actions (from both the Move and Perception standpoints) in order to enable Robotic Autonomous Systems (RAS) that can still maneuver intelligently without human control despite adversarial interference; and will begin data collection efforts to provide initial data base for learning algorithms. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	-	-	9.338

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB7 / *Army Collaborative Research and Tech Alliances*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This work represents an increase in program requirements for Artificial Intelligence Innovation efforts.			
Title: Center for Exploitation of Quantum Effects ***Description:*** This work supports needed quantum information science basic research at the Army Futures Command for next generation capabilities in security, decision aids, sensing, and position, navigation, and timekeeping (PNT) for Army dominance on the future battlefield. ***FY 2020 Plans:*** Will establish methods for efficient light-matter interaction, including the use of optical cavities and materials suitable for nanophotonic integration; will understand unique topological photonic materials for quantum state protection; and will study quantum algorithms and measurement techniques and quantum frequency conversion in atomic and solid-state defect systems to improve quantum sensors. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601104A University and Industry Research Centers/ Project VS3 Center For Quantum Science Research. The decrease in funding is due to a change in focus away from creation of an entangled three-node system and towards the understanding of efficient light-matter interaction, topological photonic materials, and quantum algorithms and measurement techniques.	-	-	3.000
Title: Neuroergonomics CTA ***Description:*** By utilizing fundamental principles that underlie Soldier neurocognitive performance, this effort provides individualized and adaptive technologies that enhance Soldier-agent interaction. ***FY 2020 Plans:*** Will identify the potential for human behavior and neurophysiological data to be used to dynamically inform an AI agent trained to learn personalized navigation polices in operationally-relevant tasks; will create sensing hardware and signal processing algorithms to enable the acquisition and interpretation of neural activity during ambulation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously PE 0601104A University and Industry Research Centers/ Project F17 Neuroergonomics Collaborative Technology Alliance. Decreasing scope of effort for final year of CRA to focus on the effect of fatigue and stress on cognition and on decision making, neural indicators/biomarkers for optimal decision making and neuro-engineering techniques to make inferences about human?s cognitive and attentional states that are particularly relevant to challenges faced by the Soldier.	-	-	1.300
Title: Identification and characterization of team-level processes for enhancing performance of heterogeneous Soldier-Agent teams CRA	-	-	3.530

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB7 / *Army Collaborative Research and Tech Alliances*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: By developing and validating theoretical principles of human-agent team states and processes, this effort defines methods for exploiting individual dynamics and variability to improve team-level properties and performance. ***FY 2020 Plans:*** Will create novel metrics of team-level states that account for specific roles and characteristics of both humans and intelligent agents as they cooperate to perform complex tasks; Will uncover fundamental relationships between team-level and individualized states and how changes in these states affect team performance over time. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work represents an increase in program requirements for Heterogeneous Soldier-Agent Team issues.			
Accomplishments/Planned Programs Subtotals	-	-	42.863

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) AB8 / *Army Educational Outreach Program*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
AB8: *Army Educational Outreach Program*	-	0.000	0.000	10.466	-	10.466	10.675	10.893	11.111	12.225	0.000	55.370

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
PE 0601104A University and Industry Research Centers
* Project J14 Army Educational Outreach Program

A. Mission Description and Budget Item Justification

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

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

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 2018	FY 2019	FY 2020
Title: AEOP Coop Agreement	-	-	10.156
Description: The Army Educational Outreach Program Cooperative Agreement encompasses a cohesive and coordinated portfolio of STEM education experiences to develop, enhance, and reward students in pursuit of STEM education. This activity supports a strong partnership with government, academia and industry to leverage assets and provide a broader and deeper STEM experience for students and teachers to address the Department?s, and the nation?s, challenge of acquiring clearable STEM literate talent in positions throughout the workforce and in the industrial base. These activities include Army-sponsored research, education, competitions, apprenticeships, internships, and practical experiences designed to engage and guide students and teachers in Army sponsored STEM programs. AEOP has targeted efforts to reach and engage underserved communities in STEM initiatives to build the pool of diverse STEM competitive talent.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AB8 / *Army Educational Outreach Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2020 Plans: Will continue Army sponsorship of students and STEM education opportunities; will provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; will streamline processes, leverage funding and build educational partnerships; and will perform annual comprehensive reviews and educational assessments to support future decisions and best practices. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601104A University and Industry Research Centers/ Project J14 Army Educational Outreach Program in FY19.			
Title: West Point Cadet Program ***Description:*** The West Point Cadet Research Program provides West Point Cadets an opportunity to work on Army research projects alongside Army and industry scientists and engineers during the summer. ***FY 2020 Plans:*** Will conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and engineering centers. Between 40 and 60 cadets will intern for a period of 3 to 6 weeks. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This work was previously performed in PE 0601104A University and Industry Research Centers/ Project J14 Army Educational Outreach Program in FY19.	-	-	0.310
Accomplishments/Planned Programs Subtotals	-	-	10.466

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) AC6 / *International Science and Technology*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
AC6: *International Science and Technology*	-	0.000	0.000	6.685	-	6.685	7.012	7.140	7.370	7.451	0.000	35.658

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601104A University and Industry Research Centers
* Project H59 International Tech Centers

A. Mission Description and Budget Item Justification

This Project funds the International Technology Centers (ITCs) and the Foreign Technology (and Science) Assessment Support (FTAS) program. The nine ITCs located in North America, South America, Asia, and Europe support the Army's goals of providing the best technology in the world to our Warfighters by leveraging the Science and Technology (S&T) investments of our international partners. The ITCs perform identification and evaluation of international technology programs to assess their potential impact on the Army's S&T investment strategy. ITC 'technology finds' are submitted to various Army S&T organizations for evaluation and consideration for further research and development. Highly promising research will be awarded seed funding by the ITC through a grant, contract, or cooperative agreement. The FTAS program also builds upon the technology finds submitted by the ITCs. In some cases the find is truly unique and may well meet an Army requirement or potentially support ongoing Army S&T investments. In such cases, the FTAS program can provide initial resources (seed money) to determine the appropriateness of these technology areas identified as having potential relevance to the Army. These efforts will provide information useful in making early assessments of the technology's potential contributions to the Army's S&T strategy.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: International Technology Centers (ITCs)	-	-	4.501
Description: The nine ITCs located in North America, South America, Asia, and Europe support the Army's goals of providing the best technology in the world to our Warfighters by leveraging the S&T investments of our international partners. The ITCs perform identification and evaluation of international technology programs to assess their potential impact on the Army's S&T investment strategy. ITC 'technology finds' are submitted to various Army S&T organizations for evaluation and consideration for further research and development through avenues such as the FTAS Program. Highly promising research is awarded seed funding by the ITC through a grant, contract, or cooperative agreement ? typically to a foreign university.			
FY 2020 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AC6 / *International Science and Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
The ITCs will continue to seek out foreign science and technology within their geographic areas of responsibility that may have United States (US) Army interest and applicability, In accordance with the Army S&T Strategy, ITCs will connect foreign researchers with US Army scientists and engineers, and ultimately fund promising research through a grant, contract, or cooperative agreement. They will also continue to enhance and refine technology search capabilities using customer feedback to focus on mid- and long-term capabilities. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort was previously performed in PE 0601104A University and Industry Research Centers/ Project H59 International Tech Centers in FY19.			
Title: Foreign Technology (& Science) Assessment Support (FTAS) ***Description:*** The FTAS program serves as a catalyst for the US Army Futures Command to assess potentially game-changing technologies discovered in friendly foreign nations by the US Army International ITCs which may meet future Army needs. The technology finds can often times be truly unique and may well meet an Army requirement or potentially support ongoing Army S&T investments. These efforts will provide information useful in making early assessments of a technology's potential contributions to the Army's S&T strategy. ***FY 2020 Plans:*** Will solicit proposals and assess scientific quality of candidate projects by utilizing US Army Senior Scientist Corps expertise. Will provide seed funding for approved proposals to US Army laboratories to develop and/or assess these technology areas identified by the Army?s ITCs. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort was previously performed in PE 0601104A University and Industry Research Centers/ Project H59 International Tech Centers in FY19.	-	-	2.184
Accomplishments/Planned Programs Subtotals	-	-	6.685

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** AC6 / *International Science and Technology*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) EA6 / *Cyber Collaborative Research Alliance*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
EA6: *Cyber Collaborative Research Alliance*	-	3.204	4.880	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.084

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601121A Cyber Collaborative Research Alliance
* Project CB5 Cyber Collaborative Research Alliance

A. Mission Description and Budget Item Justification

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

Work in this Project supports key Army needs and provides the technical underpinnings to PE 0602782A (Command, Control, Communications Technology) / Project H92 (Communications Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Cyber Security Collaborative Research Alliance	3.204	4.701	-
Description: The CSEC CRA supports basic research to enable capabilities for rapid development and adaptation of cyber tools for dynamically assessing cyber risks, detecting hostile activities on friendly networks, and supporting agile maneuver in cyber space in spite of the continuous evolution and emergence of novel threats.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** EA6 / *Cyber Collaborative Research Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: Enhance fundamental theories and methods to streamline development of new models and algorithms of dynamic cyber threats; develop new approaches and theoretical frameworks needed to provide resilient and automated capabilities for software, network and system components and overall system function; research methods for more agile human behavior models and human-machine agent functionality in increasingly complex adversarial environments; incorporate realistic experimental validation methods for developing new operationally feasible methods. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This project will move to PE 0601104A University and Industry Research Centers/ Project CB5 Cyber Collaborative Research Alliance in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.179	-
Accomplishments/Planned Programs Subtotals	3.204	4.880	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*				Project (Number/Name) F17 / *Neuroergonomics Collaborative Technology Alliance*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
F17: *Neuroergonomics Collaborative Technology Alliance*	-	4.725	4.714	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.439

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB7 Army Collaborative Research and Tech Alliances

A. Mission Description and Budget Item Justification

This Project fosters research through the Cognition and Neuroergonomics Collaborative Technology Alliance (CTA), a competitively selected industry and university consortium, to leverage world-class research in support of future force and Army transformation needs. Escalating levels of complexity and uncertainty on the current and future battlefield present conditions which have never existed before now. Solution strategies and approaches must be developed or tailored. The emerging field of neuroergonomics, which seeks to understand the brain at work and to leverage that understanding to optimize system design, offers tremendous potential for providing the solutions needed to meet the needs of Army forces in the future. This CTA addresses the solution strategies and approaches needed to design systems to fully exploit investments in revolutionary technological advances in areas such as robotics, microelectronics, and computer and network information systems. These technologies present significant opportunities to enhance Army mission capabilities, but impose significant burdens on the human brain, which will ultimately limit Soldier-system effectiveness, sustainability, and survivability. The technical barriers associated with this project include: immature knowledge base to guide the neuroergonomic approach to human-system integration; inadequate capabilities to sense and extract information about brain activity in dynamic, operational environments; lack of valid measures to robustly and uniquely characterize operationally-relevant cognitive performance; lack of techniques for integrating advanced understandings of brain activity into systems designs, including real-time use of measures of cognitive behavior as system inputs and the capability to account for individual differences in maximizing Soldier-system performance. This CTA conducts an intensive and accelerated program to formulate, validate, and transition basic research findings through multi-dimensional approaches focused in three areas: understanding fundamental principles underlying Soldier neurocognitive performance in operational environments, advancing computational approaches for the analysis and interpretation of neural functioning, and fundamental advancement in neurotechnologies that enhance Soldier-system interactions and performance.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Neurocognitive performance in operational environments	1.747	1.735	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** F17 / *Neuroergonomics Collaborative Technology Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: This effort is intended to understand fundamental principles underlying Soldier neurocognitive performance in operational environments. ***FY 2019 Plans:*** Utilize computational techniques on large-scale heterogeneous datasets to discover robust relationships between complex cognitive states and subsequent performance across a range of Army-relevant tasks; investigate the relationship between individual brain network connectivity profiles and task performance. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers/ Project AB7 Army Collaborative Research and Tech Alliances in FY20.			
Title: Computational neural analysis ***Description:*** This effort advances computational approaches for the analysis and interpretation of neural functioning. ***FY 2019 Plans:*** Elucidate the underlying components responsible for physiological signal degradation in ambulatory environments via novel multi-layered sensor systems; develop theoretical models and adaptive algorithms for optimal signal acquisition and noise mitigation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers/ Project AB7 Army Collaborative Research and Tech Alliances in FY20.	1.418	1.303	-
Title: Neurotechnologies ***Description:*** This effort provides a fundamental advancement in neurotechnologies that enhance Soldier-system interactions and performance. ***FY 2019 Plans:*** Investigate the application of computation frameworks for the prediction of behavioral performance in operationally-relevant tasks with increased temporal complexity and multifaceted objectives; develop approaches to combine information, derived from brain activity, across individuals to improve situational awareness. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers/ Project AB7 Army Collaborative Research and Tech Alliances in FY20.	1.560	1.504	-
Title: FY 2019 SBIR / STTR Transfer	-	0.172	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** F17 / *Neuroergonomics Collaborative Technology Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer			
Accomplishments/Planned Programs Subtotals	4.725	4.714	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) FF5 / *Distributed Collaborative Intelligent Systems CTA*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
FF5: *Distributed Collaborative Intelligent Systems CTA*	-	4.012	5.813	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.825

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB7 Army Collaborative Research and Tech Alliances

A. Mission Description and Budget Item Justification

This Project fosters basic research through the highly Distributed and Collaborative Intelligent Systems and Technology (DCIST) Collaborative Research Alliance (CRA), a competitively selected university consortium which leverages world-class research necessary to address future force and Army Transformation needs. The CRA links a broad range of government technology agencies, as well as industrial and academic partners with the Army Futures Command. The DCIST CRA focuses on systems with a large number of heterogeneous intelligent agents, including Soldiers that can be distributed over large areas and are required to move through contested environments and against peer capabilities at op-tempo. To meet these goals innovative research is performed in three main technical areas: distributed intelligence, large heterogeneous group control, and adaptive and resilient behaviors. The payoff to the warfighter will be extended reach, situational awareness, and operational effectiveness against dynamic threats in contested environments, and technical and operational superiority through intelligent, resilient and collaborative behaviors of Soldiers and intelligent systems. The CRA facilitates the exchange of people among the collaborating organizations to provide cross-organizational perspectives on basic research challenges, and to make available to the Alliance state-of-the-art facilities and equipment at the participating organizations.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Distributed Collaborative Intelligent Systems Technology	4.012	5.600	-
Description: Extend reach, situational awareness, and operational effectiveness against dynamic threats in contested environments through intelligent, resilient and collaborative behaviors of heterogeneous teams of Soldiers, intelligent systems, smart sensors, and knowledge sources. ***FY 2019 Plans:*** Establish the theoretical foundations of multi-faceted distributed networked intelligent systems combining autonomous agents, sensors, tactical super-computing, knowledge bases in the tactical cloud, and human experts to acquire and apply knowledge to affect and inform decisions of the collective team. Develop theory and algorithms for control of large autonomous teams with			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** FF5 / *Distributed Collaborative Intelligent Systems CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
varying levels of heterogeneity and modularity across sensing, computing, platforms, and degree of autonomy. Develop theory and methods for heterogeneous teams to carry out tasks under dynamic and varying conditions in the physical world. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Project FF5 will move to PE 0601104A University and Industry Research Centers/ Project AB7 Army Collaborative Research and Tech Alliances in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.213	-
Accomplishments/Planned Programs Subtotals	4.012	5.813	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) FF7 / *Internet of Battlefield Things CTA*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
FF7: *Internet of Battlefield Things CTA*	-	2.946	4.174	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.120

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB7 Army Collaborative Research and Tech Alliances

A. Mission Description and Budget Item Justification

This Project will foster research performed through the Internet of Battlefield Things (IoBT) Collaborative Research Alliance (CRA), a competitively selected consortium formed to advance the theoretical foundations of the Internet of Things in the context of Army Operations. The CRA will comprise academia, industry and government researchers working jointly with the objective of developing a fundamental understanding of phenomena of Internet of Things (IoT) and cyber-physical systems in tactically relevant environments. The CRA will facilitate collaboration across organizations to provide multi-disciplinary perspectives on basic research challenges, as well as the use of state-of-the-art facilities and equipment at the participating organizations. This research focuses on three interrelated aspects of pervasive and converged cyber- physical complex information systems and is conducted using a trans-disciplinary approach that takes into account the information-theoretic and human elements of Army IoBT interactions. The three aspects of the emergent Internet of Battlefield Things topical areas addressed are: 1) dynamic discovery and adaptation of cyber- physical devices, networks, and information sources, 2) resilient re-purposing and re-tasking of devices and information capabilities, and 3) algorithmic, distributed and centralized information-stream processing. Overarching goals of the basic research on Army IoBT are to investigate foundational cross-cutting theories and methods leading towards a science of heterogeneous, self-adapting, complex cyber-physical systems. This research will lead to optimized real-time adversarial situation estimates in information-enabled warfare and greatly enhance the speed and precision for complex military operations involving converged sensing, communications, and resilient actuation.

Work in this Project builds fundamental knowledge for and accelerates the transition of communications and networks technology to PE 0602783A (Computer and Software Technology).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Internet of Battlefield Things Collaborative Research Alliance (IoBT CRA)	2.946	4.021	-
Description: The Internet of IoBT CRA seeks to gain fundamental understanding of IoT phenomena and its performance in tactical environments, ranging from sparse, remote settings to complex, dense urban environments. To enable an IoBT capability,			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** FF7 / *Internet of Battlefield Things CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
research needs to address intelligent resourcing and influence in complex, constrained and uncertain networks (demand from massive numbers of dynamically connected devices, limited and unpredictable connectivity, shared civilian networks, computation at or near the device), heterogeneous sensing and actuation devices (efficient, smart devices with self-organizing/preservation/ directing capabilities), and variable, and unreliable provenance and dynamisms of information and device signals. ***FY 2019 Plans:*** Investigate theoretical foundations, models, and methods of autonomic complex systems that deliver adaptive cyber-physical capabilities and services necessary to enable effective command and control across military, adversary, and non-combatant domains; research the scientific principles, theories, and methods and predictive processing, analytics, and anomaly detection of broadly heterogeneous and varied data that may be unknown combinations of sparse and voluminous; investigate methods to augment goal-driven decision-making. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers/ Project AB7 Army Collaborative Research and Tech Alliances in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.153	-
Accomplishments/Planned Programs Subtotals	2.946	4.174	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H04 / *HBCU/MI Programs*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H04: *HBCU/MI Programs*	-	1.475	1.589	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.064

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB4 Army Research Centers

A. Mission Description and Budget Item Justification

This Project supports basic research through the Partnered Research Initiative (PRI), the Army's research initiative focused on partnerships with Historically Black Colleges and Universities and Minority Institutions (HBCU/MI). The PRI Program was established as the next phase of what was previously known as Partnership in Research Transition (PIRT) Program that ended in FY16. The focus of this effort is to enhance programs and capabilities of high-interest scientific and engineering disciplines through innovative research performed in collaboration with Collaborative Technology Alliances and Collaborative Research Alliances (CTA/CRAs). The CTA/CRAs work with Army, industry, and other academic partners to transition research to technology demonstration. In addition, the Centers of Excellence (CoEs) and CTA/CRA partnerships provide opportunities to recruit, educate, and train outstanding students and post-doctoral researchers in science and technology areas relevant to the Army.

Work performed in this Project supports key Army needs and is coordinated with one or more Projects in PE 0601104A (University and Industry Research Centers).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Centers of Excellence for Battlefield Capability Enhancements	1.475	1.538	-
Description: Four PRI effortss from HBCUs/MIs joined the CTA/CRA consortia in early FY17: New Mexico Institute of Mining and Technology will collaborate with Multiscale Modeling of Electronic Materials (MSME) CRA by investigating how Uncertainty Quantification techniques and Optimization algorithms can be used to complete the pipeline for robust design of nanoparticles; City College of New York will contribute to Cognition and Neuroergonomics (CaN) CTA by focusing on measuring the relevance of peripheral stimuli to neural reliability via experiments in combined electroencephalogram (EEG) and eye-tracking during passive free viewing of films; University of Texas at El Paso will collaborate with Cyber Security CRA by designing and running behavioral game theory experiments on group decision making; and North Carolina Agricultural & Technical State University will contribute to Materials in Extreme Dynamic Environments (MEDE) CRA with experiments to understand the effects of loading conditions			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H04 / *HBCU/MI Programs*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
such as temperature (from ambient to 773 Kelvin) and strain rate (from quasi-static to ultra-high) and their coupled effects on the mechanical properties and microstructure evolution of magnesium alloys. ***FY 2019 Plans:*** Continue to conduct research with HBCU/MIs performed in collaboration with Army Research Laboratory?s CTA/CRAs. Projects are within the scope of CTA/CRAs and pursue high quality, collaborative research in areas of strategic importance to the Army. Areas of research include: network science, cognition and neuroergonomics, multiscale modeling of materials, robotics and/or cyber security. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers/ Project AB4 Army Research Centers in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.051	-
Accomplishments/Planned Programs Subtotals	1.475	1.589	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H05 / *Institute For Collaborative Biotechnologies*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H05: *Institute For Collaborative Biotechnologies*	-	5.759	5.992	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.751

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB4 Army Research Centers
* Project AB7 Army Collaborative Research and Tech Alliances

A. Mission Description and Budget Item Justification

This Project supports research at the Army's Institute for Collaborative Biotechnologies (ICB), led by the University of California-Santa Barbara, and two major supporting partners, the California Institute of Technology and the Massachusetts Institute of Technology. The ICB was established as a University Affiliated Research Center (UARC) to support leveraging biotechnology for: advanced sensors; new electronic, magnetic, and optical materials; and information processing and bioinspired network analysis. The objective is to perform sustained multidisciplinary basic research supporting technology to provide the Army with biomolecular sensor platforms with unprecedented sensitivity, reliability, and durability; higher-order arrays of functional electronic and optoelectronic components capable of self-assembly and with multi-functions; and new biological means to process, integrate, and network information. These sensor platforms will incorporate proteomics (large scale study of proteins) technology, Deoxyribonucleic Acid (DNA) sequence identification and detection tools, and the capability for recognition of viral pathogens. A second ICB objective is to educate and train outstanding students and post-doctoral researchers in revolutionary areas of science to support Army Transformation. The ICB has many industrial partners, such as International Business Machine (IBM) and Science Applications International Corporation (SAIC), and has strong collaborations with Argonne, Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, and Sandia National Laboratories, the Army's Institute for Soldier Nanotechnologies, the Institute for Creative Technologies, and Army Medical Research and Materiel Command (MRMC) laboratories.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Institute for Collaborative Biotechnologies	5.128	5.139	-
Description: Perform sustained multidisciplinary basic research supporting technology to provide the Army with bio-inspired materials and biomolecular sensor platforms.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H05 / *Institute For Collaborative Biotechnologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Support new set of basic research projects in synthetic and systems biology, bio-inspired materials, and biotechnology tools. The new efforts include creating novel inorganic-organic hybrid materials with novel photo and ion-conducting properties, mechanistic study of infrared detection system of rattlesnakes, and engineering novel biocatalysts for abiological chemistry. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Research effort will move to PE 0601104A University and Industry Research Centers/ Project AB4 Army Research Centers in FY20.			
Title: Neuroscience ***Description:*** Perform multidisciplinary basic research in the area of neuroscience. ***FY 2019 Plans:*** Support a new set basic research projects in cognitive neuroscience including new mapping strategies for the neural systems for planning skills, understanding the cognitive priority control, and development of multiscale hierarchical framework for analysis of dynamic neuroscience data. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Research effort will move to PE 0601104A University and Industry Research Centers/ Project AB7 Army Collaborative Research and Tech Alliances in FY 2020.	0.631	0.634	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.219	-
Accomplishments/Planned Programs Subtotals	5.759	5.992	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H05 / *Institute For Collaborative Biotechnologies*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H09 / *Robotics CTA*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H09: *Robotics CTA*	-	3.971	4.235	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.206

Note

This Project concludes after Fiscal Year (FY) 2019.

A. Mission Description and Budget Item Justification

This Project supports a collaborative effort between the competitively selected industry and university consortium, the Robotics Collaborative Technology Alliance (CTA), and the Army Futures Command for the purpose of leveraging world-class research in support of the future force and Army transformation needs. This Project conducts basic research in areas that will expand the capabilities of intelligent mobile robotic systems for military applications with a focus on enhanced, innate intelligence, ultimately approaching that of a dog or other intelligent animal, to permit unmanned systems to function as productive members of a military team. Research is conducted in machine perception, including the exploration of sensor phenomenology, and the investigation of basic machine vision algorithms enabling future unmanned systems to better understand their local environment for enhanced mobility and tactical performance; intelligent control, including the advancement of artificial intelligence techniques for robot behaviors permitting future systems to autonomously adapt, and alter their behavior to dynamic tactical situations; understanding the interaction of humans with machines focusing upon intuitive control by Soldiers to minimize cognitive burden; dexterous manipulation of the environment by unmanned systems; and unique modes of mobility to enable unmanned systems to seamlessly navigate complex or highly constrained three dimensional environments. The program will conduct both analytic and validation studies.

Work in this Project builds fundamental knowledge for and complements the companion applied technology program, Program Element (PE) 0602120A, Project TS2 (Robotics).

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 2018	FY 2019	FY 2020
Title: Autonomous Systems	3.971	4.080	-
Description: Explore opportunities enabling revolutionary, autonomous, and highly mobile systems for the future force. Research focuses on unmanned systems operating as a team with human supervisors and displaying a high degree of adaptability to dynamic environmental and tactical situations.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H09 / *Robotics CTA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Create a framework to demonstrate integrated cognitive, perceptual, motion and manipulation planning, and human multi-modal interface capabilities to assess ability for robots to maneuver in unstructured environments, team with humans to execute complex missions, and perform autonomous mobile manipulation in ad hoc scenarios. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This Project concludes after FY19			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.155	-
Accomplishments/Planned Programs Subtotals	3.971	4.235	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H50 / *Network Sciences Cta*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H50: *Network Sciences Cta*	-	6.208	5.821	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	12.029

Note

This Project concludes after Fiscal Year (FY) 2019.

A. Mission Description and Budget Item Justification

This Project supports a competitively selected university and industry consortium, the Network Sciences Collaborative Technology Alliance (NS CTA), formed to leverage commercial research investments to provide solutions to Army's requirements for robust, survivable, and highly mobile wireless communications networks, while meeting the Army's needs for a state-of-the-art wireless mobile communications networks for command-on-the-move. The NS CTA performs foundational, cross-cutting network science research leading to: a fundamental understanding of the interplay and common underlying science among social/cognitive, information, and communications networks; determination of how processes and parameters in one network affect and are affected by those in other networks; and prediction and control of the individual and composite behavior of these complex interacting networks. This research will lead to optimized human performance in network-enabled warfare and greatly enhanced speed and precision for complex military operations. The CTA facilitates the exchange of people among the collaborating organizations to provide cross-organizational perspectives on basic research challenges, as well as the use of state-of-the-art facilities and equipment at the participating organizations. Many of the results of the NS CTA provide a foundation for the Internet of Battlefield Things Collaborative Research Alliance that began in FY18.

Work in this Project builds fundamental knowledge for and accelerates the transition of communications and networks technology to Program Element (PE) 0602783A (Computer and Software 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 2018	FY 2019	FY 2020
Title: Network Sciences Collaborative Technology Alliance (NS CTA)	6.208	5.608	-
Description: The Network Sciences CTA focuses on four major research areas: Information Networks, Communication Networks, Social/Cognitive Networks, and Interdisciplinary Research to develop a fundamental understanding of the ways that information, social/cognitive, and communications networks can be designed, composed, and controlled to dramatically increase mission effectiveness and ultimately enable humans to effectively exploit information for timely decision-making. Information Networks research develops the fundamental understanding of autonomous network activities and its linkage to the physical and human domains as related to human decision making within the networked command and control (C2) structure. Social/Cognitive Networks research is developing the fundamental understanding of the interplay of the various aspects of the social and cognitive networks with information and communications. Communications Networks research is developing the foundational techniques to model, analyze, predict, and control the behavior of secure tactical communication networks as an enabler for information and C2			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H50 / *Network Sciences Cta*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
networks. Integration is focused on achieving an integrated Information Networks, Social/Cognitive Networks, Communications Networks research program that significantly enhances the fundamental understanding of the underlying science of networks. ***FY 2019 Plans:*** Explore machine learning techniques that can classify different types of networks, including social networks, using deep network signatures to identify networks of special interest (e.g. adversarial) in early stages of their growth. Develop techniques to jointly model changes in information streams and multi-genre networks to enable the prediction of the impact of external events and anomalies in dynamic networks; techniques for combining user-oriented multidimensional summarization mechanisms with information-centric networking offers the potential to enable effective analytics in combined communications, information, and social networks. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This Project concludes after FY19.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.213	-
Accomplishments/Planned Programs Subtotals	6.208	5.821	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) H59 / *International Tech Centers*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H59: *International Tech Centers*	-	6.459	6.549	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	13.008

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AC6 International Science and Technology

A. Mission Description and Budget Item Justification

This Project funds the International Technology Centers (ITCs) and the Foreign Technology (and Science) Assessment Support (FTAS) program.

The nine ITCs located in in North America, South America, Asia, and Europe support the Army's goals of providing the best technology in the world to our Warfighters by leveraging the Science and Technology (S&T) investments of our international partners. The ITCs perform identification and evaluation of international technology programs to assess their potential impact on the Army's S&T investment strategy. ITC 'technology finds' are submitted to various Army S&T organizations for evaluation and consideration for further research and development. Highly promising research will be awarded seed funding by the ITC through a grant, contract, or cooperative agreement. The FTAS program also builds upon the "technology finds" submitted by the ITCs. In some cases the technology is truly unique and may well meet an Army requirement or potentially support ongoing Army S&T investments. In such cases, the FTAS program can provide initial resources (seed money) to determine the appropriateness of these technology areas identified as having potential relevance to the Army. These efforts will provide information useful in making early assessments of the technology's potential contributions to the Army's S&T strategy.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: International Technology Centers (ITC)	6.459	4.311	-
Description: This effort funds the technology search function of the ITCs. Research and/ or technologies that have possible interest to the Army are disseminated to the Army research enterprise. Review of these technologies by the research community provides useful information in making early assessments of the technology's potential contributions to the Army's S&T strategy. Highly promising international basic research will be provided seed funding by the ITC for further evaluation through a grant, contract, or cooperative agreement, typically to a university.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H59 / *International Tech Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
The ITCs continue to seek out foreign science and technologies that may have United States Army interest within their area of responsibility. Highly promising international basic research is awarded seed funding for further evaluation through a grant, contract, or cooperative agreement, typically to a university. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This Project will move to PE 0601104A University and Industry Research Centers/ Project AC6 International Science and Technology in FY20.			
Title: Foreign Technology (and Science) Assessment Support (FTAS) ***Description:*** This effort funds the Foreign Technology (and Science) Assessment Support (FTAS) program. The FTAS program builds upon the ?technology finds? submitted by the ITCs. In some cases a technology is truly unique and may well meet an Army requirement or potentially support ongoing Army S&T investments. In such cases, the FTAS program can provide initial resources (seed money) to determine the appropriateness of technology areas identified to meet Army needs. These efforts will provide information useful in making early assessments of the technology's potential contributions to the Army's S&T strategy. ***FY 2019 Plans:*** Solicit projects and build on the success of the FTAS Program. Once scientific quality of candidate projects is assessed by the U.S. Army Senior Scientist Corps seed funding will be provided to U.S. Army laboratories to further determine the appropriateness of technology areas identified as having potential relevance to the Army. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This Project will move to PE 0601104A University and Industry Research Centers/ Project AC6 International Science and Technology in FY20.	-	2.034	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.204	-
Accomplishments/Planned Programs Subtotals	6.459	6.549	-

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H59 / *International Tech Centers*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army					Date: March 2019							
Appropriation/Budget Activity 2040 / 1					R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*				Project (Number/Name) H73 / *Automotive Research Center (ARC)*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
H73: *Automotive Research Center (ARC)*	-	3.113	3.292	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.405

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB4 Army Research Centers

A. Mission Description and Budget Item Justification

This Project fosters basic research in novel, high payoff technologies that can be integrated into Army ground platforms. The Center of Excellence for Automotive Research is part of the basic research component of the Army Futures Command. The Center of Excellence for Automotive Research is an innovative university/ industry/government consortium leveraging commercial technology for potential application in Army vehicle systems through ongoing and new programs in automotive research, resulting in significant cost savings and performance enhancing technological opportunities. The research performed in this Project contributes to formulating and establishing the basic scientific and engineering principles for these technologies.

Work in this Project complements and is fully coordinated with work under PE 0602601A (Combat Vehicle and Automotive Technology). Selected university partners include: University of Michigan, Virginia Tech, Wayne State University, University of Iowa, Oakland University, and Clemson University. Key industry partners include all major United States automotive manufacturers and suppliers. The Automotive Research Center (ARC) formulates and evaluates advanced automotive technologies and advances state-of-the-art modeling and simulation for the Army's future ground vehicle platforms.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Automotive Research Center (ARC)	3.113	3.192	-
Description: The ARC is an United States (US) Army Center of Excellence for Modeling and Simulation of ground vehicles. The Center relies on the collaboration of researchers from multiple universities and disciplines in order to bridge fundamental technology gaps in five research thrust areas of strategic importance to the Army, associated with conversion and management of power and energy within vehicles, mobility and survivability of the complete vehicle system, including the human occupants, and vehicle integration/optimization.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** H73 / *Automotive Research Center (ARC)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Continue advanced modeling and simulation research on ground vehicle power generation, storage, and distribution while expanding more into autonomy and mobility problems for ground vehicles. Topics include teleoperated, semi-autonomous, fully-autonomous, and multiple autonomous vehicle operation and control, high fidelity simulation environments for operational evaluations of autonomy related technologies, high performance terramechanics models, perception in degraded sensor environments, machine learning, robotic trust, etc. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers Project AB4 Army Research Centers in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.100	-
Accomplishments/Planned Programs Subtotals	3.113	3.292	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J08 / *Institute For Creative Technologies (ICT)*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
J08: *Institute For Creative Technologies (ICT)*	-	6.057	6.432	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	12.489

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB4 Army Research Centers

A. Mission Description and Budget Item Justification

This Project supports simulation and training technology research at the Army's Institute for Creative Technologies (ICT) at the University of Southern California. The ICT was established as a University Affiliated Research Center (UARC) to support Army training and readiness through research into simulation, mixed and virtual reality, artificial intelligence, computer graphics, and learning sciences. ICT applies the results of this research and proves its value in Army relevant applications such as training, mission rehearsal, leadership development, cultural awareness, negotiation, health and medical, and distance learning. The ICT actively performs research and engages industry and academic institutions internationally to incorporate the latest research results and hardware and software into its research program and application development and exploit dual-use technology. The ICT serves as a means for the military to learn about, benefit from, and facilitate the transfer of applicable technologies into military systems. In addition the ICT works with creative talent from the entertainment industry to advance and leverage techniques and capabilities and adapt concepts of story and character to increase the degree of participant immersion in synthetic environments in order to improve the realism and usefulness of these experiences. In developing a true synthesis of the creativity, research, technology, and capability of industry and the research and development community, the ICT is revolutionizing capabilities for the Army by making it more effective in terms of cost, time, range of experiences and the quality of the result and by producing research and applications that will benefit the Army of the 21st century.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Immersive Environments	2.299	2.452	-
Description: Conduct basic research in immersive environments, to include virtual humans, three-dimensional (3D) sound and visual media, to achieve more efficient and affordable training, modeling, simulation and application solutions and tools. Research includes investigation of techniques and methods to address the rapid development of synthetic environments and the study of perception and cognition to help direct the development of new technologies and techniques that evoke more realistic responses			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
from users. Perform research into auditory aspects of immersion to provide the sound stimulus for increasing the realism for military training and simulation devices. ***FY 2019 Plans:*** Examine characteristics of virtual humans that promote trust in domains such as persuasion tasks, social dilemmas and interviews (with sensitive questions) and will examine differences between normative influence (emphasizing social norms) and informational influence (e.g. conveying expert information); these areas have potential applications for not only virtual humans but also robotics. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers Project AB4 Army Research Centers in FY20.			
Title: Graphics and Animations ***Description:*** Conduct basic research to identify new computational techniques in graphics for achieving real-time photo-realistic rendering of physical and synthetic environments for training and simulations. Research innovative methods for automatically generating animations and gestures for virtual humans based on what is being communicated. Research new technologies for scanning real people and rapidly generating virtual humans which look like these people significantly reducing the time, expense and effort required to develop virtual humans and virtual environments. ***FY 2019 Plans:*** Research virtual reality and augmented reality-driven teleportation system that will use detailed 3D models created in prior research to in-person, photo-realistic communication for remote participants; research techniques for rapidly capturing movement and speech animations that are specific to individuals. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers Project AB4 Army Research Centers in FY20.	1.404	1.211	-
Title: Techniques and Human-Virtual Human Interaction ***Description:*** Basic research to investigate methods and techniques for creating virtual human computer-generated characters that look, communicate and behave like real people, meaning the virtual humans will be autonomous, use verbal and non-verbal communication, exhibit emotions, model their own beliefs, desires and intentions as well as those of others, and reason using advanced artificial intelligence. Investigate methods and techniques for improving the perception, communication, understanding, and responsiveness of virtual humans when interacting with live humans and explore how people relate to virtual humans. ***FY 2019 Plans:***	2.354	2.533	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J08 / *Institute For Creative Technologies (ICT)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Study how extended interaction occurs in groups larger than a dyad, investigate how information can span multiple conversations, and research how to endow virtual humans with these capabilities. Develop techniques that will allow virtual humans to automatically identify strategic emotional manipulation and defend against it. Leverage Sigma cognitive architecture?s combined neural and symbolic representations to create a model of question answering. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers Project AB4 Army Research Centers in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.236	-
Accomplishments/Planned Programs Subtotals	6.057	6.432	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J12 / *Institute For Soldier Nanotechnology (ISN)*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
J12: *Institute For Soldier Nanotechnology (ISN)*	-	5.759	5.992	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.751

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB4 Army Research Centers

A. Mission Description and Budget Item Justification

This Project supports sustained multidisciplinary research at the Army's Institute for Soldier Nanotechnologies (ISN) at the Massachusetts Institute of Technology. The ISN was established as a University Affiliated Research Center (UARC) to support research to devise nanotechnology-based solutions for the Soldier. The ISN emphasizes revolutionary materials research for advanced Soldier protection and survivability. The ISN works in close collaboration with the United States (US) Army Futures Command as well as several major industrial partners, including Raytheon and DuPont, in pursuit of its goals. This Project emphasizes revolutionary materials research toward an advanced uniform concept. The future uniform will integrate a wide range of functionality, including ballistic protection, responsive passive cooling and insulating, screening of chemical and biological agents, biomedical monitoring, performance enhancement, and extremities protection. The objective is to lighten the Soldier's load through system integration and multifunctional devices while increasing survivability. The new technologies will be compatible with other Soldier requirements, including Soldier performance, limited power generation, integrated sensors, communication and display technologies, weapons systems, and expected extremes of temperature, humidity, storage lifetimes, damage, and spoilage.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Nanomaterials and Nanotechnologies for Soldier Application (formerly Nanomaterials)	5.759	5.773	-
Description: Nanomaterials research efforts focus on light-weight, multifunctional nanostructured fibers and materials.			
FY 2019 Plans: Support continuing basic research projects in nanomaterials to improve protection against blast and ballistic threats. Continue to support nano-optoelectronics and novel light-matter interactions for optical sensing and energy conversion platforms. Continue to			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J12 / *Institute For Soldier Nanotechnology (ISN)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
support battlefield medicine through novel strategies for treatment of incompressible wounds, and improved vaccination/infection control strategies by leveraging targeted nano-therapies. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers Project AB4 Army Research Centers in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.219	-
Accomplishments/Planned Programs Subtotals	5.759	5.992	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J13 / *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
J13: *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*	-	20.000	22.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	42.000

Note

Congressional Increase

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for University and Industry Initiatives.

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Congressional Program Increase - University and Industry Research Centers ***FY 2018 Accomplishments:*** Congressional Program Increase - University and Industry Research Centers ***FY 2019 Plans:*** Congressional Program Increase - University and Industry Research Centers	15.000	10.000
Congressional Add: Congressional Program increase - Materials in Extreme Dynamic Environments ***FY 2018 Accomplishments:*** Congressional Program increase - Materials in Extreme Dynamic Environments ***FY 2019 Plans:*** Congressional Program increase - Materials in Extreme Dynamic Environments	5.000	10.000
Congressional Add: Congressional Program Increase - university assisted hypervelocity testing ***FY 2019 Plans:*** Congressional Program Increase - university assisted hypervelocity testing	-	2.000
Congressional Adds Subtotals	20.000	22.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J13 / *UNIVERSITY AND INDUSTRY INITIATIVES (CA)*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J14 / *Army Educational Outreach Program*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
J14: *Army Educational Outreach Program*	-	9.646	10.259	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	19.905

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB8 Army Educational Outreach Program

A. Mission Description and Budget Item Justification

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

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

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 2018	FY 2019	FY 2020
Title: eCYBERMISSION ***Description:*** This program supports a nation-wide, web-based STEM competition for students in grades 6 through 9, designed to stimulate interest and encourage continued education in these areas among middle and high school students nationwide.	3.668	-	-
Title: Educational Outreach and Workforce Development ***Description:*** This effort aims to broaden STEM competencies through various outreach and workforce development initiatives at participating Army labs and research centers. ***FY 2019 Plans:***	2.112	1.924	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Continue AEOP support and outreach to under-represented and economically disadvantaged areas to enhance STEM education through student experiences in Army labs and academic partner institutions, and mentor students to broaden their interest in and their development of STEM education. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort moves to PE 0601104A University and Industry Research Centers / Project AB8 Army Educational Outreach Program in FY20.			
Title: Army Educational Outreach Program (AEOP) Cooperative Agreement ***Description:*** The Army Educational Outreach Program Cooperative Agreement encompasses a variety of outreach activities under AEOP that includes a comprehensive evaluation and assessment component, a holistic marketing strategy, and an alumni management element. Collectively, this activity supports a strategic partnership with government, academia and industry to address the shortfall of clearable STEM skilled talent preparing for the workforce with a concentration on leveraged partnerships/investments, quality program capabilities with qualitative and quantitative data support, and evidence-based program management. These activities include Army-sponsored research, education, competitions, internships and practical experiences designed to engage and guide students and teachers in Army sponsored STEM programs. AEOP has targeted efforts to reach and engage underserved and underrepresented communities in STEM initiatives to build the pool of diverse STEM competitive talent. Outcomes are reported annually online at https://www.usaeop.com/about/our-impact/. ***FY 2019 Plans:*** Continue Army lab and research center sponsorship of students and STEM education opportunities; provide incentives in STEM competitions that include scholarships, experiences and mentorships as well as expose students to DoD career opportunities; streamline processes, leverage funding and build educational partnerships; and perform annual comprehensive review and educational assessments to support future decisions and best practices. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort moves to PE 0601104A University and Industry Research Centers / Project AB8 Army Educational Outreach Program in FY20.	3.562	7.709	-
Title: West Point Cadet Research ***Description:*** The West Point Cadet Research Program provides 40 to 60 West Point Cadets an opportunity to work on Army research projects alongside Army and industry scientists and engineers for a period of 3 to 6 weeks during the summer. ***FY 2019 Plans:***	0.304	0.250	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J14 / *Army Educational Outreach Program*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Conduct West Point cadet research internship program to enhance cadet training through field experience in Army research labs and engineering centers. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort moves to PE 0601104A University and Industry Research Centers / Project AB8 Army Educational Outreach Program in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.376	-
Accomplishments/Planned Programs Subtotals	9.646	10.259	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J15 / *Network Sciences ITA*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
J15: *Network Sciences ITA*	-	3.919	4.106	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.025

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB7 Army Collaborative Research and Tech Alliances

A. Mission Description and Budget Item Justification

This Project supports research at a competitively selected United States (US)/United Kingdom (UK) government, university, and industry consortium established to perform fundamental network and information science investigations in the areas of network theory, system-of-systems security, sensor processing and delivery, and distributed coalition planning and decision making. The focus is on enhancing distributed, secure, and flexible decision-making to improve coalition operations, and developing the scientific foundations for complex and dynamic networked systems-of-systems to support the complex human, social, and technical interactions anticipated in future coalition operations with the emphasis on integration of multiple technical disciplines in an international arena. The Army Futures Command and the UK Ministry of Defense (MOD) established the jointly funded and managed US and UK consortium, known as the International Technology Alliance (ITA) on Network and Information Sciences, in FY06.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Distributed Analytics and Information Science for U.S./U.K. Coalition Operations Information (formerly Network and Information Science Basic Research for US/UK Coalition Operations Information)	3.919	3.955	-
Description: This research will address the fundamental science underpinning the complex information network issues that are vital to future US/UK coalition military operations and to fully exploit the joint development of emerging technologies necessary to enable coalition operations. These efforts provide enhanced ability to perform adaptive, goal-driven, semantically-aware, distributed analytics for situational understanding in coalition operations.			
FY 2019 Plans: Investigate and formally model new generative policy techniques in which elements can generate their policies under a loose set of guidance from a central coalition commander; investigate algorithms that ensure consistency and coherence in the operation of such a system to enable ad hoc and dynamic coalition formation; investigate fundamental limits and models for agile code and agile data to support distributed analytics in coalitions with mechanisms that dynamically adapt analytics processing in a			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J15 / *Network Sciences ITA*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
tactical coalition environment as missions and coalitions change; develop deep learning techniques for multi-layer situational understanding with information fusion at varying levels of semantic granularity to obtain situational understanding in complex multi-layer coalition environments. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers/ Project AB7 Army Collaborative Research and Tech Alliances in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.151	-
Accomplishments/Planned Programs Subtotals	3.919	4.106	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) J17 / *Vertical Lift Research Center Of Excellence*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
J17: *Vertical Lift Research Center Of Excellence*	-	3.005	3.182	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.187

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB4 Army Research Centers

A. Mission Description and Budget Item Justification

This Project fosters research to provide vertical lift capability and engineering expertise for the Army. The focus of the Vertical Lift Research Center of Excellence (VLRCOE) is to couple state-of-the-art research programs with broad-based graduate education programs at academic institutions with the goal of increasing the supply of scientists and engineers who can contribute to Army Transformation. Work will provide research into technologies that can improve tactical mobility, reduce the logistics footprint, and increase survivability for rotary wing vehicles.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Vertical Lift Research Center of Excellence (VLRCOE)	3.005	3.080	-
Description: VLRCOE agreements with Penn State University, University of Maryland, and Georgia Institute of Technology to supplement a robust experimental and analytic basic research program in rotorcraft technologies including: Aeromechanics, Structures, Flight Dynamics and Control, Rotorcraft Design and Concepts, Vibration and Noise Control, Propulsion, Affordability, Safety and Survivability, and Naval Operations.			
FY 2019 Plans: Execute the third annual review of the VLRCOE program with a diverse team of Government subject matter experts (SMEs) and organizational leaders from the Army, the Navy, and the National Aeronautics and Space Administration (NASA), to provide technical direction for the research tasks. Execute the cooperative agreement with the Centers of Excellence at Georgia Institute of Technology, Pennsylvania State University, and University of Maryland, incorporating the reviewers' feedback to realign the research tasks with the Army's strategic science and technology plans. The Centers conduct a robust experimental and analytic basic research program in close collaboration with government SMEs in areas relevant to future vertical lift to include			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** J17 / *Vertical Lift Research Center Of Excellence*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
nanocomposites to enhance fatigue life of rotorcraft components, optimal control allocation methods, and advanced cueing & flight control algorithms. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers / Project AB4 Army Research Centers in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.102	-
Accomplishments/Planned Programs Subtotals	3.005	3.182	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) VS2 / *Multi-Scale Materials Modeling Centers*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
VS2: *Multi-Scale Materials Modeling Centers*	-	8.686	8.743	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	17.429

Note

In Fiscal Year (FY) 2020, this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB7 Army Collaborative Research and Tech Alliances

A. Mission Description and Budget Item Justification

This Project supports two competitively awarded Collaborative Research Alliances (CRAs) to provide the Army with next generation multi-functional materials for ballistic and electronic applications and to address the extreme challenges associated with understanding and modeling materials subject to Army operational environments. The Materials in Extreme Dynamic Environments consortium, led by Johns Hopkins University partnered with CalTech, Rutgers University, and University of Delaware, focuses on understanding materials under high strain rates. The Multiscale Multidisciplinary Modeling of Electronic Materials consortium, led by University of Utah partnered with Boston University and Rensselaer Polytechnic Institute, focuses on microscale properties to design macroscale behavior for electronics. Research at both CRAs will address the modeling and experimental challenges associated with developing multidisciplinary physics simulations across multiple length scales for materials to include: a limited ability to relate materials chemistry, structure, and defects to materials response and failure under extreme conditions; an inadequate ability to predict the roles of materials structure, processing, and properties on performance in relevant extreme environments and designs; and the lack of experimental capabilities to quantify multiscale response and failure of materials under extreme conditions.

Work in this Project supports key Army needs and is coordinated with work performed in PE 0601102A (Defense Research Sciences) / Project H44 (Adv Sensor Research) and H42 (Materials and Mechanics).

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Collaborative Research Alliances in Materials in Extreme Dynamic Environments and Multiscale Multidisciplinary Modeling of Electronic Materials.	8.686	8.423	-
Description: Research will focus on the following areas: two-way multiscale modeling for predicting performance and designing materials, investigating analytical and theoretical analyses to effectively define the interface physics across length scales; advancing experimental capabilities for verification and validation of multiscale physics; and modeling and strategies for the synthesis of high loading rate tolerant materials so that all of the latter lead to the development of a comprehensive set of			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** VS2 / *Multi-Scale Materials Modeling Centers*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
metrics that define high loading rate tolerant material systems. The multiscale modeling capability will be applied across multiple disciplines to facilitate revolutionary advances in materials for coupled environments (electromagnetic, high rate, high pressure and other extreme environments). ***FY 2019 Plans:*** Implement data-sharing protocols and processes for sharing fundamental materials research data within the program. Complete integrated multiscale models for high rate deformation and failure in all three material classes: metals, ceramics, and composites. Investigate solid solution strengthening of magnesium and the effects on spall strength, and the design of interface behavior and increased matrix strain in glass epoxy composites. Implement uncertainty quantification techniques across the three materials classes and applications; design and implement algorithms and tools for coupled multiscale modeling capable of enhancing/optimizing the design of individual components and systems across the three electronic materials research areas; develop methodologies for Uncertainty Quantification-driven bridging/mapping between models and simulation techniques and assessment of reliability of simulation-predicted outcomes for polymer membranes and electrode/electrolytes interfaces; and extend the Nonequilibrium Green's function code (inclusion of carrier-carrier scattering and parallel implementation) to evaluate key quantities not accessible to other simulation approaches, e.g. phonon-assisted Auger-induced leakage, trap- and phonon-assisted tunneling for electro-optical materials. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort will move to PE 0601104A University and Industry Research Centers/ Project AB7 Army Collaborative Research and Tech Alliances in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.320	-
Accomplishments/Planned Programs Subtotals	8.686	8.743	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** VS2 / *Multi-Scale Materials Modeling Centers*

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601104A / *University and Industry Research Centers*	Project (Number/Name) VS3 / *Center For Quantum Science Research*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
VS3: *Center For Quantum Science Research*	-	5.013	6.230	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	11.243

Note

In Fiscal Year (FY) 2020, this Project is being realigned to:
Program Element (PE) 0601104A University and Industry Research Centers
* Project AB7 Army Collaborative Research and Tech Alliances

A. Mission Description and Budget Item Justification

This Project supports an extramural research consortium, which will bring together a critical mass of preeminent university and industry researchers to explore and develop critical emerging concepts in Quantum Information Science (QIS). The focus will be on establishing a first of its kind, multi-site distributed quantum network based on quantum memories. The Center for Distributed Quantum Information will study and demonstrate both the physical backbone and network layer for a robust quantum information network that will provide secure and tamper-proof communications and exponentially greater information processing capabilities for the future Army. The Center for Distributed Quantum Information will perform collaborative research with Army in-house scientists and engineers to help accelerate the transition of the research. In addition to providing the required expertise and critical mass to the effort, the consortium will also bring together a broad but unified multi-disciplinary research team needed to accelerate progress in the field of quantum information sciences.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Center for Distributed Quantum Information	5.013	6.002	-
Description: This work supports critical quantum science basic research at the United States (US) Army Futures Command exploiting quantum effects to greatly enhance computing, communications, imaging, sensing, and security, ensuring Army dominance on the future battlefield.			
FY 2019 Plans: Simultaneously entangle three or more physically separate quantum nodes and investigate quantum networking algorithms and protocols. Continue to refine and improve quantum-state transfer, node-to-node entanglement, error protection protocols, and frequency conversion.			
FY 2019 to FY 2020 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601104A / *University and Industry Research Centers*	**Project (Number/Name)** VS3 / *Center For Quantum Science Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
This research effort will move to PE 0601104A University and Industry Research Centers/ Project AB7 Army Collaborative Research and Tech Alliances in FY20.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.228	-
Accomplishments/Planned Programs Subtotals	5.013	6.230	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601121A *I Cyber Collaborative Research Alliance*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	-	0.000	0.000	4.982	-	4.982	5.082	5.186	5.290	5.349	0.000	25.889
CB5: *Cyber Collaborative Research Alliance*	-	0.000	0.000	4.982	-	4.982	5.082	5.186	5.290	5.349	0.000	25.889

Note

In Fiscal Year (FY) 2020 this Program Element (PE) was previously funded, with continuity of effort realigned from the following PE:
* PE 0601104A University and Industry Research Centers

A. Mission Description and Budget Item Justification

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

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army					Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research*			R-1 Program Element (Number/Name) PE 0601121A / *Cyber Collaborative Research Alliance*		
B. Program Change Summary ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Previous President's Budget	0.000	0.000	0.000	-	0.000
Current President's Budget	0.000	0.000	4.982	-	4.982
Total Adjustments	0.000	0.000	4.982	-	4.982
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	4.982	-	4.982

Change Summary Explanation

FY20 funding increase adjustments related to Science and Technology Financial Restructuring.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 1	R-1 Program Element (Number/Name) PE 0601121A / *Cyber Collaborative Research Alliance*	Project (Number/Name) CB5 / *Cyber Collaborative Research Alliance*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
CB5: *Cyber Collaborative Research Alliance*	-	0.000	0.000	4.982	-	4.982	5.082	5.186	5.290	5.349	0.000	25.889

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0601104A (University and Industry Research Centers)
* EA6 Cyber Collaborative Research Alliance

A. Mission Description and Budget Item Justification

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

Work in this Project supports key Army needs and provides the technical underpinnings to PE 0602146A Network C3I Technology.

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Cyber Security Collaborative Research Alliance	-	-	4.982
Description: The Cyber Security Collaborative Research Alliance (CSEC CRA) supports basic research to enable capabilities for rapid development and adaptation of cyber tools for dynamically assessing cyber risks, detecting hostile activities on friendly networks, and supporting agile maneuver in cyber space in spite of the emergence of novel threats.			
FY 2020 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 1	**R-1 Program Element (Number/Name)** PE 0601121A / *Cyber Collaborative Research Alliance*	**Project (Number/Name)** CB5 / *Cyber Collaborative Research Alliance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Will model distributed, dynamic, secure coalition communication/information infrastructures that support distributed analytics to derive situational understanding; develop techniques for dynamic self-configuring services "on demand" based on mission needs, context and resource constraints; model underlying distributed analytics and situational understanding that supports dynamic coalition operations involving complex multi-actor situations. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned from PE 0601104A (University and Industry Research Centers) / Project EA6 (Cyber Collaborative Research Alliance) in FY20.			
Accomplishments/Planned Programs Subtotals	-	-	4.982

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A