Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army											Date: May 2021	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602182A *I C3I Applied Research*							
COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
Total Program Element	-	-	-	12.406	-	12.406	-	-	-	-	-	-
CM9: *Convergent CEMA Deception*	-	-	-	5.626	-	5.626	-	-	-	-	-	-
CN4: *Network Enabling University Applied Research*	-	-	-	2.578	-	2.578	-	-	-	-	-	-
CN5: *Network Vuln/ Effectiveness Assess Methods (N-VEAM)*	-	-	-	4.202	-	4.202	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022, funding is realigned from:
PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology)
PE 0602145A (Next Generation Combat Vehicle Technology) Project BF8 (Artificial Intelligence & Machine Learning Tech)

A. Mission Description and Budget Item Justification

This Program Element (PE) investigates, designs, validates, and conducts experimentation to establish technical solutions for creating integrated future equipment and systems that improve resiliency, survivability, operational effectiveness, mobility, sustainability, and readiness of ground forces. This PE provides mid-to-long term tactical Command, Control, Communications and Intelligence (C3I) capabilities (e.g. networking, cyber, electronic warfare, Positioning, Navigation and Timing (PNT), space, persistent surveillance) based upon promising technologies that address emerging and future threats, and includes research critical and unique to the Army and DoD (e.g., atmospheric modeling and meteorological technologies). Applied research investments focus on the design and investigation of materials, processes, technologies, methodologies, and models to establish architectures, systems, and interfaces that enhance and optimize performance on the future battlefield. The outputs of these efforts inform and transition to advanced research efforts that demonstrate improved C3I capabilities.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy. Work in this Project is performed by the United States (US) Army Futures Command (AFC).

Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Army					Date: May 2021
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*		R-1 Program Element (Number/Name) PE 0602182A / *C3I Applied Research*			
B. Program Change Summary ($ in Millions)	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**
Previous President's Budget	0.000	0.000	0.000	-	0.000
Current President's Budget	0.000	0.000	12.406	-	12.406
Total Adjustments	0.000	0.000	12.406	-	12.406
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	12.406	-	12.406

Change Summary Explanation

New Program Element in Fiscal Year (FY) 2022 established for enabling science and technology efforts that support applied network research

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army									Date: May 2021			
Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602182A / *C3I Applied Research*				Project (Number/Name) CM9 / *Convergent CEMA Deception*			
COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
CM9: *Convergent CEMA Deception*	-	-	-	5.626	-	5.626	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project is a realignment from:
PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology)

A. Mission Description and Budget Item Justification

This Project develops and characterizes hardware and software to enable cyber and radio frequency (RF) technical effects electronic spoofing and cyber deception along with inconspicuous Cyber Electromagnetic Activity (CEMA) and network operations of Army platforms and dismounts, while maintaining freedom to maneuver, communicate, and sense. This research is critical to counter near-peer ability to geo-locate and put indirect fires onto our positions.

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

Work in this Project is performed by the United States Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Radio Frequency/Cyber Sensing and Effects	-	-	3.131
Description: This effort develops technologies to avoid geolocation of blue force radio frequency (RF) emissions by peer/near-peer adversaries. Research will focus on developing low probability of detection (LPD) communications and RF transceivers to increase freedom of maneuver while maintaining effective communications.			
FY 2022 Plans: Will investigate synchronization techniques for a heterogeneous set of distributed transmitters; design and develop signals and waveforms for RF emissions on wideband reconfigurable transceivers; investigate interoperability for wideband reconfigurable RF transceiver hardware, including compact antennas, RF frontend hardware, and data converters; further develop materials, device designs, and components for non-RF communication techniques.			
FY 2021 to FY 2022 Increase/Decrease Statement: In FY 2022, this effort is realigned from PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology).			
Title: Dynamic Intelligent Networks and Cyber Technical Effects for CEMA	-	-	2.495
Description: This effort investigates techniques and develops methods for combining the physical (Radio Frequency) and network (cyber) layers for enhanced effects when coupled with electromagnetic technical effects.			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602182A / *C3I Applied Research*	**Project (Number/Name)** CM9 / *Convergent CEMA Deception*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
FY 2022 Plans: Will explore methods for employing unconventional spectrum and communication modalities for enhanced robustness and reduced signature; investigate the combination of low signature networking methods with advanced technical effects; research and develop algorithms and methodologies in a rigorous approach to cyber security such as game theory; model attacker-defender interaction and scalable algorithms for cyber security application and verify algorithms by mathematical proofs, simulation, and experiment; develop and examine adaptive cyber approaches, involving network emulators and camouflaging systems, to bolster network security and resilience; using game theory and machine learning, develop and assess an adaptive honeynet to monitor and study unauthorized network users? exploits; introduce and examine dynamic honeynet processes to incorporate what is learned about the adversaries? network behaviors and intended network targets; investigate advanced methods to model approaches for the prediction of frequency and occurrence of network attacks by type for effectively implementing adaptive honeynets; research impact of Software Defined Networking (SDN) for mobile network architectures on implementation of adaptive honeynets for tactical networks. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort is realigned from PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology).			
Accomplishments/Planned Programs Subtotals	-	-	5.626

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / *C3I Applied Research*	Project (Number/Name) CN4 / *Network Enabling University Applied Research*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CN4: *Network Enabling University Applied Research*	-	-	-	2.578	-	2.578	-	-	-	-	-	-

Note

This is a new start in FY 2022.

In Fiscal Year (FY) 2022, this project is a new start.

A. Mission Description and Budget Item Justification

The Project leverages applied research from academia, in the focus areas of intelligent networks, self-sensing/self-healing networks, network security, air and ground vehicle teaming and alternatives to Global Positioning System (GPS). This new proposed project will perform mid-to-long term tactical Command, Control, Communications and Intelligence (C3I) capabilities (e.g. networking, cyber, electronic warfare, Positioning, Navigation and Timing (PNT), space, persistent surveillance) based while maintaining delivery of near-term technologies. This project focuses on research technologies originating from applied research in academia pertaining to intelligent networks, self-sensing/self-healing networks, and network security and artificial intelligence/machine learning as applied to C3I, and other innovative communication as well as alternatives to GPS, enabling applied research technologies that will accelerate the Army modernization in Network and Assured PNT (APNT). This effort conducts applied research and development leading to potential emerging technologies in areas of strategic importance to the Army in secure and intelligent communication and networking by bringing competitively selected Universities with research and development teams into Technical Alliances.

Work in this Project complements PE 0603042A (C3I Advanced Technology) Project CN3 (Network Enabling University Advanced Development).

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

Work in this Project is performed by the United States Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Intelligent, Secure and Self-Sensing/Self-Healing Networks Applied Technology	-	-	1.210
Description: Design fused networks and decision-making architecture into intelligent networks to provide the actionable autonomous intelligence while denying corruption, and/or attack and to execute operational missions securely and reliably. ***FY 2022 Plans:*** Will research artificial intelligence and machine learning (AI/ML) software, predictive analytics software, intelligent data integration software, edge computer processing platforms, edge sensing systems, and other technologies; investigate distributed AI and the communication between computing nodes and edge computing AI/ML solutions for network-driven intelligence; design			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602182A / *C3I Applied Research*	**Project (Number/Name)** CN4 / *Network Enabling University Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
intelligent multi-modal communication and more reliable, efficient, and effective use of available communication technologies; and investigate biometric and biosensor solutions for intelligent network credentialing and access. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort is a Fiscal Year (FY) 2022 New Start.			
Title: Real-Time Tactical Networks Applied Research ***Description:*** Investigate and design resilient and adaptable network communications to support intelligent systems in challenged environments with denied and constrained resources. ***FY 2022 Plans:*** Will construct a resilient information network to deliver reliable information pathways with caching, value-based prioritization, and information optimization; improve time and reliability of information/data over secure tactical networks; and investigate decentralized networks with knowledge bases, reasoning, planning, sensing, self-healing and control capabilities for advance teaming and collaborative operations. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort is a Fiscal Year (FY) 2022 New Start.	-	-	0.600
Title: Alternatives to GPS Applied Research ***Description:*** Research performance and assurance improvements against both electronic and kinetic attacks relative to current state of-the-art GPS, and that can provide PNT technology to users in disrupted, degraded or denied GPS environments. ***FY 2022 Plans:*** Will investigate direct use of signals from satellite constellations in low Earth orbit (LEO) for Assured Positioning, Navigation, and Timing (APNT); design dedicated navigation signal for a "hosted payload" alternative to direct use of signals from the satellites in LEO; investigate vision-based autonomous relative navigation solutions to address the critical need for reliable operability within GPS denied and contested environments; develop fusing vision, radar, inertial, and other sensors technologies to develop GPS alternatives; and research Global Navigation Satellite System (GNSS) independent navigation solution that is computationally lightweight enough to be implemented on low-cost, physically lightweight platforms. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** This effort is a Fiscal Year (FY) 2022 New Start.	-	-	0.768
Accomplishments/Planned Programs Subtotals	-	-	2.578

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602182A / *C3I Applied Research*	**Project (Number/Name)** CN4 / *Network Enabling University Applied Research*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army			Date: May 2021
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / *C3I Applied Research*	Project (Number/Name) CN5 / *Network Vuln/Effectiveness Assess Methods (N-VEAM)*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
CN5: *Network Vuln/ Effectiveness Assess Methods (N-VEAM)*	-	-	-	4.202	-	4.202	-	-	-	-	-	-

Note

In Fiscal Year (FY) 2022 this Project is an Administrative realignment from: PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology)

A. Mission Description and Budget Item Justification

This Project develops analytical methodology and capabilities to characterize hardware and software that enable Electromagnetic Warfare and Cyber capabilities to assess operations of Army Network and communication platforms and dismounts, while maintaining freedom to maneuver, communicate, and sense. This project develops a holistic cross-domain analysis and assessment methodology for network and communication technologies faced with advanced Cyber Electromagnetic Activity (CEMA). These investigations are critical to identifying vulnerabilities of United States systems and technologies so that network and network-enabled systems can be hardened as early in development as possible.

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

Work in this Project is performed by the United States Army Futures Command.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
Title: Understanding, Protecting, and Enabling CEMA Effects	-	-	2.142
Description: This effort develops and continually improves methodology and approaches for estimating and predicting Cyber Electromagnetic Activity (CEMA) effects on networks and network-enabled systems during complex multi-domain operations when significant cross-domain effects can be expected. Methods include drawing upon past research concerning the interaction of cyber and Electromagnetic Warfare threats on operational networks; laboratory operations, over-the-air anechoic chamber experimentation, and open-air field experimentation; and first principles Modeling and Simulation (M&S) and engineering analysis. Abstracting, generalizing, and automating multi-domain CEMA operations will enable the development of analysis and assessment capabilities to anticipate the impact of future threats. Live, virtual, and simulated environments will be developed to estimate the potential operational impact of threat CEMA technologies on friendly systems.			
FY 2022 Plans: Will apply combined Electromagnetic Electronic Warfare (EW) and cyber techniques for a converged assessment of CEMA effects on prototype network systems and components, to include technologies operation in the Integrated Tactical Network and Information Assurance and Network Resiliency technologies. Models for performance and behavior of Network technologies			

Exhibit R-2A, RDT&E Project Justification: PB 2022 Army		Date: May 2021
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602182A / *C3I Applied Research*	**Project (Number/Name)** CN5 / *Network Vuln/Effectiveness Assess Methods (N-VEAM)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022
and systems will be updated to reduce risks of Integrated Tactical Network failures in congested and contested electromagnetic environments. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort is realigned from PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology).			
Title: Vulnerability Analysis Methodology for CEMA Threats ***Description:*** This effort investigates threat/target interactions to develop experimental and analytical methodology for separate and cross-domain cyber and electromagnetic threat attack so that assessed vulnerabilities in a multi-domain complex environment can be reduced or eliminated before fielding new networks and network-enabled systems. Experimental and analysis methodology will be developed to investigate vulnerabilities of specific configurations of complex future networks with multiple communications modalities, advanced deception techniques in the cyber and electromagnetic areas, and advanced Positioning, Navigation, and Timing (PNT) systems. ***FY 2022 Plans:*** Will continue to verify and validate assessment tools, methodologies and metrics (e.g., probability of detection, path loss, scattering in contested/congested electromagnetic environments) for novel Non-traditional waveforms communications such as millimeter wave, ultraviolet (UV)-based communication technologies and the vulnerabilities of beamforming techniques and network protocols; analyze automated software capabilities, refining methodology to increase speed of vulnerability detection and library of network protocols; update the contested/congested electromagnetic environment to reflect emerging threats; and provide threat environments to technology experimentation and technology exploration activities to inform vulnerability mitigations improving critical technologies to include Assured PNT (A-PNT) capabilities. ***FY 2021 to FY 2022 Increase/Decrease Statement:*** In FY 2022, this effort is realigned from PE 0602146A (Network C3I Technology) Project AP4 (CEMA Camouflage Technology).	-	-	2.060
Accomplishments/Planned Programs Subtotals	-	-	4.202

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A