| Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army | | | | | | | | | | | Date: March 2019 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appropriation/Budget Activity<br>2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research* | | | | | R-1 Program Element (Number/Name)<br>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<br>2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research* | | | | | R-1 Program Element (Number/Name)<br>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<br>2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research* | | | | | R-1 Program Element (Number/Name)<br>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**<br>2040: *Research, Development, Test & Evaluation, Army* / BA 1: *Basic Research* | **R-1 Program Element (Number/Name)**<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to Project AA8 Sensing and Electromagnetics in FY 2020. | 0.994 | 0.991 | - |
| ***Title:*** Advanced Materials<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to Project AA8 Sensing and Electromagnetics in FY 2020. | 2.706 | 2.723 | - |
| ***Title:*** FY 2019 SBIR / STTR Transfer<br><br>***Description:*** FY 2019 SBIR / STTR Transfer | - | 0.033 | - |

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY 2020. | | | |
| ***Title:*** FY 2019 SBIR / STTR Transfer<br><br>***Description:*** FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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.<br><br>***FY 2019 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE0601102A / Project AA4 in FY20. | | | |
| ***Title:*** Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A / Project AA4 in FY20. | 3.777 | 4.116 | - |
| ***Title:*** Training and Soldier Performance<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A / Project AA4 in FY20. | | | |
| ***Title:*** FY 2019 SBIR / STTR Transfer<br><br>***Description:*** FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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)<br><br>***Description:*** Basic research to develop innovative theories, models, and methods to improve personnel assessment, training, and leader development.<br><br>***FY 2019 Plans:***<br>Conduct research to identify job-performance measures that can inform assignment and to examine the validity of using non-traditional data for personnel assessment.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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).<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***Description:*** FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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)<br><br>***Description:*** This effort funds basic research in ground vehicle technologies to include power, mobility, and unmanned systems.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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)<br><br>***Description:*** This effort funds basic research in food sciences, textiles, and lightweight materials with potential for individual protection.<br><br>***FY 2020 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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)<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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)<br><br>***Description:*** This effort funds basic research for aviation enabling technologies in the areas of aerodynamics, structural dynamics, and material science.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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)<br><br>***Description:*** Funds basic research for communication and network enabling technologies in the areas of antenna design, network management, power generation and storage, and sensors.<br><br>***FY 2020 Plans:*** | - | - | 2.239 |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Army | | Date: March 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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).<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>AA3 / *Single Investigator Basic Research* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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.<br><br>***FY 2020 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:*** | | | |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Army | | Date: March 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>Will identify behavioral and physiological correlates of positive and negative gamification feedback mechanisms for adaptive individualized training.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:*** | - | - | 0.994 |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Army | | Date: March 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** This research develops advanced psychometric theory and measurement of Soldiers and teams to maximize talent management.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** This research develops methods and models to understand the relationship of human states, traits, and behaviors on individual, group, and organizational dynamics.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This work represents an increase in program requirements for novel multi-fuel tolerant small vehicle power efforts. | - | - | 4.000 |
| ***Title:*** Fundamentals for Alternative Energy<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>AA6 / *Robotics and Mobile Energy* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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).<br><br>***FY 2020 Plans:***<br>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.<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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 | - | - | 0.765 |
| ***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This work was previously performed in PE 0601102A Defense Research Sciences / Project F22 Rsch In Veh Mobility in FY 2019. | | | |
| **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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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.<br><br>***FY 2020 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This work was previously performed in PE 0601102A Defense Research Sciences / Project H42 Materials & Mechanics in FY 2019. | | | |
| ***Title:*** High Deformation Rate Materials<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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).<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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).<br><br>***FY 2020 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** This effort conducts research on innovative environmentally-friendly technologies that support the warfighter focusing on pollution prevention technologies.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This work was previously performed in PE 0601102A Defense Research Sciences / Project H67 Environmental Research in FY 2019. | - | - | 1.085 |
| ***Title:*** Surface Science Research<br>***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.<br>***FY 2020 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This work was previously performed in PE 0601102A Defense Research Sciences / Project 31B Infrared Optics Rsch in FY 2019. | | | |
| ***Title:*** Advanced Materials Research<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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)<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:*** | - | - | 5.161 |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Army | | Date: March 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of-the-art techniques in machine translation and natural language processing.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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 |

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|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:*** | | | |

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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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).<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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 |

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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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 |

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| 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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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 |
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| Appropriation/Budget Activity<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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 |
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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** This effort conducts basic science studies to determine physiological responses to trauma and aid in development of life-saving interventions.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:*** | - | - | 0.993 |

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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***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<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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 |

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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:*** | - | - | 1.184 |

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|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:*** | - | - | 6.564 |

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|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:*** | - | - | 1.820 |

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|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2020 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2020 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***Description:*** Develop the fundamental understanding necessary to design, process, and characterize materials specifically intended for high loading-rate applications, as in armor and armaments.<br>***FY 2019 Plans:***<br>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).<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>H42 / *Materials & Mechanics* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>Identify synthesis methods for novel 2D polymer molecules assembled with intermolecular hydrogen bonding to create graphene-like materials with enhanced toughness relative to graphene.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY20. | 2.819 | 2.900 | - |
| ***Title:*** Armor Research<br>***Description:*** Develop fundamental knowledge of mechanisms that can be exploited to ensure the next generation of lightweight and efficient armor technologies.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>Develop a computational framework to study the effects of mechanical loading on voltage sensitive ion channels of the brain.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer | - | 0.293 | - |

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA8 Sensing and Electromagnetics in FY20. | | | |
| ***Title:*** Multi-scale Modeling for Novel Materials<br><br>***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).<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***Description:*** Create synthetic biological materials for devices and sensors that can be used by the Army to improve force protection and reduce logistical burden.<br><br>***FY 2019 Plans:*** | 4.359 | 2.026 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Army | | Date: March 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA5 Biotechnology and Systems Biology in FY20. | | | |
| ***Title:*** Living Materials<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>H47 / *Applied Physics Rsch* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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.<br>***FY 2019 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20. | | | |
| ***Title:*** FY 2019 SBIR / STTR Transfer<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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. | | | |

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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>H48 / *Battlespace Info & Comm Rsc* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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. .<br>***FY 2019 Plans:***<br>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 | - |

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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** Establishes formal methods for bridging language barriers in tactical environments, incorporating state-of- the-art techniques in machine translation and natural language processing.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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 | - |

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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20. | | | |
| ***Title:*** Experimental Methods in Network Science<br><br>***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).<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20. | | | |
| ***Title:*** Mobile Network Modeling<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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 |
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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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).<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA9 Information and Networking in FY20. | | | |
| ***Title:*** FY 2019 SBIR / STTR Transfer<br><br>***Description:*** FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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 |
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| Appropriation/Budget Activity<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:*** | | | |

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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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:***<br>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 |
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| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20. | | | |
| ***Title:*** Basic Research in Computing Sciences<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20. | | | |
| ***Title:*** Basic Research in Mechanical Sciences<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>H57 / *Single Investigator Basic Research* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA3 Single Investigator Basic Research in FY20. | | | |
| ***Title:*** Basic Research in Social Sciences<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***Description:*** FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 Plans:*** | - | 3.269 | - |

| Exhibit R-2A, RDT&E Project Justification: PB 2020 Army | | Date: March 2019 |
|---|---|---|
| **Appropriation/Budget Activity**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20. | | | |
| ***Title:*** Reconfigurable Platform Mechanics & Propulsion<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***Description:*** FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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).<br><br>***FY 2019 Plans:***<br>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.<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>S14 / *Sci BS/Cbt Cas Care Rs* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>Study physiological effects of reintroducing circulation to a limb after long-term administration of oxygen-carrying blood substitutes.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer | - | 0.188 | - |

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

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>S15 / *Sci BS/Army Op Med Rsh* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>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).<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***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.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***Description:*** Conduct fundamental research on material interactions at the micro- and nano-scales to determine how they affect macroscale properties<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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.<br><br>***FY 2019 Plans:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** Conduct fundamental research to increase the understanding of the physical and chemical characteristics of insensitive munitions<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** Conduct fundamental research on the molecular interactions of plants and animals with environmental stimuli.<br>***FY 2019 Plans:***<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>T25 / *Environmental Science Basic Research* |

| B. Accomplishments/Planned Programs ($ in Millions) | FY 2018 | FY 2019 | FY 2020 |
|---|---|---|---|
| ***FY 2019 Plans:***<br>Compare nectar defense in generalist and specialist plants that are in pollination networks, and model crowd confusion and evacuation in complex networks.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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<br><br>***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.<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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).<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br><br>***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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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..<br><br>***FY 2019 Plans:***<br>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.<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>This effort will move to PE 0601102A Defense Research Sciences / Project AA6 Robotics and Mobile Energy in FY20. | | | |
| ***Title:*** FY 2019 SBIR / STTR Transfer<br><br>***Description:*** FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br><br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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<br>2040 / 1 | | | | | R-1 Program Element (Number/Name)<br>PE 0601102A / *Defense Research Sciences* | | | | Project (Number/Name)<br>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:***<br>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**<br>2040 / 1 | **R-1 Program Element (Number/Name)**<br>PE 0601102A / *Defense Research Sciences* | **Project (Number/Name)**<br>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.<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>Project VR9 will move to PE 0601102A Defense Research Sciences / Project AA7 Mechanics and Ballistics in FY20. | | | |
| ***Title:*** FY 2019 SBIR / STTR Transfer<br>***Description:*** FY 2019 SBIR / STTR Transfer<br>***FY 2019 Plans:***<br>FY 2019 SBIR / STTR Transfer<br>***FY 2019 to FY 2020 Increase/Decrease Statement:***<br>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