Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army											Date: February 2018	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602120A / *Sensors & Electronic Survivability*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	50.574	35.730	32.366	-	32.366	31.106	32.339	32.858	33.515	0.000	248.488
H16: *S3I Technology*	-	19.589	16.890	19.423	-	19.423	17.031	18.640	19.021	19.401	0.000	129.995
SA1: *Sensors and Electronic Initiatives (CA)*	-	15.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	15.000
SA2: *Biotechnology Applied Research*	-	1.327	1.683	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.010
TS1: *Tactical Space Research*	-	6.482	7.032	3.498	-	3.498	4.444	3.875	3.812	3.888	0.000	33.031
TS2: *Robotics Technology*	-	8.176	10.125	9.445	-	9.445	9.631	9.824	10.025	10.226	0.000	67.452

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 SA1 (Congressional Interest Item) focuses on the design and development of Assured Positioning, Navigation, and Timing, and Robust Communications technologies for the Warfighter in disadvantaged/degraded environments. 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 in this PE is performed by the Army Research Development and Engineering Command (RDECOM)

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Army	Date: February 2018
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602120A *I Sensors & Electronic Survivability*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	36.109	35.730	29.882	-	29.882
Current President's Budget	50.574	35.730	32.366	-	32.366
Total Adjustments	14.465	0.000	2.484	-	2.484
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	15.000	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.529	-			
• Adjustments to Budget Years	-	-	2.484	-	2.484
• FFRDC	-0.006	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: SA1: *Sensors and Electronic Initiatives (CA)*		
Congressional Add: *Program Increase*	5.000	-
Congressional Add: *Space and Small Satellites Technologies Demonstration*	7.000	-
Congressional Add: *Signals Detection Research*	3.000	-
Congressional Add Subtotals for Project: SA1	15.000	-
Congressional Add Totals for all Projects	15.000	-

Change Summary Explanation

FY17 Congressional increase in SA1 Sensors and Electronic Survivability

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors & Electronic Survivability*	Project (Number/Name) H16 / *S3I Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
H16: *S3I Technology*	-	19.589	16.890	19.423	-	19.423	17.031	18.640	19.021	19.401	0.000	129.995

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 battle space 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 J15 (Network Science and Technology Research Center International Technology Alliance).

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Non-Imaging Intelligence, Surveillance, and Reconnaissance (ISR) Sensing	4.675	6.014	6.169
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 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 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors & Electronic Survivability*	**Project (Number/Name)** H16 / *S3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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; develop infrasound propagation data analysis, and a corresponding modeling/simulation capability; develop acoustic techniques for locating of surface and subsurface events; investigate and E/H fields from power-lines, electrical equipment, and Earth; develop improved E/H-field sensors and algorithms; improve size, weight, power and cost (SWaP-C) of monitoring nodes; provide persistent Intelligence, Surveillance, and Reconnaissance (ISR) and decision support capabilities to lower Army command echelons; improve networked sensor coverage and probability of detection and false alarm rate with distributed processing and fusion techniques; support information sharing and decision making and improve information density of sensor data streams; 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 characterize and assess technologies and sensor modalities that can detect and identify improvised explosive device systems and components that are buried or non-buried. ***FY 2019 Plans:*** Will develop robust, low-cost acoustic sensors with 1 to 10000 Hz frequency response to detect and locate Army-relevant target signals in environments of interest; will focus on sensor miniaturization and small arrays; will develop novel wind noise reduction techniques that are necessary for successful particle-velocity sensor operation in complex military scenarios and on mobile platforms; will develop new tools to calibrate and characterize quasi-static E/H field sensors for long-wavelength applications, such as power-line sensing, anomaly detection, and low-frequency positioning/navigation/timing; will develop novel detection, classification, and identification algorithms for new classes of targets; will characterize and assess technologies and sensing modalities that can detect and identify improvised explosive threats, detect their components, and mitigate their delivery platforms; and will develop and integrate automated multi-modal detection, tracking, classification and decision support tools for deployment on low resource tactical platforms, ground stations and sensors. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increased funding to develop multi-modal detection and tracking capabilities			
Title: Networked Sensing and Data Fusion	5.496	5.137	4.633
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, radio frequency (RF) emissions, chemicals, and computers in hidden and confined spaces, (2) interoperability and networking of disparate sensors and information sources, (3) distributed information for decision-making, and (4) approaches for fusing results of processed outputs of multi-modal sensors, such as visible, infrared (IR), and hyperspectral imagers, and acoustic, magnetic, and electric field sensors. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors & Electronic Survivability*	**Project (Number/Name)** H16 / *S3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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; develop sensor interoperability/integration standards to enable rapid cueing of coalition imaging and acoustic sensors for robust target classification; develop robust methods to detect, classify, and track humans using networked, multi-modal sensing and fusion as an alternative replacement to anti-personnel landmines; 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 develop tools for biometric and human activity recognition from video feeds. ***FY 2019 Plans:*** Will develop focused infrasonic classification methods and integrate them with long-range sound propagation models to increase classification accuracy; will develop algorithms to provide automated tipping and cueing at each sensor array for incorporation into the analyst?s common operating picture; will develop tools for creating and visualizing a multi-sensor 3D common operating picture for real-time data geo-registration and fusion of heterogeneous data from multiple aerial and ground-based passive and active imaging sensors for increased situational awareness; will develop tools for multimodal biometrics and human activity recognition using unconstrained video; will explore scene representation models for optimized, real time implementation; will develop theory for inference and subjective networks that benchmark performance against other uncertain reasoning methods; will develop higher level fusion of event tracking from sensor and social media data in uncertain environments via subjective logic Bayesian networks; and will develop robust capability for communications, sensors and data management and information fusion for a large network of ground sensors. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Decreased funding due to maturity of signal processing algorithms to support multi-mode air defense radar			
Title: RF Sensing for Concealed/Low-Signature Threat Detection (previously Ultra Wideband (UWB) Radar) ***Description:*** This effort develops the technical underpinnings of ultra-wideband (UWB) radar and other active and passive radio frequency (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, unmanned aerial system (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. ***FY 2018 Plans:***	1.794	2.713	2.967

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors & Electronic Survivability*	**Project (Number/Name)** H16 / *S3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Incorporate passive RF sensing modality with UWB radar to improve detection of electronic targets (e.g., radio controlled triggers); 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; 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 utilize low-cost software-defined radio (SDR) technology and 2D antenna arrays to detect, geo-locate, and track aerial- and ground-based electronic threats. ***FY 2019 Plans:*** Will reduce sensor size with on-board signal processing for automated detection and tracking; will investigate the benefits of cooperative RF sensing in complex environments; and will assess the processing constraints introduced by distributed sensing. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increased funding to shift program focus towards distributed sensing			
Title: Laser Protection Technologies (previously Networked Compact Radar, Wide Bandgap Optoelectronics, and Laser Protection Technologies) ***Description:*** This effort develops new materials and devices for the protection of Army sensors and eyes behind day-view optical sights from a variety of laser threats 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 2018 Plans:*** 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; develop and test solid material limiters for nanosecond to microsecond threats and compare their performance to liquid material limiters; and explore advanced concepts to protect optical systems, both visible and infrared (IR) high-power continuous wave lasers. ***FY 2019 Plans:*** Will improve multi-chromophore solid-state optical limiter based on previous experimental results; will investigate femtosecond limiter concepts in the mid-wave infrared; and will conduct experiments to validate high power continuous wave laser protection	3.757	2.957	5.154

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors & Electronic Survivability*	**Project (Number/Name)** H16 / *S3I Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
concepts. These combined efforts will enable transmission of low light intensities, while blocking laser radiation with excessively high irradiance hence preventing sensor damage. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increased funding in laser protection technologies to develop limiter solutions for reducing light transmission intensities			
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 radio frequency (RF) spoofing, RF jamming, and RF signature management technologies to determine their impact on the performance of air defense radars. Electromagnetic modeling, RF measurements, and experiments will be used to identify mitigation techniques for spoofing and jamming, and to identify useful signature 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 2018 Plans:*** Finalize and document electromagnetic modeling results, advanced circuit designs, and cognitive algorithm development work. ***FY 2019 Plans:*** Will adapt front end RF technologies for next generation fires radars. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increased investments to enable development of scalable, multi-band RF components that can survive congested spectral environments	3.867	0.069	0.500
Accomplishments/Planned Programs Subtotals	19.589	16.890	19.423

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors & Electronic Survivability*	Project (Number/Name) SA1 / *Sensors and Electronic Initiatives (CA)*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
SA1: *Sensors and Electronic Initiatives (CA)*	-	15.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	15.000

Note

Congressional Increase for FY17

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Sensors and Electronic Initiatives.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018
Congressional Add: Program Increase ***FY 2017 Accomplishments:*** N/A	5.000	-
Congressional Add: Space and Small Satellites Technologies Demonstration ***FY 2017 Accomplishments:*** N/A	7.000	-
Congressional Add: Signals Detection Research ***FY 2017 Accomplishments:*** N/A	3.000	-
Congressional Adds Subtotals	15.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors & Electronic Survivability*	Project (Number/Name) SA2 / *Biotechnology Applied Research*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
SA2: *Biotechnology Applied Research*	-	1.327	1.683	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	3.010

Note

This project ends in FY18.

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Biotechnology Applied Research	1.327	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 2018 Plans: 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; 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 investigate components of a high-throughput platform for on-demand assay development for robust biosensor reagents. Effort completes in FY 2018 and transitions to an Army Research, Development and Engineering Center (RDEC) partner to mature this research.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors & Electronic Survivability*	**Project (Number/Name)** SA2 / *Biotechnology Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Project ends and transitions in FY18			
Accomplishments/Planned Programs Subtotals	1.327	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: PB 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors & Electronic Survivability*	Project (Number/Name) TS1 / *Tactical Space Research*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
TS1: *Tactical Space Research*	-	6.482	7.032	3.498	-	3.498	4.444	3.875	3.812	3.888	0.000	33.031

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Tactical Space Research	5.444	5.916	2.371
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 2018 Plans: Design and develop small satellite components to support the Army?s multi-band beyond-line-of-sight (BLOS) and on-the-move communications 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 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.			
FY 2019 Plans: Will refine tag, track and locate capabilities for ground objects of interest, advance space-based data exploitation technologies and components, space-based signal detection/processing/dissemination technologies, and software algorithms to enable cohesive exploitation from single or multiple small satellite platforms. Will design and refine small satellite/payload components focused on			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors & Electronic Survivability*	**Project (Number/Name)** TS1 / *Tactical Space Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
the improvement of warfighter tag, track, and location capabilities to include planning for tasking, processing, exploitation, and dissemination. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** In FY 2019, funds from this effort are realigned to support the Army Modernization Priorities.			
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 2018 Plans:*** Complete the development of experimental small satellite payloads and prepare for integration on flight vehicle; and validate capabilities through the use of in-house distributed bench assessment and Hardware In The Loop capabilities. ***FY 2019 Plans:*** Will develop in-house research capabilities for small satellite/payload and component design, development and validation for tactical spacecraft; and will assess new technologies for spacecraft components. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funding increased due to inflation.	1.038	1.116	1.127
Accomplishments/Planned Programs Subtotals	6.482	7.032	3.498

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 2019 Army			Date: February 2018
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602120A / *Sensors & Electronic Survivability*	Project (Number/Name) TS2 / *Robotics Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
TS2: *Robotics Technology*	-	8.176	10.125	9.445	-	9.445	9.631	9.824	10.025	10.226	0.000	67.452

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. The Ground Portfolio technology investments are improving logistics throughput and surge capability supporting maneuver forces (Leader-Follower technology) and allow experimentation with manned and unmanned teams to develop the advantages that inform/protect the maneuver force..

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Robotics CTA	3.540	4.023	3.317
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.			
FY 2018 Plans: 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. Planning on near-field			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602120A / *Sensors & Electronic Survivability*	**Project (Number/Name)** TS2 / *Robotics Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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)). Conduct a performance assessment with the aim of transition to concept demonstrations conducted by an Army Research, Development and Engineering Center (RDEC). ***FY 2019 Plans:*** Will demonstrate cognitive architecture with the integrated capabilities of perception, intelligent control and tactical behavior, human-robot interaction, robotic manipulation, and unique mobility. A limbed robot employing dynamic locomotion solely through electromotive rotary actuators will be assessed with the Robotics collaborative technology alliance (CTA) cognitive architecture for autonomous capability. Perception and intelligence for a dynamic limbed platform will be demonstrated to show its capacity for teaming in an optempo scenario. Whole body manipulation will be employed in conjunction with the cognitive architecture to demonstrate the ability to perform environment interactions autonomously in ad hoc scenarios. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Funds realigned to higher priority areas.			
Title: Perception and Intelligent Control ***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 2018 Plans:*** Expand the perceptual, reasoning, and learning capabilities into a comprehensive architecture and conducting experimentation. Utilize a cognitive construct for abstract reasoning to more effectively integrate individual perceptual algorithms together with contextual information. ***FY 2019 Plans:*** Will integrate a map-based and an ontology focused World Model to provide a more complete architecture for reasoning and understanding the environment. Cognitive approaches to perception will be implemented on robotic platforms and methods for artificial intelligence assessment will be employed to ensure future unmanned systems can offer transparency in their cognitive processes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY19 funding reduced due to less design time needed	4.636	4.640	4.662
Title: Ground Robotic Vehicle Mobility and Propulsion Technology	-	1.462	1.466

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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:*** Explore hybrid modes of mobility to enable energy efficient mobility at operational tempo. ***FY 2019 Plans:*** Will explore novel mechanics and perception/proprioception technology to enable robust, resilient, and self-sustaining mobility of ground vehicle platforms. Research will be conducted in embedded and inherent sensing, actuation, control of complex structural dynamics, and cognitive/perceptual architectures. Embedded and inherent sensing will also be investigated as a technique to enable locally-controlled reflexive and intuitive behaviors. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase due to inflation.			
Accomplishments/Planned Programs Subtotals	8.176	10.125	9.445

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A