Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602120A / *Sensors and Electronic Survivability*							
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	57.202	36.109	35.730	-	35.730	29.882	31.618	32.862	33.392	-	-
H16: *S3I Technology*	-	20.605	19.599	16.890	-	16.890	17.323	17.031	18.640	19.021	-	-
SA1: *Sensors and Electronic Initiatives (CA)*	-	20.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
SA2: *Biotechnology Applied Research*	-	2.871	1.361	1.683	-	1.683	0.503	0.512	0.523	0.534	-	-
TS1: *Tactical Space Research*	-	5.578	6.702	7.032	-	7.032	2.611	4.444	3.875	3.812	-	-
TS2: *Robotics Technology*	-	8.148	8.447	10.125	-	10.125	9.445	9.631	9.824	10.025	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) investigates designs and evaluates sensors and electronic components and software that enhance situational awareness, survivability, lethality, and autonomous mobility for tactical ground forces. Project H15 focuses on Combat Identification (CID) technologies, which include devices to locate, identify, track, and engage targets in the Joint fires environment. Project H16 investigates sensors, signal processing and information fusion technologies to increase target detection range and speed of engagement. Project SA2 conducts applied research on biological sensors and biologically derived electronics that exploits breakthroughs in biotechnology basic research in collaboration with the Institute for Collaborative Biotechnology (ICB), a University Affiliated Research Center (UARC) led by the University of California, Santa Barbara in partnership with California Institute of Technology and Massachusetts Institute of Technology and their industry partners. Project TS1 researches and evaluates space-based remote sensing, signal, and information processing software in collaboration with other Department of Defense (DoD) and government agencies to support space force enhancement and space superiority advanced technology integration into Army battlefield operating systems. Project TS2 focuses on advancing perception for autonomous ground mobility, intelligent vehicle control and behaviors, human-robot interaction, robotic manipulation, and unique mobility for unmanned vehicles.

Work in this PE complements and is fully coordinated with efforts in PE 0602307A (Advanced Weapons Technology), PE 0602705A (Electronics and Electronic Devices), PE 0602709A (Night Vision Technology), PE 0602782A (Command, Control, Communications Technology), PE 0603001A (Warfighter Advanced Technology), PE 0603006A (Command, Control, Communications Advanced Technology), PE 0603008A (Command Electronic Warfare Advanced Technology), PE 0603710A (Night Vision Advanced Technologies), and PE 0603772A (Advanced Tactical Computer Science and Sensor Technology),

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

Work is performed by the Army Research Laboratory, Adelphi, MD and Aberdeen Proving Ground, MD; the Communications-Electronics Research, Development, and Engineering Center, Aberdeen Proving Ground, MD; and the United States (US) Army Space and Missile Defense Technical Center, Huntsville, AL.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army	Date: May 2017
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*

B. Program Change Summary ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	58.374	36.109	32.972	-	32.972
Current President's Budget	57.202	36.109	35.730	-	35.730
Total Adjustments	-1.172	0.000	2.758	-	2.758
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.172	-			
• Adjustments to Budget Years	0.000	0.000	2.637	-	2.637
• Civ Pay Adjustments	0.000	0.000	0.121	-	0.121

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: SA1: *Sensors and Electronic Initiatives (CA)*		
Congressional Add: *Program Increase*	12.500	-
Congressional Add: *Space and High Altitude Assets Survivability*	7.500	-
Congressional Add Subtotals for Project: SA1	20.000	-
Congressional Add Totals for all Projects	20.000	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors and Electronic Survivability*	Project (Number/Name) H16 / *S3I Technology*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
H16: *S3I Technology*	-	20.605	19.599	16.890	-	16.890	17.323	17.031	18.640	19.021	-	-

A. Mission Description and Budget Item Justification

This Project designs, investigates, evaluates, and characterizes advanced sensor components, signal processing, and information fusion algorithms that will provide the future Soldier decisive new capabilities to locate, identify, and make decisions about and engage battlefield targets in tactical environments. The ultimate impact and utility of this work will be to greatly increase the lethality, range, and speed of engagement of the Soldier. Emphasis is on solving critical Army-specific battlefield sensing and information management problems, such as false targets, complex terrain (including urban applications), movement of sensors on military vehicles, and exploitation of multimodal sensors. Significant areas of research include low-cost networked sensors for force protection, hostile fire defeat, homeland defense, counter terrorism operations, munitions, and fusion of disparate sensors (e.g., acoustic, seismic, electric-field (E-field), magnetic field) to passively detect, classify, and track battlefield targets such as personnel, heavy/light vehicles, and helicopters. Other areas of research include sensing technologies for tagging, tracking, and locating (TTL) non-traditional targets and the location of direct and indirect fires and other hostile threats. Further areas of research include ultraviolet (UV) optoelectronics for battlefield sensors, networked compact radar for vehicle and dismount identification and tracking; ultra-wideband radar for buried and concealed threat detection, enhanced robotic mobility, stand-off characterization of infrastructure, and the detection, classification, and tracking of humans in urban terrain. Additional areas of research are aided/ automatic target recognition (ATR), advanced battlefield sensor and information processing to conduct a dynamic and real time situational assessment to present a common picture of the battlespace focused on low echelon commanders; protection of sensors, especially human eyes, from battlefield laser threats; and advanced computational methods to provide automatic information technologies from widely dispersed sensor and legacy information sources for improved situational awareness.

This Project supports Army Science and Technology efforts in the Command Control and Communications, Ground, and Soldier portfolios. The sensor-related work in this Project complements efforts funded in Program Element (PE) 0601104A (University and Industry Research Centers), PE 0602709A (Night Vision Technology), PE 0603710A (Night Vision Advanced Technologies), and PE 0603001A (Warfighter Advanced Technology). The networked sensing and data fusion efforts performed in this Project complement efforts funded in PE 0601104A / Project H50 (Network Sciences CTA) and PE 0601104A / Project J22 (Network Science and Technology Research Center CTA).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology priority focus areas.

Work in this area is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Non-Imaging Intelligence, Surveillance, and Reconnaissance (ISR) Sensing	5.292	4.675	6.014
Description: This effort designs and characterizes technologies for multi-modal (acoustic, seismic, infrasound, electric and magnetic (E/H) field, and passive radio frequency (RF)), low-cost networked sensors to enhance persistent sensing capabilities for			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** H16 / *S3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
increased probability of target detection and reduced false alarms. These combined sensors have unique capabilities that enable detection of electrical equipment operation, underground facilities, vehicles, weapons launch, gunfire, and explosions. ***FY 2016 Accomplishments:*** Developed advanced acoustic, magnetic- and electric-field sensors and arrays to detect and locate threats in complex environments; implemented algorithms to mitigate effects of acoustic propagation channel and signature modifications to optimize transient classification of mortar, rocket, gunfire and explosive events; applied electric and magnetic field phasor processing to detect and classify equipment and power events; and developed methods for detecting and classifying humans and human activities with multimodal image, video, and text data. ***FY 2017 Plans:*** Will develop sensor and processing algorithms to acoustically detect, track, and classify transients, vehicles, unmanned aerial systems (UAS), and infrasound sources, and integrate wind noise reduction and propagation error correction; develop electric- and magnetic-field phase measurements to extract target signatures in complex environments; develop sensors and methods to characterize device signatures and power events; and develop multi-modal processing algorithms to reliably detect targets in complex environments and under diverse environmental conditions. ***FY 2018 Plans:*** Will further improve acoustic and infrasound sensors and algorithms for detection, localization, tracking, and classification of air and ground platforms and transient weapon/explosive events; research geophysical/seismological sensing methods; will develop infrasound propagation data analysis, and a corresponding modeling/simulation capability; will develop acoustic techniques for locating of surface and subsurface events; will investigate and E/H fields from power-lines, electrical equipment, and Earth; will develop improved E/H-field sensors and algorithms; will improve size, weight, power and cost (SWaP-C) of monitoring nodes; provide persistent ISR and decision support capabilities to lower Army command echelons; will improve networked sensor coverage and probability of detection and false alarm rate with distributed processing and fusion techniques; will support information sharing and decision making and improve information density of sensor data streams; will improve Special Operations Command (SOCOM) mobility by developing (1) faster, quieter and more accurate Landing Zone assessment techniques with minimal over-watch and (2) a streamlined method of data input and analysis; and will characterize and assess technologies and sensor modalities that can detect and identify improvised explosive device systems and components that are buried or non-buried.			
Title: Networked Sensing and Data Fusion ***Description:*** This effort will develop and assess a concept to link physical sensors and information sources to Soldiers and small units. Specifically, the research focuses on (1) multi-modal sensor fusion for detection and classification of human activities and infrastructures such as personnel, vehicles, machinery, RF emissions, chemicals, and computers in hidden and confined spaces, (2) interoperability and networking of disparate sensors and information sources, (3) distributed information for decision-	3.626	5.506	5.137

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** H16 / *S3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
making, and (4) approaches for fusing results of processed outputs of multi-modal sensors, such as visible, infrared (IR), and hyperspectral imagers, and acoustic, magnetic, and electric field sensors. ***FY 2016 Accomplishments:*** Expanded tools to improve search capabilities of relevant social media data to fuse with sensor data; expanded interoperability for sensor plug-and-play capabilities and quick integration across unmanned sensors; designed algorithms that will exploit electric and magnetic field sensor fusion for electrical power event monitoring; and designed detection, tracking and cueing methodologies for counter-unmanned aircraft system (C-UAS) using fusion of acoustic, passive RF, and imaging modalities. ***FY 2017 Plans:*** Will research holistic approaches to networked sensor/data fusion by exploiting signatures in support of anti-personnel landmine alternatives (APL-A); research personnel and ground vehicle classification and anomaly determination algorithms using multi-modal sensors for robust, high confidence reports; research automatic human and vehicle activity classification in full motion video (FMV) and Wide Area Motion Imagery (WAMI); investigate a collaborative sensor environment to enhance data collection and collaborative design of fusion algorithms with the Army Cold Regions Research and Engineering Laboratory and the Air Force Research Laboratory. ***FY 2018 Plans:*** Will develop distributed processing and fusion algorithms that use shared decision-making processes over low-power, short-lifetime sensors with limited communication capabilities for efficient battlefield situational awareness to the dismounted Soldier; will develop sensor interoperability/integration standards to enable rapid cueing of coalition imaging and acoustic sensors for robust target classification; will develop robust methods to detect, classify, and track humans using networked, multi-modal sensing and fusion as an alternative replacement to anti-personnel landmines; will develop tools for creating and visualizing a multi-sensor three-dimensional (3D) common operating picture (COP) capable of performing real-time data geo-registration and fusion from multiple aerial and ground-based passive and active imaging sensors for increased situational awareness; and will develop tools for biometric and human activity recognition from video feeds.			
Title: RF Sensing for Concealed/Low-Signature Threat Detection (previously Ultra Wideband (UWB) Radar) ***Description:*** This effort develops the technical underpinnings of UWB radar and other active and passive RF sensing modalities for several key Army concealed and low-signature target detection requirements, including landmine and improvised explosive device (IED) detection, sensing through-the-wall, foliage penetration, UAS detection, other electronic threat detection, and obstacle avoidance for autonomous navigation. This research uses a combination of advanced computational electromagnetic models and algorithms, radar measurements, active and passive RF sensing technologies, and advanced signal processing techniques to define the performance boundaries of state-of-the-art airborne and ground-based UWB radar and other RF sensing modalities for concealed and low-signature target detection and classification.	3.419	1.794	2.713

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** H16 / *S3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Investigated utility of combining forward looking radar with electro-optical/infrared (EO/IR) sensor to improve detection and reduce false alarms for standoff detection of explosive hazards; incorporated stereo visible cameras to provide three-dimensional reconstruction of the environment that can be fused with radar image formation algorithms; and investigated and validated disturbed earth computational UWB forward-looking radar models. ***FY 2017 Plans:*** Will collect and assess new UWB stepped-frequency, radar standoff explosive hazard detection data sets to address radio frequency interference, clutter mitigation, and self-interference in relevant environments; combine and assess data with electro-optic/IR standoff detection sensor data sets to further reduce false-alarms associated with explosive hazard threat deployments; exploit two-dimensional (2D) and 3D reconstruction of the environment across standoff sensors and algorithms for improved performance; and develop exploitation algorithms for detection and discrimination of explosive hazards relating to forward-looking standoff radar. ***FY 2018 Plans:*** Will incorporate passive RF sensing modality with UWB radar to improve detection of electronic targets (e.g., radio controlled triggers); will assess performance of combined forward-looking sensors against relevant threat; develop a lightweight UAS-compatible RF sensor with equivalent sensitivity to a vehicle-mounted stepped frequency radar in order to increase standoff protection beyond the blast radius; will investigate an adaptive and learning (i.e., cognitive) electronic front-end that can be incorporated with a UWB radar that will improve operations in congested and contested RF environments; and will utilize low-cost software-defined radio (SDR) technology and 2D antenna arrays to detect, geo-locate, and track aerial- and ground-based electronic threats.			
Title: Laser Protection Technologies (previously Networked Compact Radar, Wide Bandgap Optoelectronics, and Laser Protection Technologies)	2.940	3.757	2.957
Description: This effort develops new materials and devices for the protection of Army sensors and eyes behind day-view optical sights from a variety of laser threats including high-power continuous wave and ultrashort (femto-second) pulsed lasers. This research utilizes a combination of technologies based on the nature of the different threats, as well as the fundamental differences in sensors operating over different frequency ranges. Passive organic and inorganic optical limiter materials that block specific frequency bands of light will be investigated and developed for the visible and short-wave infrared (SWIR) spectrum, and active man-made material-based solutions will be investigated for uncooled sensors in the long-wave IR (LWIR). Vulnerability of sensors and optical sensor systems will be studied against high-power and ultrashort pulsed laser threats to determine protection requirements.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** H16 / *S3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Studied and characterized non-linear optical materials (including two novel platinum bipyridine complexes and several iridium dyes) for eye and camera protection on mounted ground vehicle platforms and investigated active long wavelength protection filters for uncooled infrared cameras and focal plane arrays to reduce their vulnerability to damage and dazzle. ***FY 2017 Plans:*** Will develop exploitation algorithms for detection and discrimination of explosive hazards relating to forward-looking standoff radar, design distributed and decentralized algorithms using consensus methods of networked sensors for a moving ground vehicle, and determine the improvement in ground vehicle tracking accuracy and efficiency versus conventional centralized approaches; research advanced active protection techniques and new non-linear optical materials based on results for bipyridine and iridium dye experiments, to increase protection against laser-induced damage of eyes and cameras in wavelength ranges from visible through shortwave IR; perform studies and create UV sources (e.g., light-emitting diodes and lasers) with output power greater than 20 mW in the wavelength range of 200-290 nm, and photodetectors with single-photon detection capability across the ultra violet (UV) spectral range for Army applications including water sterilization, non-line-of-sight communications, and chemical-biological detection. ***FY 2018 Plans:*** Will investigate the use of short-pulsed (femto-second) optical limiting materials to prevent sensor damage, and determine if some of the secondary destructive effects of these types of pulses can be mitigated; will develop and test solid material limiters for nanosecond to microsecond threats and compare their performance to liquid material limiters; and will explore advanced concepts to protect optical systems, both visible and IR, from high-power continuous wave lasers.			
Title: Multi-Mode Air Defense Radar ***Description:*** This research supports the current and future technical challenges associated with air defense radar technology. In particular, this effort will analyze current and emerging RF spoofing, RF jamming, and RF signature management technologies to determine their impact on the performance of air defense radars. Electromagnetic modeling, RF measurements, and experiments will be used to identify mitigation techniques for spoofing and jamming, and to identify useful signature management technologies. This will also include research in electronic devices, sub-assembly design, and laboratory experiments to advance the state-of-the-art of air defense radars operating in contested electronic environments. ***FY 2016 Accomplishments:*** Modeled air targets to investigate multiband architectures, alternative spectrum configurations, and broadband apertures; investigated spectrum sensing algorithms specific to air defense radar bands (e.g., L-band thru X-band and beyond); and investigated novel tracking algorithms for rockets, artillery, and mortar targets for next generation air defense radar. ***FY 2017 Plans:***	5.328	3.867	0.069

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** H16 / *S3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will design and characterize multiband elements with integrated front-end radar components including the amplifier and mixer; validate electromagnetic models of both target and physical phenomenology; extract radar architecture and circuit requirements from assessments and simulations; and emulate cognitive algorithms for electronic protection in a contested RF environment. ***FY 2018 Plans:*** Will finalize and document electromagnetic modeling results, advanced circuit designs, and cognitive algorithm development work.			
Accomplishments/Planned Programs Subtotals	20.605	19.599	16.890

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: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors and Electronic Survivability*	Project (Number/Name) SA1 / *Sensors and Electronic Initiatives (CA)*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
SA1: *Sensors and Electronic Initiatives (CA)*	-	20.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Sensors and Electronic Initiatives.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** This is a Congressional Interest Item	12.500	-
Congressional Add: Space and High Altitude Assets Survivability ***FY 2016 Accomplishments:*** This is a Congressional Interest Item	7.500	-
Congressional Adds Subtotals	20.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors and Electronic Survivability*	Project (Number/Name) SA2 / *Biotechnology Applied Research*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
SA2: *Biotechnology Applied Research*	-	2.871	1.361	1.683	-	1.683	0.503	0.512	0.523	0.534	-	-

A. Mission Description and Budget Item Justification

This Project designs, develops and evaluates biotechnology with application to sensors, electronics, photonics, and network science. This Project funds collaborative applied research and integration of government, academic, and industry scientific research on biotechnology from Program Element (PE) 0601104/H05, Institute for Collaborative Biotechnologies (ICB) University Affiliated Research Center (UARC), to advance innovative capabilities. Areas of applied research include bio-array sensors, biological, and bio-inspired power generation and storage, biomimetics, proteomics, genomics, network science, deoxyribonucleic acid (DNA) research and development, and control of protein and gene expression.

The ICB is a collaborative effort led by the University of California, Santa Barbara (Santa Barbara, CA) in partnership with the California Institute of Technology (Pasadena, CA), the Massachusetts Institute of Technology (Cambridge, MA), the Army Laboratories and Research, Development and Engineering Centers, and the ICB industrial partners.

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology priority focus areas.

Work is performed by the Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Biotechnology Applied Research	2.871	1.361	1.683
Description: This effort exploits breakthroughs in biotechnology basic research accomplished at the ICB UARC to enable new capabilities in sensors, electronics, photonics, and network science.			
FY 2016 Accomplishments: Tested hybrid biofuel cells; developed and tested assays with advanced protein capture agents to validate capability to rapidly respond to emerging threats; evaluated bio-inspired algorithms for control applications including decision support tools to unburden unmanned aerial vehicle (UAV) operators; and conducted field evaluation of combined bio-inspired algorithms for distributed mobile gunfire detection.			
FY 2017 Plans: Will evaluate microbial communities for the generation of fuel for bio-hybrid fuel cells that can accept multiple types of fuel; develop, integrate, and assess pairs of advanced capture agents for threat materials and evaluate assays to validate capability to rapidly respond to emerging threats; evaluate bio-inspired algorithms for control applications including decision support tools			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** SA2 / *Biotechnology Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
for mounted soldiers; develop experimental platforms to evaluate bio-inspired protocols to unburden the cognitive load on UAV operators; and complete analysis of combined bio-inspired algorithms for distributed mobile gunfire detection. ***FY 2018 Plans:*** Will integrate microbial communities for the conversion of waste and indigenous feedstocks or simulants to chemicals useful for waste-to-energy systems and starting materials for agile materials synthesis; will integrate biological and non-biological components to convert waste and indigenous feedstocks to chemicals potentially useful for bio-hybrid fuel cells, and evaluate them for transition to waste-to-energy / alternative energy development programs; and will investigate components of a high-throughput platform for on-demand assay development for robust biosensor reagents.			
Accomplishments/Planned Programs Subtotals	2.871	1.361	1.683

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: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors and Electronic Survivability*	Project (Number/Name) TS1 / *Tactical Space Research*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
TS1: *Tactical Space Research*	-	5.578	6.702	7.032	-	7.032	2.611	4.444	3.875	3.812	-	-

A. Mission Description and Budget Item Justification

This Project researches, evaluates, and adapts technologies for space-based and high altitude applications for Army tactical ground forces. Applied research efforts include the design and development of sensors and electronic components for communications, signal and information processing, target acquisition, position/ navigation, and threat warning within space and high altitude environments. The applied research and technology evaluations conducted under this Project leverage other Department of Defense (DoD) space science and technology applications to support Army space force enhancement and cooperative satellite payload development.

Work in this Project complements and is fully coordinated with Program Element (PE) 0603006A (Space Applications Technology).

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology priority focus areas and the Army Warfighting Challenges.

Work in this Project is performed by the Army Space and Missile Defense Command/Army Forces Strategic Command (SMDC/ARSTRAT) in Huntsville, AL.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Tactical Space Research	4.557	5.664	5.921
Description: This effort designs, develops, and evaluates space-based technologies, components, and tools that lead to smaller, lighter, more responsive payloads and applications. These technologies allow for the rapid integration and development of tactical payloads in support of responsive space environments. Work related to standard Army networks is done in coordination with the Communications-Electronics Research Development and Engineering Center (CERDEC) and Army Cyber Center of Excellence.			
FY 2016 Accomplishments: Investigate and develop network hardware and software interfaces and information dissemination architecture that allows Software Defined Radio (SDR) and imagery payloads to be controlled from any node and products distributed to tactical ground units; develop follow-on small satellite antenna and guidance, navigation, and control (GNC) components that have less mass, are more accurate, and are more power efficient; and investigate technologies and explore collaboration opportunities with other Services and Agencies for small satellite affordable launch capabilities.			
FY 2017 Plans: Will design and develop small satellite components to support the Army's Warfighter Information Network – Tactical (WIN-T); develop data processing algorithms and network integration interfaces to improve Army tracking and locating capabilities for			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** TS1 / *Tactical Space Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
ground objects of interest; investigate satellite-to-satellite communications components to reduce forward-deployed ground control station requirements by enabling control of beyond-line-of-sight satellites and continue to explore collaboration opportunities with other Services and Agencies for small satellite affordable launch capabilities. ***FY 2018 Plans:*** Design and develop small satellite components to support the Army's multi-band beyond-line-of-sight (BLOS) and on-the-move comms for disadvantaged users; refine data processing algorithms and define network integration interfaces to improve Army tracking and locating capabilities for ground objects of interest; initial accreditation of network used to verify satellite command and control capabilities and conduct experiments with on orbit demonstration satellites, as well as incremental advances in capabilities to incorporate additional science and technology (S&T) satellite technology efforts; and continue to monitor collaboration opportunities with other Services and Agencies on small satellite and affordable launch capabilities.			
Title: Space and Analysis Lab ***Description:*** This effort provides an in-house capability to design and conduct analytic evaluations of space and high altitude technologies. ***FY 2016 Accomplishments:*** Developed components for follow-on small satellite designs, to include propulsion and distributed aperture imager components. ***FY 2017 Plans:*** Will continue small satellite design and assess capabilities through the use of in-house distributed bench assessment and Hardware In The Loop capabilities. ***FY 2018 Plans:*** Complete the development of experimental small satellite payloads and prepare for integration on flight vehicle; validate capabilities through the use of in-house distributed bench assessment and Hardware In The Loop capabilities.	1.021	1.038	1.111
Accomplishments/Planned Programs Subtotals	5.578	6.702	7.032

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** TS1 / *Tactical Space Research*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors and Electronic Survivability*	Project (Number/Name) TS2 / *Robotics Technology*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
TS2: *Robotics Technology*	-	8.148	8.447	10.125	-	10.125	9.445	9.631	9.824	10.025	-	-

A. Mission Description and Budget Item Justification

This Project designs, evaluates, and investigates autonomous technologies to enable robotics to assist military missions. Technical efforts are focused on advancing perception for autonomous ground and air mobility, intelligent vehicle control and behaviors, human-robot interaction, robotic manipulation, and improved mobility for unmanned vehicles of scales from micro-systems through tactical combat vehicles. The Project provides the underpinning research of the Robotics Collaborative Technology Alliance (CTA), a cooperative arrangement with industry and academia to conduct a concerted, collaborative effort advancing key enabling robotic technologies required for future unmanned systems. The Robotics CTA research is funded in Program Element (PE) 0601104A/Project H09.

This Project sustains Army Science and Technology efforts supporting the Air and Ground Maneuver portfolios.

This Project leverages basic research conducted under PE 0601102A/Project T63 (Robotics Autonomy, Manipulation and Portability) and PE 0601104A/Project H09 (Robotics CTA) and transitions knowledge and emerging technologies to PE 0603005A (Combat Vehicle and Automotive Advanced Technology) for maturation and demonstration.

The cited work is consistent with the Assistant Secretary of Defense for Research and Engineering Science and Technology focus areas, and the Army Modernization Strategy.

Work in this Project is performed by the Army Research Laboratory (ARL) at the Aberdeen Proving Ground, MD, and the Robotics Collaborative Technology Alliance consisting of Carnegie Mellon University, Florida State University, General Dynamics Robotics Systems, Jet Propulsion Laboratory, QinetiQ North America, University of Central Florida, and University of Pennsylvania.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Robotics CTA	3.512	3.811	4.023
Description: Conduct applied research to provide essential capabilities for advanced perception, intelligent control and tactical behavior, human-robot interaction, robotic manipulation, and unique mobility for unmanned systems to conduct multiple military missions for a full range of robots from man-portable to larger systems. Research focuses on new sensor and sensor processing algorithms for rapid detection and classification of objects in cluttered and unknown environments, enabling autonomous mobility and intelligent tactical behavior by future unmanned systems; implementing adaptive control strategies that will enable unmanned systems to display intelligent tactical behavior, formulation of control strategies that will facilitate use of unmanned systems in populated environments and minimize the cognitive workload on Soldier operators enabling more dexterous manipulation of objects.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** TS2 / *Robotics Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Instantiate enhanced hybrid cognitive architecture on robots to explore teaming behaviors including natural modes of communication and control in the context of a mixed small unit; incorporate mechanisms and software to permit robots to effectively perform basic manipulation skills; integrate resultant technology into test bed platforms to assess technology maturity. The hybrid architecture permits command and communication to be at a natural or abstract level similar to a Soldier issuing a command (e.g., open the third door on the right) to a subordinate. ***FY 2017 Plans:*** Will incorporate advanced algorithms for reasoning, learning, and multi-modal communication between human and robot into existing architecture and conduct virtual and live experiments to determine limits of performance; expand implantation of the architecture for whole body manipulation that efficiently utilizes interaction with objects in an environment to mimic capabilities of biological systems. ***FY 2018 Plans:*** Will instantiate full capability for an unmanned ground robot Talon and below size) to conduct a simplified, yet realistic military mission at less than human operational speed, including perceptual, mobility, and manipulation capabilities. ARL plans on near-field recognizance to demo technology with applicability to multiple Research, Development and Engineering Center (RDEC) demos for ground platforms (e.g, convoy operations, tactical logistics, Intelligence, Surveillance, and Reconnaissance (ISR)). Will conduct a performance assessment with the aim of transition to concept demonstrations conducted by an Army Research, Development and Engineering Center (RDEC).			
Title: Perception and Intelligent Control	4.636	4.636	4.640
Description: Advance perception and intelligent control technologies required to achieve autonomous tactical behaviors, based on the environment,and other objective capabilities for future unmanned vehicles of multiple size scales and to transition this technology to advanced development programs being conducted under PE 0603005A (Combat Vehicle and Automotive Advanced Technology)/Project 515 (Robotic Ground Systems) for integration into test bed systems. ***FY 2016 Accomplishments:*** Continued extension of perceptual, reasoning, and learning techniques for unmanned systems to enable creation of a common, though not necessarily equivalent, mental model of the surrounding world facilitating planning and execution of tasks, as well as communication with human teammates; and conducted experiments focused upon establishing technology maturity and performance gaps. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors and Electronic Survivability*	**Project (Number/Name)** TS2 / *Robotics Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will incorporate initial perceptual, reasoning, and learning capabilities into a comprehensive architecture and conduct both virtual and live experiments; explore concepts for whole body manipulation and hybrid mobility modes in simulation and live experimentation; instantiate intelligent control architecture into appropriate virtual environment and on appropriate surrogate unmanned air and ground systems; and explore initial behaviors for manned-unmanned teaming and for manipulation of objects by unmanned air and ground systems. ***FY 2018 Plans:*** Will expand the perceptual, reasoning, and learning capabilities into a comprehensive architecture and conduct experimentation. Will utilize a cognitive construct for abstract reasoning to more effectively integrate individual perceptual algorithms together with contextual information.			
Title: Ground Robotic Vehicle Mobility and Propulsion Technology ***Description:*** Advance the speed and agility of unmanned vehicles in complex three-dimensional environments through exploration of advanced and unconventional mobility and propulsion technologies integrated with innovative application of perceptual and reasoning capabilities. Ground robotic platforms may have legs, may be able to climb or may even be robots restricted to small confined spaces. Research will focus on developing actuation mechanism that intelligently achieve movement while minimizing the use of energy to ensure longer range and endurance of the system. ***FY 2018 Plans:*** Will explore hybrid modes of mobility to enable energy efficient mobility at operational tempo.	-	-	1.462
Accomplishments/Planned Programs Subtotals	8.148	8.447	10.125

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A