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 0602782A *I Command, Control, Communications 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
Total Program Element	-	36.396	33.123	55.003	-	55.003	49.895	44.840	36.143	34.826	0.000	290.226
779: *Command, Control And Platform Electronics Tech*	-	15.835	12.837	11.148	-	11.148	13.426	13.959	12.228	12.473	0.000	91.906
CY2: *Applied Defensive Cyber*	-	0.000	0.000	8.267	-	8.267	9.423	9.533	9.714	9.908	0.000	46.845
H92: *Communications Technology*	-	20.561	20.286	35.588	-	35.588	27.046	21.348	14.201	12.445	0.000	151.475

A. Mission Description and Budget Item Justification

This Program Element (PE) researches and investigates communications, mission command (MC), and electronics components, sub-components, software and protocols that provide the Army with enhanced capabilities for secure, mobile, networked communications, assured information delivery, and presentation of information that enables decision-making. Commercial technologies are continuously investigated and leveraged where possible. Project 779 researches and develops MC software, algorithms, protocols, architectures, and devices that enable management of information across the tactical and strategic battle space; provides automated cognitive reasoning and decision making aids; allows timely distribution, presentation/display and use of MC data on Army platforms; and researches alternatives to Global Positioning System (GPS) for positioning, navigation and timing. Project CY2 investigates cyber electromagnetic activities (CEMA), cyber security devices, software and techniques to harden wireless communications networks against cyber-attacks and new mobile networking protocols that afford resilience within our networks to autonomically 'fight through' and/or evade hostile cyber effects. Project H92 supports research in communications components, software, algorithms and protocols, which allow field commanders to communicate on-the-move to/from virtually any location, through a seamless, secure, self-organizing, self-healing network.

Work in this PE complements PE 0601104A (University and Industry Research Centers), PE 0602270A (Electronic Warfare Technology) , PE 0602705A (Electronics and Electronic Devices), PE 0603270A (Electronic Warfare Technology), PE 0603772A (Advanced Tactical Computer Science and Sensor Technology), and PE 0603794A (Command, Control and Communications Advanced Technology), and is coordinated with PE 0601104A (University and Industry Research Centers), PE 0602120A, (Sensors and Electronic Survivability), PE 0602783A (Computer and Software Technology), and PE 0602874A (Advanced Concepts and Simulation).

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), Aberdeen Proving Ground, MD.

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 0602782A *I Command, Control, Communications Technology*

B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	37.803	33.123	37.798	-	37.798
Current President's Budget	36.396	33.123	55.003	-	55.003
Total Adjustments	-1.407	0.000	17.205	-	17.205
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.389	-			
• Adjustments to Budget Years	-	-	17.205	-	17.205
• FFRDC	-0.018	-	-	-	-

Change Summary Explanation

Increases in this Program Element support the Army's Modernization priority for Network/ Command, Control, Communications and Intelligence (C3I).

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018

Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602782A I Command, Control, Communications Technology	Project (Number/Name) 779 I Command, Control And Platform Electronics Tech

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
779: Command, Control And Platform Electronics Tech	-	15.835	12.837	11.148	-	11.148	13.426	13.959	12.228	12.473	0.000	91.906

A. Mission Description and Budget Item Justification

This Project researches moveable and mobile command post hardware and other components, software and algorithms that enable commanders at all echelons to have more accurate, useful, and timely information and allows them to execute mission command (MC) from anywhere on the battlefield. Emphasis is on advancements to MC computing platforms, with a specific emphasis on positioning, navigation, and timing (PNT); user/computing platform interaction and cognitive burden reduction; informed operations; and commander-centric capabilities, including using automation to augment or supply staff capabilities. This Project researches technologies that support multi-modal man-machine interaction, battle space visualization, positioning and navigation in degraded environments (poor Global Positioning System (GPS) performance), automated cognitive decision aids, real-time collaborative tactical planning tools, open system architectures, and integration concepts which contribute to more efficient expeditionary and uninterrupted operations.

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 Priority for Network/C3I.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2017	FY 2018	FY 2019
Title: Assured Positioning, Navigation, and Timing (A-PNT) **Description:** This effort investigates positioning, navigation and timing sensor and sensor integration technologies to provide position, velocity, and time information to support operational and training requirements, especially in global positioning system (GPS) denied/degraded environments. This effort also designs Position, Navigation and Timing (PNT) modeling and simulation (M&S) architectures, frameworks and models. Work being accomplished under Program Element (PE) 0603772A/Project 101 complements this effort. **FY 2018 Plans:** Investigate new methods of time transfer and novel ways to reduce size, weight and power for micro autonomous pseudolites to create expendable pseudolites that minimize the risks resulting from compromised assets; conduct research on machine learning concepts applied to navigation of autonomous vehicles to improve an autonomous vehicle?s localization and movement through a complex environment over time; continue investigation through an iterative process of design, fabrication, and test for size and performance improvements to miniature inertial sensors to augment PNT in GPS denied environments; complete validation of the use of Multi Global Navigation Satellite Systems signals (signals from foreign nation navigation satellite systems) in military applications; investigate new signals of opportunity for augmenting positioning and timing solutions on the battlefield; research dismounted anti-jam (AJ) technologies, such as wearable fabric antenna systems; explore potential applications for leveraging the new M-Code GPS signal for offensive and defensive navigation warfare operations; and develop models of PNT sensors,	5.690	7.313	6.445

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 0602782A / *Command, Control, Communications Technology*	**Project (Number/Name)** 779 / *Command, Control And Platform Electronics Tech*	

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019**
systems, and platforms and conduct simulations of operational scenarios to support Department of Defense (DoD) analysis of the behaviors of PNT devices and the effects these sensors have on the capabilities of United States (U.S.) forces, especially under GPS challenged conditions. *FY 2019 Plans:* Will research and investigate new and novel GPS-independent sensors; investigate innovative ways to use exiting PNT sensors; design and develop sensor fusion algorithms; develop portable sensor fusion core, allowing for a platform-agnostic solution for navigation in GPS denied or degraded environments that can be tailored based on mission or size, weight and power (SWAP) requirements; develop interfaces for GPS independent sensors, allowing connectivity with the portable sensor fusion core; continue investigation of miniature inertial sensors to augment PNT in GPS denied environments; continue research involving LIDAR odometry, visual navigation, and map building as potential sensor packages for use with the sensor fusion core; investigate new signals of opportunity for augmenting positioning and timing solutions on the battlefield; continue to improve localization and movement of an autonomous vehicle using PNT sensors through a complex environment; and continue to develop models of PNT sensors and conduct simulations of operational scenarios, especially under GPS challenged conditions. *FY 2018 to FY 2019 Increase/Decrease Statement:* Decrease due to completion of Science and Technology Objective program completion. The program completed the investigation of technologies for alternative navigation.			
Title: Next Generation Mission Command Technologies *Description:* This effort investigates, designs and codes software to enable a uniform mission command (MC) capability and experience for the commander in the command post, on the move in vehicles, or dismounted, increases the situational awareness through software data architectures and algorithms that intelligently share data across low bandwidth networks and across dismounted, mounted and command post platforms, and improves decision making capacity across the battlefield by using software knowledge representation to model mission, enabling artificial intelligence techniques to use the model to automate staff tasks, correlate and analyze information and provide recommendations. Work being accomplished under PE 0603772A/Project 101 complements this effort. In Fiscal Year 2019, funds in this effort are realigned to support the Army science and technology (S&T) priorities as identified at the December 2016 S&T Army Requirements Oversight Council by the Chief of Staff of the Army. *FY 2018 Plans:* Further research, in the second of a three year effort, to develop a software model that is a knowledge representation of a mission to enable automation of tasks such as developing course of action and staff assignment recommendations; research and develop a framework with standard interfaces that allows externally developed software to communicate with the mission model and leverage the data to perform real time analytics such as continuous power predictions for the mission; research and refine business process modeling technologies to assist users with dynamic and reusable workflows that align with the military	10.145	5.524	4.703

Exhibit R-2A, **RDT&E Project Justification:** PB 2019 Army		**Date:** February 2018
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602782A *I Command, Control, Communications Technology*	**Project (Number/Name)** 779 *I Command, Control And Platform Electronics Tech*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019**
decision making process or a unit?s standard operating procedures; and complete research and investigation of several artificial intelligence techniques including machine learning and intelligent agents that will be down selected and implemented in Fiscal Year (FY) 2019 and FY 2020 to assess the mission objectives and current situation to help with situational understanding by providing visualizations of how the situation is deviating from intent with continuous running estimates and an on-going analysis of risks and opportunities. *FY 2019 Plans:* Will investigate and leverage relevant research and technology in pattern matching and cognitive science; develop data-driven decision tools with pre-populated decision models, user directed machine learning, and machine directed human learning to enhance the speed of decision making in high operational tempo environments; design a software framework to allow the dynamic connection of information sources and sensors to decision tools; and develop and validate visualization techniques that supply increased situational awareness, understanding, and recommendations based on the primary, secondary, and third order effects of decisions through the identification of patterns detected in available battle-space data, resulting in improved decision cycles for commanders and staff. *FY 2018 to FY 2019 Increase/Decrease Statement:* Decrease to meet Army priority for Network/C3I.			
Accomplishments/Planned Programs Subtotals	15.835	12.837	11.148

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 I 2			R-1 Program Element (Number/Name) PE 0602782A I Command, Control, Communications Technology						Project (Number/Name) CY2 I Applied Defensive Cyber		

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
CY2: Applied Defensive Cyber	-	0.000	0.000	8.267	-	8.267	9.423	9.533	9.714	9.908	0.000	46.845

Note

Project funding was realigned in FY19 from Project H92, Communications Technology, to Project CY2, Applied Defensive Cyber. Funding was realigned in accordance with Volume 2B, Chapter 18, of the DoD Financial Management Regulation (FMR), requiring all "cyberspace activities" funding move into pure budget Projects.

A. Mission Description and Budget Item Justification

This Project investigates cyber electromagnetic activities (CEMA), cyber security devices, software and techniques to harden wireless communications networks against cyber-attacks and new mobile networking protocols that afford resilience within our networks to autonomically 'fight through' and/or evade hostile cyber effects. This Project also investigates and applies robust cyber security techniques and applications to advanced communications and networking devices, software, algorithms and protocols utilized within wireless tactical networks to protect against nation state level cyber effects and maintain Warfighter confidence in network information, resources, identities and mission partners by hardening the blue force attack surface.

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Defensive Cyber Operations	-	-	6.588

Description: This effort investigates and applies robust cyber security techniques and applications to advanced communications and networking devices, software, algorithms and protocols utilized within wireless tactical networks to protect against nation state level cyber effects and maintain Warfighter confidence in network information, resources, identities and mission partners by hardening the blue force attack surface. These capabilities will harden the attack surface by ensuring trustworthy software (SW), hardware (HW), information systems, communications and networks. This effort affords resilience within our networks to autonomically ?fight through? and/or evade hostile cyber effects and provide situational understanding (SU) to enable effective mission planning and execution. Work being accomplished under 0602782A/Project H92 and 0603794A/Project EL5 complements this effort, and this effort is fully coordinated with the Army Research Lab Cyber Security Collaborative Research Alliance, 0601104A/Project EA6. In FY19 this effort was moved from Project H92 per an Office of the Secretary of Defense directive to identify cyber investments in cyber unique Projects.

FY 2019 Plans:
Will research and validate cyber security technologies to improve the depiction, perception, and understanding of cyber space as it pertains to a commander?s operational environment to speed actionable decisions; will research cyber hardening methodologies for software, hardware, identities, and information to create trusted architectures and measures of provable

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 0602782A / Command, Control, Communications Technology	**Project (Number/Name)** CY2 / Applied Defensive Cyber

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
identity, pedigree, and provenance; will investigate robust built-in techniques that enable systems and networks to absorb, fight through, and adapt to adversary attacks; will research and design autonomic techniques, models and algorithms to support convergence of defensive cyber, offensive cyber, EW, and network/spectrum management information to improve decision response; will research and validate block-chaining methodologies to trace and validate pedigree of tactical information as it traverses the network; will research and validate robust non-intrusive identity authentication techniques that supports tactical access control; and will research models and algorithms that can provably determine a confidence factor associated with software vulnerability prioritization. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New Cyber project created in FY19 per an Office of the Secretary of Defense directive to identify cyber investments in cyber unique Projects.			
Title: Cyber Collaborative Research Alliance (CRA) ***Description:*** This effort will take innovative basic research theories from the Cyber Collaborative Research Alliance (CRA) and experimentally validate the hypothesis and create proof-of-concept defensive cyber software implementations. Work being accomplished under 0602782A/Project H92 complements this effort, and this effort is fully coordinated with the Army Research Lab Cyber Security Collaborative Research Alliance, 0601104A/Project EA6. In FY19 this effort was moved from Project H92 per an Office of the Secretary of Defense directive to identify cyber investments in cyber unique Projects. ***FY 2019 Plans:*** Will investigate and validate artificial intelligence and machine learning models and methods for reasoning on real time vulnerability prediction/analysis at a system-of-system perspective; will investigate use of modeling methodologies and techniques to capture and specify system properties (e.g., structural and behavioral), and will characterize cybersecurity attributes (e.g., confidentiality, integrity and availability); will investigate biological-inspired self-securing models and methods that can support capabilities to autonomously perform analytic monitoring, maintain dynamic representation, realign their resources as necessary, and be able to substantiate integrity; and will investigate models and methods that can estimate what likely impact a vulnerability will cause to a system or network based on incomplete and inaccurate data. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** New Cyber project created In FY19 per an Office of the Secretary of Defense directive to identify cyber investments in cyber unique Projects.	-	-	1.679
Accomplishments/Planned Programs Subtotals	-	-	8.267

C. Other Program Funding Summary ($ in Millions)

 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 0602782A / Command, Control, Communications Technology	**Project (Number/Name)** CY2 / Applied Defensive Cyber

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

 N/A

E. Performance Metrics

 N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army										Date: February 2018	
Appropriation/Budget Activity 2040 *I* 2				**R-1 Program Element (Number/Name)** PE 0602782A *I Command, Control, Communications Technology*					**Project (Number/Name)** H92 *I Communications 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
H92: *Communications Technology*	-	20.561	20.286	35.588	-	35.588	27.046	21.348	14.201	12.445	0.000	151.475

Note

Project funding was realigned in FY19 from Project H92, Communications Technology, to Project CY2, Applied Defensive Cyber. Funding was realigned in accordance with Volume 2B, Chapter 18, of the Department of Defense Financial Management Regulation (FMR), requiring all "cyberspace activities" funding move into pure budget Projects.

A. Mission Description and Budget Item Justification

This Project investigates and applies advanced communications and network devices, software, algorithms and services by leveraging and adapting commercial research and new communications and network sciences work by the Army Research Lab, Network Science Collaborative Technology Alliance or other Basic Research efforts. This Project leverages developments in wireless transport (e.g. mobile radio based communications systems) to design new techniques for improving communications in high radio frequency (RF) interference environments, such as in the presence of electronic warfare (EW), and to increase the communications capacity of terrestrial and satellite communications (SATCOM) systems. This Project also investigates antenna components, materials, designs and configurations to reduce the visual signature of antennas on Soldier, vehicular and airborne platforms and to reduce co-site interference on platforms with multiple transceivers, such as radios and jammers. Additionally, this Project investigates defensive cyber, cyber security devices, software and techniques to harden wireless communications networks against cyber attacks and new mobile networking protocols to make wireless, on-the-move (OTM) communications networks more responsive to user needs. Beginning in FY19 cyber efforts are being reported in Project CY2. This Project also investigates software and techniques that improve the ability of the Soldier to manage and maintain complex, dynamic networks; and it designs spectrum management software tools to make more efficient use of the congested RF spectrum. This Project also designs new technology and techniques to lower the size, weight, power and cost of networking systems deployed on Army platforms.

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Antenna and Hardware Technologies	3.293	-	-
Description: This effort investigates low cost, power efficient, conformal and directional antenna technologies for terrestrial, airborne, and tactical satellite communications (SATCOM) ground terminals to enable them to operate on-the-move (OTM) over multiple frequency bands, and it further investigates armor embedded antenna and distributed array technologies. Together these efforts will improve ground forces electronic protection, increase signal power and range and provide greater connectivity for both mounted and dismounted forces. Work being accomplished under Program Element (PE) 0602270A/project 906, PE 0603270A/ project K15 and PE 0603794A/Project EL4 complements this effort.			

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 0602782A / Command, Control, Communications Technology	**Project (Number/Name)** H92 / Communications Technology

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Communications, Adaptive Networks to Improve Maneuver Operations, formerly Networking to Improve Maneuver and Expeditionary Operations	-	4.508	15.205
Description: This effort investigates new capabilities to provide a range of robust, reliable, scalable, agile, interoperable and resource efficient communications capabilities to forces on the move. These capabilities allow forces to conduct maneuver operations, develop situational understanding, and sustain operations while maintaining freedom of movement.			
FY 2018 Plans: Research, brassboard, and conduct laboratory experiments on new short range wireless transmission technologies to improve performance and robustness of secure wireless personal area networks for on-Soldier sensors and ancillary devices; conduct studies, simulations, laboratory experiments and provide incremental enhancements to commercial wireless technologies, such as cellular Long Term Evolution (LTE), to adapt them for use in the tactical environment as a low cost and rapidly adaptive capability to the warfighter; conduct research, simulations and lab experiments for next generation terrestrial and SATCOM radios and code waveform protocols to conduct reliable communications in austere environments; conduct analysis, simulations and lab experiments to design and code networking protocols for network relays to be carried by autonomous systems and to optimize networking capabilities resulting from autonomous maneuvering of these relays on the battlefield; and conduct research, simulations and lab experiments to minimize the burden of network configurations and to visualize, gather information from and control all networked devices in the battlefield.			
FY 2019 Plans: Will design and develop exquisite local communication techniques with inherent low probability of interception/low probability of detection (LPI/LPD) characteristics and high frequency reuse for spectrum supportability; investigate use of non-traditional networking methods for high bandwidth needs; design and develop techniques to extend the range of waveforms with propagation limitations and challenges operating through obstruction blockages (e.g. foliage, building, etc.) for line of sight networking; investigate technology with large channel bandwidths that support high data-rate transfer; design and develop mature non-traditional transceiver components for increased capacity, and reduced interference; conduct experiments for high bandwidth, resilient communications for high data rate applications, with improved communications protection between nearby vehicles with LPI/LPD; investigate improved methods to adapt LPI/LPD techniques to mesh networks to counter contested threats in the spectrum environment; mature distributed dismounted beam forming algorithms that enable two distributed beam forming nets to communicate; design and develop an architecture, and related protocols, for secure connection onto existing or third party transport infrastructure; investigate methods to utilize existing networks that will increase available network bandwidth and provide access to resources through a local network topology in which infrastructure nodes cooperatively connect directly, dynamically, and non-hierarchically; begin the design and development of a system that integrates sensor data which is harvested from existing fielded receivers, and propagated across the network to enable improved situational understanding; design and develop components that will help incorporate future radio systems into the sensing architecture; develop data analytics			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 *I* 2	R-1 Program Element (Number/Name) PE 0602782A *I Command, Control, Communications Technology*	Project (Number/Name) H92 *I Communications Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
algorithms to identify, evaluate, and correlate specific events from available tactical and intelligence data, leveraging standard protocols and interfaces to current and future tactical receivers with associated visualization and data analytics tools; investigate components for low cost, unattended sensors that can be readily distributed ,then discarded, within an area of interest; develop interfaces and methods to use existing tactical radios and receivers; develop small, easily dispersible sensors to deliver large scale sensing over designated areas; develop data consolidation and sampling methods to minimize bandwidth use of large scale sensing devices available through tasking existing receivers. *FY 2018 to FY 2019 Increase/Decrease Statement:* Increase to meet Army priority for Network/C3I, including non-traditional waveform development , technologies for communications and mission command over non-tactical network infrastructures, and research development of components for low cost, dispersible unattended sensors that can be utilized to gain and maintain situational awareness of the status of the tactical network.			
Title: Tactical Information Assurance (IA) and Cyber Defense *Description:* This effort investigates, codes and fabricates software, algorithms and devices to protect wireless tactical networks against computer network attacks. Effort includes technologies that are proactive rather than reactive in countering attacks against tactical military networks. Work being accomplished 0603794A/Project EL5 complements this effort, and is fully coordinated with the Army Research Lab Cyber Security Collaborative Research Alliance, PE 0601104A/Project EA6.	6.396	-	-
Title: Communications Security *Description:* This effort researches technologies to improve the security posture of wired and wireless communications components, software and algorithms. Work being accomplished under 0603794A/ Project EL5 complements this effort.	3.717	-	-
Title: Defensive Cyber Operations, formerly Cyber/CEMA Operations *Description:* This effort investigates and applies robust cyber security techniques and applications to advanced communications and networking devices, software, algorithms and protocols utilized within wireless tactical networks to protect against nation state level cyber effects and maintain Warfighter confidence in network information, resources, identities and mission partners by hardening the blue force attack surface. These capabilities will harden the attack surface by ensuring trustworthy software (SW), hardware (HW), information systems, communications and networks. This effort affords resilience within our networks to autonomically ?fight through? and/or evade hostile cyber effects and provide situational understanding (SU) to enable effective mission planning and execution. Work being accomplished under 0602872A/Project CY2 and 0603794A/Project EL5 complements this effort, and this effort is fully coordinated with the Army Research Lab Cyber Security Collaborative Research Alliance, PE 0601104A/Project EA6. In FY19 this effort was moved to Project CY2 per an Office of the Secretary of Defense directive to identify cyber investments in cyber unique Projects.	-	7.596	-

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 0602782A / *Command, Control,* *Communications Technology*	**Project (Number/Name)** H92 / *Communications Technology*	

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Research and design cyber security technologies to improve situational awareness (SA) and SU of cyber threat correlated to mission impact across Cyberspace Electromagnetic Activities (CEMA) elements to enable actionable decisions, and enable self-defending qualities within Army networks that can absorb, deflect, evade, and deceive adversarial cyber actions; research and conduct experiments on robust wearable 2 factor (i.e., token plus personal identification number) identity and network access capabilities to improve identity verification and authentication processes; research and develop anomalous behavior and insider threat detection techniques to apply to tactical radio waveforms to improve communications security against cyber threats; research and experiment with mechanisms to track data flows, monitor data modification, and ensure trusted pedigree of the information flowing across tactical networks; develop models and algorithms to reason on cyber adversary intent and predict next action; research and code intelligent algorithms to efficiently pin point potentially exploitable areas within software; design and code models and techniques utilizing a software defined networking architecture to improve tactical network resilience; design and code spectrum awareness models and algorithms to detect denied spectrum conditions from jamming or other interference; and design a security architecture that supports convergence across the intelligence, network operations, cyber, EW, Fires, and information operations functions within a tactical Command Post. *FY 2018 to FY 2019 Increase/Decrease Statement:* In FY19 this effort was moved to Project CY2 per an Office of the Secretary of Defense directive to identify cyber investments in cyber unique Projects.			
Title: Cyber Collaborative Research Alliance (CRA) *Description:* This effort will take innovative basic research theories from the Cyber CRA and experimentally validate the hypothesis and create proof-of-concept defensive cyber software implementations. Work being accomplished under 0602872A/ Project CY2 complements this effort, and this effort is fully coordinated with the Army Research Lab Cyber Security Collaborative Research Alliance, PE 0601104A/Project EA6. In FY19 this effort was moved to Project CY2 per an Office of the Secretary of Defense directive to identify cyber investments in cyber unique Projects. *FY 2018 Plans:* Validate new defensive cyber theories in stealthy virtual machine migration, advanced persistent threat detection, malware communication detection, port scanning attack detection, and evidence collection for cyber-attacks; design models and algorithms in support of computer network defense and counter attack technologies; develop software to address cyber risk, detection, agility, and human psychosocial elements as they relate to cyber defense; develop and validate new defensive cyber metrics; run defensive cyber operation experiments to assess tactical applicability of new cyber theories/models; make determinations on how new validated cyber theories impact other on-going cyber research and how those programs should shift their technical	-	2.916	-

Exhibit R-2A, RDT&E Project Justification: PB 2019 Army		Date: February 2018
Appropriation/Budget Activity 2040 I 2	R-1 Program Element (Number/Name) PE 0602782A I *Command, Control, Communications Technology*	Project (Number/Name) H92 I *Communications Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
implementations; and mature cyber theories into software capabilities that can transition into ongoing and future Cyber/CEMA Operations programs of record. *FY 2018 to FY 2019 Increase/Decrease Statement:* In FY19 this effort was moved to Project CY2 per an Office of the Secretary of Defense directive to identify cyber investments in cyber unique Projects.			
Title: Future Communications and Networking Technologies *Description:* This effort investigates and fabricates components and codes software for radios and network management systems to enable access to spectrum that is unavailable because of current inefficient spectrum management methods. This includes new management and visualization modalities as well as improved RF modulation techniques, devices and software. This effort investigates technologies for networking protocol development as well as networking technologies for routing and disruption tolerant networks. This effort also investigates RF signal processing, signal transmission and codes software to detect and overcome the interference of SATCOM due to jamming or atmospheric conditions. Work being accomplished under 0603794A/ Project EL4 complements this effort.	7.155	-	-
Title: Communications, Robust Tactical Systems, formerly Uninterrupted Communications *Description:* This effort designs and matures components, software and algorithms that enable Army tactical wireless networks to provide assured uninterrupted access to critical communications and information links so that they operate more robustly in congested, contested and competitive electromagnetic environments. These capabilities will result in robust, reliable and secure terrestrial and SATCOM networks with greater survivability in austere, congested and hostile electromagnetic environments while ensuring that the capabilities are interoperable and resource efficient and will allow forces to develop SU and conduct operations to support mission command networks even under adverse operational conditions. Work accomplished under PE 0603794A/ Project EL4 complements this effort. *FY 2018 Plans:* Conduct studies, simulations and laboratory experiments to mature low-cost integrated directional networking (DN) capability to enable operation in Global Positioning System (GPS)-denied environments; construct DN algorithms to implement adaptive antenna nulling techniques to direct emissions only in the desired direction for robust and undetectable communications while maintaining a robust tactical networking capability; conduct studies, simulations and laboratory experiments to develop efficient techniques to maintain capacity across multiple networks while providing low probability of interception (LPI) and low probability of detection (LPD) capability for individual users; and leverage techniques resulting from earlier efforts to make blue force electronic	-	5.266	15.583

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 0602782A / *Command, Control,* *Communications Technology*	**Project (Number/Name)** H92 / *Communications Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
warfare (EW) and communications more interoperable and provide spectrum situational awareness (SA) in real time to develop techniques for improved LPI/LPD while maintaining robust tactical communications. ***FY 2019 Plans:*** Will design and develop an agile network architecture that globally manages traffic from traditional and non-traditional networks; design and develop algorithms and software to enable resilient controls to support network traffic over Commercial and Government satellite communications (SATCOM) systems; conduct experiments to develop methods for robust narrowband SATCOM with resilience against adversary jamming; research to resilient Mission Command designs that are transport agnostic; investigate and design software-based algorithms for anti-jam, Low Probability of Interception and Deception (LPI/LPD) high frequency communications that incorporate state of the art protection against threat systems and enable operation in a contested environment of High Frequency systems; design and develop a standard interface specification to enable tactical Army units to interoperate with Navy and Air Force components; investigate components for a reliable, long range, and low data rate communications link to provide uninterrupted communications in a contested environment for the Army Tactical network; design a proof of concept adaptive system that supports multiple simultaneous radio frequency connections, multiple types of interference cancellation, incorporating diverse paths and waveforms, beam forming, and power control; design and develop a control modem supporting required connectivity, throughput, and protection to support resiliency functions in a contested environment; design and develop a software based adaptive system that supports multiple types of Wideband SATCOM interference mitigation techniques; validate applicability of cognitive reasoning software to recognize interference signals and select the appropriate mitigation techniques and, through machine-learning, grow in responsiveness; conduct experiments to evaluate uninterrupted SATCOM configurations; conduct analysis to determine approach for developing and adding interference cancellation to the Army tactical modems; design and develop algorithms for improved interference rejection and improved jammer stand-off distance to address the tactical Army threats; investigate and design a decoy signal generator of multiple waveforms, capable of deceiving Intelligence, Surveillance, & Reconnaissance (ISR) systems; design and develop obfuscator hardware, supporting sensor and policy-based dynamic spectrum access (DSA) and transmitting obfuscation (flooding)waveforms, and frequency obfuscation to hide troop?s radio frequency signatures and spend enemy resources; conduct research to enable extended reach back, data link, and localized communications for long range precision fires; design and develop a single, autonomous and intelligent network across the tactical Army, providing a common user interface and drawing on the available resilient links to maintain data flow; develop solutions to provide reliable voice/data links for the next generation combat vehicles, and tele-operation and data links for Manned/Unmanned-Teaming (MUM-T); develop components to improve resilience of Air-to-Air and Air-to-Ground links for future vertical lift and next generation unmanned aerial system; design algorithms for intelligent networks to enable resilient links and data flow capability for Fire control, sensor data flow, and proximity/distance networking for air and missile defense; validate network-enabled mission command to the dismount soldier through intelligence and situational understanding-based routing of data over resilient communication links. ***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 *I* 2	**R-1 Program Element (Number/Name)** PE 0602782A *I Command, Control, Communications Technology*	**Project (Number/Name)** H92 *I Communications Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Increase to meet Army priority for Network/C3I, including beyond line-of-site communications, next generation HF, spectral obfuscation and protected SATCOM. Efforts will include the design and development of an agile network architecture, controls to support network traffic over Commercial and Government satellite communications systems, and a control modem supporting required connectivity, throughput, and protection to support resiliency functions in a contested environment.			
Title: Modular Radio Frequency (RF)	-	-	4.800
Description: This effort enables connectivity in contested & congested environments by applying automated networking techniques to modular radio frequency (RF) technology & networking techniques to adapt and continue operation under interference signals. This is a new effort, beginning in FY 2019. *FY 2019 Plans:* Will design and develop product architectures based on a Modular Open System Architecture (MOSA) approach that incorporates components of network technologies into a unified solution; identify, validate, and develop standards for major internal interfaces and all external interfaces to product components and network capabilities and services; identify, develop, and validate quality attribute requirements that reflect a focus on resilience for autonomous networking to addresses critical product qualities that span a design space of feasible solutions that will allow high value services to maintain persistent network connectivity in congested and contested environments; investigate alternative requirement allocations for different network technology components that will incorporate identified technologies currently in use, and new network technologies, within an agile and resilient autonomous network; develop alternative solutions and validate selection criteria for autonomous networking approaches that provide agile detection and switching among available network connections in order to sustain the network in dense and hostile spectrum environments; investigate situation-adaptive communications to inform networks of current spectrum environment changes (e.g. interference, congestion) for the tactical network links, in an effort to optimize their performance based on available resiliency features, to implement mitigation techniques to maintain operation and inform the automated network of their status and any degradations; investigate the methods for agile networking algorithms to detect network technologies available for inclusion in the automated network processing and determine techniques to minimize user input to establish the detections, authentications, and incorporation of the technologies into the automation. *FY 2018 to FY 2019 Increase/Decrease Statement:* This is a new effort, beginning in FY 2019.			
Accomplishments/Planned Programs Subtotals	20.561	20.286	35.588

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, **RDT&E Project Justification:** PB 2019 Army		**Date:** February 2018
Appropriation/Budget Activity 2040 *I* 2	**R-1 Program Element (Number/Name)** PE 0602782A *I Command, Control, Communications Technology*	**Project (Number/Name)** H92 *I Communications Technology*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy
 N/A

E. Performance Metrics
 N/A