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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Army **Date:** April 2022

Appropriation/Budget Activity 2040: <i>Research, Development, Test & Evaluation, Army / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research
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COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
Total Program Element	-	-	12.406	27.892	-	27.892	29.518	23.735	29.288	29.852	0.000	152.691
CM9: <i>Convergent CEMA Deception</i>	-	-	5.626	-	-	-	-	-	-	-	0.000	5.626
CN4: <i>Network Enabling University Applied Research</i>	-	-	2.578	2.655	-	2.655	2.663	2.507	2.254	2.253	0.000	14.910
CN5: <i>Network Vuln/ Effectiveness Assess Methods (N-VEAM)</i>	-	-	4.202	4.418	-	4.418	4.458	4.453	4.455	4.454	0.000	26.440
CW2: <i>Exploitation of Atmospheric Impacts across Domains</i>	-	-	-	3.051	-	3.051	1.507	-	-	-	0.000	4.558
CX3: <i>Intelligent Env Battlefield Awareness Apl Tech</i>	-	-	-	3.141	-	3.141	2.191	0.613	3.161	3.561	0.000	12.667
CX4: <i>Persistent Geophysical Sensing-Infrasound Apl Tech</i>	-	-	-	2.761	-	2.761	2.565	2.069	3.116	2.595	0.000	13.106
CX5: <i>Sensing in Contested Environments Technologies</i>	-	-	-	1.007	-	1.007	1.023	-	1.259	2.063	0.000	5.352
CX6: <i>Subterranean Detection and Monitoring Apl Tech</i>	-	-	-	1.587	-	1.587	1.681	1.524	1.524	1.026	0.000	7.342
CZ6: <i>Assured PNT Enabling Applied Technology</i>	-	-	-	3.661	-	3.661	3.332	2.306	2.257	2.121	0.000	13.677
CZ7: <i>Convergent CEMA Technical Effects</i>	-	-	-	5.611	-	5.611	5.448	5.542	5.544	5.543	0.000	27.688
DA8: <i>Quantum PNT & Radio Frequency Sensing*</i>	-	-	-	-	-	-	2.601	3.637	5.198	5.197	0.000	16.633
DB4: <i>Enabling Long Standoff 3D (ELS3D) Tech*</i>	-	-	-	-	-	-	2.049	1.084	0.520	1.039	0.000	4.692

*This project's R-2a exhibit has been suppressed due to funding not beginning until after FY 2023

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Army	Date: April 2022
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Appropriation/Budget Activity 2040: <i>Research, Development, Test & Evaluation, Army / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602182A / <i>C3I Applied Research</i>
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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 research is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Research in this Project is performed by the United States (US) Army Futures Command (AFC).

B. Program Change Summary (\$ in Millions)	<u>FY 2021</u>	<u>FY 2022</u>	<u>FY 2023 Base</u>	<u>FY 2023 OCO</u>	<u>FY 2023 Total</u>
Previous President's Budget	0.000	12.406	0.000	-	0.000
Current President's Budget	0.000	12.406	27.892	-	27.892
Total Adjustments	0.000	0.000	27.892	-	27.892
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	27.892	-	27.892

Change Summary Explanation

Fiscal Year 2023 (FY23) funding increase reflects the fact that the FY22 President's Budget request did not include out-year funding.

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022		
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 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CM9: <i>Convergent CEMA Deception</i>	-	-	5.626	-	-	-	-	-	-	-	0.000	5.626

Note

In Fiscal Year 2023 (FY23), this Project is realigned to Program Element (PE) 0602182A (C3I Applied Research) / Project CZ7 (Convergent CEMA Technical Effects).

A. Mission Description and Budget Item Justification

This Project investigates, designs, and develops 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 research is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022	FY 2023
<p>Title: Radio Frequency/Cyber Sensing and Effects</p> <p>Description: This effort develops technologies to avoid geolocation of blue force 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.</p> <p>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.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned to PE 0602182A (C3I Applied Research) / Project CZ7 (Convergent CEMA Technical Effects).</p>	-	3.017	-
<p>Title: Dynamic Intelligent Networks and Cyber Technical Effects for CEMA</p> <p>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.</p> <p>FY 2022 Plans:</p>	-	2.404	-

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army	Date: April 2022
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Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CM9 / Convergent CEMA Deception
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
<p>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.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned to PE 0602182A (C3I Applied Research) / Project CZ7 (Convergent CEMA Technical Effects).</p>			
<p>Title: FY2022 SBIR/STTR Transfer</p> <p>Description: Funding transferred in accordance with Title 15 USC ?638</p> <p>FY 2022 Plans: Funding transferred in accordance with Title 15 USC ?638</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding transferred in accordance with Title 15 USC ?638</p>	-	0.205	-
Accomplishments/Planned Programs Subtotals	-	5.626	-

C. Other Program Funding Summary (\$ in Millions)
N/A

Remarks

D. Acquisition Strategy
N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022		
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 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CN4: <i>Network Enabling University Applied Research</i>	-	-	2.578	2.655	-	2.655	2.663	2.507	2.254	2.253	0.000	14.910

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 Project will focus on research that supports 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). This Project also focuses on bringing competitively selected Universities with research and development teams into Technical Alliances that will investigate and develop 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, leading to potential emerging technologies in areas of strategic importance to the Army in secure and intelligent communication and networking.

Research in this Project complements Program Element (PE) 0603042A (C3I Advanced Technology) / Project CN3 (Network Enabling University Adv Development).

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

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

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022	FY 2023
Title: Intelligent, Secure and Self-Sensing/Self-Healing Networks Applied Technology	-	1.179	1.287
Description: Investigate and 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 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 2023 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022		
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 2021	FY 2022	FY 2023
<p>Will continue research in AI/ML software for Network technologies, predictive analytics software, intelligent data integration software, edge computer processing platforms, edge sensing systems, and other technologies; will continue to research in distributed learning under privacy and resource constraints, and the communication between computing nodes and edge computing AI/ML solutions for network-driven intelligence; will design intelligent multi-modal communication and more reliable, efficient, and effective use of available communication technologies; and will continue to investigate wireless networking and biosensor solutions for intelligent networks.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.</p>				
<p>Title: Real-Time Tactical Networks Applied Research</p> <p>Description: Investigate and design resilient and adaptable network communications to support intelligent systems in challenged environments with denied and constrained resources.</p> <p>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.</p> <p>FY 2023 Plans: Will continue to investigate methods and techniques that support a resilient network capable of delivering reliable information pathways with caching, value-based prioritization, and information optimization; will improve time and reliability of information/data over secure tactical networks; and will continue to investigate decentralized networks with knowledge bases, reasoning, planning, sensing, self-healing and control capabilities for advanced teaming and collaborative operations.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.</p>		-	0.569	0.600
<p>Title: Alternatives to GPS Applied Research</p> <p>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.</p> <p>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</p>		-	0.736	0.768

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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 2021	FY 2022	FY 2023
<p>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.</p> <p>FY 2023 Plans: Will continue to investigate direct use of signals from satellite constellations in LEO for APNT; will investigate autonomous vision-based navigation solutions to address the critical need for reliable operability within GPS denied and contested environments; will develop fusing approaches for vision, radar, inertial, and other sensors technologies for GPS denied/degraded environments; and will research a GNSS independent navigation solution that is computationally lightweight enough to be implemented on low-cost, physically lightweight platforms.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding change reflects planned lifecycle of this effort.</p>			
<p>Title: SBIR/STTR Transfer</p> <p>FY 2022 Plans: Funding transferred in accordance with Title 15 USC ?638</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding transferred in accordance with Title 15 USC ?638</p>	-	0.094	-
Accomplishments/Planned Programs Subtotals	-	2.578	2.655

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022		
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 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CN5: Network Vuln/Effectiveness Assess Methods (N-VEAM)	-	-	4.202	4.418	-	4.418	4.458	4.453	4.455	4.454	0.000	26.440

A. Mission Description and Budget Item Justification

This Project develops analytical methodology and capabilities to characterize hardware and software that enable Electromagnetic Warfare (EW) and Cyber capabilities to assess operations of Army Network and communication platforms and dismounts, while maintaining freedom to maneuver, communicate, and sense. This Project also 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 research is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

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

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022	FY 2023
Title: Understanding, Protecting, and Enabling CEMA Effects	-	2.064	2.233
<p>Description: This effort develops and continually improves methodology and approaches for estimating and predicting 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 of 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.</p> <p>FY 2022 Plans: Will apply combined Electromagnetic 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 and systems will be updated to reduce risks of Integrated Tactical Network failures in congested and contested electromagnetic environments.</p> <p>FY 2023 Plans:</p>			

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022		
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 2021	FY 2022	FY 2023
<p>Will investigate EW and cyber techniques for converged assessment of EW and Cyber effects on network systems addressing network technology for Integrated Tactical Network Capability Set 23 production and fielded equipment. Will investigate EW and cyber techniques for assessment of EW and Cyber effects on network systems through component development and in support of Capability Set 25.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding increase reflects planned lifecycle of this effort.</p>				
<p>Title: Vulnerability Analysis Methodology for CEMA Threats</p> <p>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 methodologies 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.</p> <p>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.</p> <p>FY 2023 Plans: Will verify and validate assessment tools, methodologies and metrics (e.g. path loss, scattering in contested/congested electromagnetic environments, Low Probability of Detect, Low Probability of Intercept, UV & optical communication performance) for Integrated Tactical Network technology; will design and develop cyber tool stimulus for maturation of tactical network autonomous decision-making engines; will continue to develop the contested/congested electromagnetic environment to reflect emerging threats; and determine threat environments for technology experimentation and technology exploration activities to inform them on vulnerability mitigations that will improve critical technologies.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement:</p>		-	1.985	2.185

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022		
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 2021	FY 2022	FY 2023
Funding increase reflects planned lifecycle of this effort.				
Title: FY2022 SBIR/STTR Transfer		-	0.153	-
Description: Funding transferred in accordance with Title 15 USC ?638				
FY 2022 Plans: Funding transferred in accordance with Title 15 USC ?638				
FY 2022 to FY 2023 Increase/Decrease Statement: Funding transferred in accordance with Title 15 USC ?638				
Accomplishments/Planned Programs Subtotals		-	4.202	4.418
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army	Date: April 2022
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Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CW2 / Exploitation of Atmospheric Impacts across Domains
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COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CW2: <i>Exploitation of Atmospheric Impacts across Domains</i>	-	-	-	3.051	-	3.051	1.507	-	-	-	0.000	4.558

Note

In Fiscal Year 2023 (FY23), this Project is realigned from Program Element (PE) 0602146A (Network C3I Technology) / Project AV7 (Atmospheric Modeling and Meteorological Technology).

A. Mission Description and Budget Item Justification

This Project enables identification and exploitation of how atmospheric phenomena impact windows of superiority for Army capabilities by developing technologies that characterize, predict, and efficiently express atmospheric impacts in future operating environments. New sensing technologies and algorithms enable heterogeneous sensor networks to extract critical environmental information optimizing performance and reducing the need for dedicated meteorological sensors. Novel physics-based models, empirical parameterizations, and machine learning applications extrapolate this environmental information both spatially and temporally. Uncertainty-aware decision support tools leverage this situational awareness to efficiently express atmospheric effects on friendly and threat weapons systems, sensors, and operations at the point of need and across multiple domains. This information can be exploited by autonomous and human decision makers for mission planning and execution; battlefield visualization; reconnaissance, surveillance, and target acquisition; route planning to maximize stealth and efficiency; long-range precision fires; and modeling of environmental impacts for combat simulations and war games.

This research provides technologies for evaluation by and/or transitions to the Department of Defense weather and operations community including: Program Executive Office (PEO) Ammunition-Program Manager (PM) Combat Ammunition Systems (CAS) and Marine Corps Systems Command (MCSC) for meteorological message input to field artillery targeting systems, PM Intelligence Systems and Analytics (DCGS-A), and the US Air Force 557th Weather Wing to improve their operational weather support to the Army.

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

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

B. Accomplishments/Planned Programs (\$ in Millions)

Title: Atmospheric Impacts	FY 2021	FY 2022	FY 2023
Description: This effort develops environmental exploitation capabilities though coupled sensing, numerical prediction, and decision support technologies for data-sparse, computationally-limited, and network-constrained domains.	-	-	3.051
FY 2023 Plans:			

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Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CW2 / Exploitation of Atmospheric Impacts across Domains		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2021	FY 2022	FY 2023
<p>Will mature combined multi-modal sensing capabilities for detection, classification, and localization of small Unmanned Aerial Systems (sUAS); develop new machine-learning-based algorithms to support tactical adaptability of software-defined, portable radar; mature capabilities for rapid optical characterization of hazardous, biological and non-biological aerosols; validate methods to predict bulk atmospheric impacts on directed energy from multi-modal sensor data; mature dispersion calculations of Atmospheric Boundary Layer Environment Lattice-Boltzmann Method (ABLE-LBM) in urban domains; validate uncertainty propagation algorithms in tactical, urban models when assimilating non-traditional, environmental observations.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned from PE 0602146A (Network C3I Technology) / Project AV7 (Atmospheric Modeling and Meteorological Technology).</p>				
Accomplishments/Planned Programs Subtotals		-	-	3.051
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022		
Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research				Project (Number/Name) CX3 / Intelligent Env Battlefield Awareness Apl Tech			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
<i>CX3: Intelligent Env Battlefield Awareness Apl Tech</i>	-	-	-	3.141	-	3.141	2.191	0.613	3.161	3.561	0.000	12.667

Note

In Fiscal Year 2023 (FY23), this Project is realigned from Program Element (PE) 0602146A (Network C3I Technology) / Project AR3 (Intelligent Environmental Battlefield Awareness).

A. Mission Description and Budget Item Justification

This Project investigates, develops, and designs technologies to allow Soldiers to maneuver faster in dynamic environments as informed by physical, geological, and biological constraints. This Project enhances visualization tools for mission planning through delivering web modules/software tools which contain crucial geochemical resources and advanced knowledge of geo-environmental infrastructure for mission planners.

This Project supports the Common Operating Environment Army Modernization Priority. These technologies provide situational awareness for multi-source intelligence, particularly in anti-access/area denied (A2/AD) operational environments.

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

Research is performed at the United States (U.S.) Army Engineer Research and Development Center and coordinated with U.S. Army Futures Command.

This research complements Program Element (PE) 0603042A (C3I Advanced Technology) / Project CX7 (Intelligent Env Battlefield Awareness Adv Tech).

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022	FY 2023
Title: Hydrology Mapping	-	-	1.029
Description: This effort provides data tools and models to support high-fidelity battlefield overlay maps that accurately show hydrologic/soil moisture threats (soil, hydrology, and snow/ice) not captured by current terrain mapping capabilities.			
FY 2023 Plans: Will identify data, models, and techniques to measure, simulate, and forecast hydrologic conditions in the field with a focus on knowledge gaps and develop integration plans to create global coverage in existing tools.			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned from PE 0602146A (Network C3I Technology) / Project AR3 (Intelligent Environmental Battlefield Awareness).			
Title: Predictive Geographic Information System (GIS) Mapping (physical)	-	-	1.302

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CX3 I Intelligent Env Battlefield Awareness Apl Tech

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
<p>Description: This effort develops a comprehensive GIS tool that integrates predictive models of soil, vegetation, hydrology, and permafrost conditions in Outside Continental United States (OCONUS) dark sites from the statistical analysis of known datasets and the application of geophysical principles.</p> <p>FY 2023 Plans: Will identify geophysical model component gaps in temporal and static feature capture sections of planned GIS Mapping capability.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned from PE 0602146A (Network C3I Technology) / Project AR3 (Intelligent Environmental Battlefield Awareness).</p>			
<p>Title: Vegetation Property Mapping Tech</p> <p>Description: This effort investigates and develops the required data to build geospatial overlays that describe forest type and structure as it relates to maneuver and concealment.</p> <p>FY 2023 Plans: Will identify existing tools and data to describe forest type and structure as it relates to maneuver and concealment for integration onto geospatial overlays.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned from PE 0602146A (Network C3I Technology) / Project AR3 (Intelligent Environmental Battlefield Awareness).</p>	-	-	0.207
<p>Title: Extreme Environments Environmental Effects on Operations Tech</p> <p>Description: This effort designs and develops modeling of natural terrain following extreme disturbances that impact operational environments such as wildfires, flash floods, earthquakes and landscape changes induced by high intensity military conflict.</p> <p>FY 2023 Plans: Will identify critical environmental parameters for baseline adaptations, select study and analog sites, and collect pre- and post-disturbance event data.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned from PE 0602146A (Network C3I Technology) / Project AR3 (Intelligent Environmental Battlefield Awareness).</p>	-	-	0.603
Accomplishments/Planned Programs Subtotals	-	-	3.141

C. Other Program Funding Summary (\$ in Millions) N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CX3 / Intelligent Env Battlefield Awareness Apl Tech

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022		
Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research				Project (Number/Name) CX4 / Persistent Geophysical Sensing-Infrasound Apl Tech			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
<i>CX4: Persistent Geophysical Sensing-Infrasound Apl Tech</i>	-	-	-	2.761	-	2.761	2.565	2.069	3.116	2.595	0.000	13.106

Note

In Fiscal Year 2023 (FY23), this Project is realigned from Program Element (PE) 0602146A (Network C3I Technology) / Project AR9 (Persistent Geophysical Sensing-Infrasound Tech).

A. Mission Description and Budget Item Justification

This Project designs and develops algorithms, software, and hardware components to enable near-real-time battlespace awareness to persistently monitor (through non line-of-sight sensing including infrasound) critical infrastructure conditions and threat activities in dynamic battlefields. These technologies provide near real time data collection, processing, and alerts of infrastructure go/no-go condition required for maneuver planning. This Project also designs and develops methodologies to assign maneuver relevant engineering attributes to geospatial feature data such as bridge load classification, road condition, and bathymetry. These technologies are critical to providing increased situational awareness leading to faster decision making and informing battlefield and maneuver operations.

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

Research is performed at the United States (U.S.) Army Engineer Research and Development Center and coordinated with U.S. Army Futures Command.

This research complements Program Element (PE) 0603042A (C3I Advanced Technology) / Project CX8 (Persistent Geophysical Sensing-Infrasound Adv Tech).

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022	FY 2023
Title: Battlefield Intelligence by Geophysical Sensing (BIGS)	-	-	2.761
Description: This effort develops a suite of geophysical and geo-sensing technologies to persistently assess battlefield elements to include infrastructure and additional sources of interest such as explosive and fires events and various air platforms; refines terrain, topography, and meteorological models related to acoustic propagation detected by the employed sensor suite as well as detection and classification signal processing algorithms for a broader range of sources and/or threats.			
FY 2023 Plans: Will investigate and validate classification algorithms for additional sources of interest as determined by stakeholders and provide software updates. Will utilize a military user assessment to evaluate alternate array geometry for feedback loop.			
FY 2022 to FY 2023 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022		
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CX4 / Persistent Geophysical Sensing-Infrasound Apl Tech		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2021	FY 2022	FY 2023
Funding realigned from PE 0602146A (Network C3I Technology) / Project AR9 (Persistent Geophysical Sensing-Infrasound Tech).				
Accomplishments/Planned Programs Subtotals		-	-	2.761
C. Other Program Funding Summary (\$ in Millions) N/A				
Remarks				
D. Acquisition Strategy N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022		
Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research				Project (Number/Name) CX5 / Sensing in Contested Environments Technologies			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CX5: Sensing in Contested Environments Technologies	-	-	-	1.007	-	1.007	1.023	-	1.259	2.063	0.000	5.352

Note

In Fiscal Year 2023 (FY23), this Project is realigned from Program Element (PE) 0602146A (Network C3I Technology) / Project AR7 (Sensing in Contested Environments Technology).

A. Mission Description and Budget Item Justification

This Project characterizes through direct or inferential methods the identification of non-weaponized biological hazards posed to Soldiers in operational environments by advancing sensor technologies and software modules that will detect and characterize hazards including water quality, heavy metals in soils, breath-ability, and non-weaponized radiological hazards within confined environments. This research provides Soldiers the capability to understand biological hazards present in subterranean environments and take necessary steps to mitigate or avoid these threats.

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

Research is performed at the United States (U.S.) Army Engineer Research and Development Center and coordinated with U.S. Army Futures Command.

This research complements Program Element (PE) 0603042A (C3I Advanced Technology) / Project CX9 (Sensing in Contested Environments Adv Technologies).

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022	FY 2023
Title: Non-traditional Threat Detection in Contested Environments Tech	-	-	1.007
Description: This effort identifies, examines and prioritizes commercial of the shelf (COTS) capabilities from multiple sources that can accurately detect biological hazards relevant to operations in subterranean environments from point of ingress/egress to evaluate exposure potential and affects.			
FY 2023 Plans: Will develop additional detection algorithms for macroscopic threats and create additional zoonotic threat assays.			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned from PE 0602146A (Network C3I Technology) / Project AR7 (Sensing in Contested Environments Technology).			
Accomplishments/Planned Programs Subtotals	-	-	1.007

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / <i>C3I Applied Research</i>	Project (Number/Name) <i>CX5 / Sensing in Contested Environments Technologies</i>
C. Other Program Funding Summary (\$ in Millions) N/A		
Remarks		
D. Acquisition Strategy N/A		

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022		
Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research				Project (Number/Name) CX6 / Subterranean Detection and Monitoring Apl Tech			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
CX6: Subterranean Detection and Monitoring Apl Tech	-	-	-	1.587	-	1.587	1.681	1.524	1.524	1.026	0.000	7.342

Note

In Fiscal Year 2023 (FY23), this Project is realigned from Program Element (PE) 0602146A (Network C3I Technology) / Project AT2 (Subterranean Detection and Monitoring Technology).

A. Mission Description and Budget Item Justification

This Project designs and develops an integrated suite of tunnel detection, subterranean monitoring solutions, and vulnerability assessment technologies to detect, identify, and monitor subterranean threat activities in urban environments through advanced sensing and rapid analysis capabilities. This Project also develops and investigates enhanced technologies to detect tunnels and tunneling activity in complex and varied environments. This research is critical to provide greater situational awareness of the subterranean domain and enhanced survivability for the Soldier.

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

Research is performed at the United States (U.S.) Army Engineer Research and Development Center and coordinated with U.S. Army Futures Command.

This research complements Program Element (PE) 0603042A (C3I Advanced Technology) / Project CZ5 (Subterranean Detection and Monitoring Adv Tech).

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022	FY 2023
Title: Cavity Assessment in Variable Environments-Subterranean (CAVES)	-	-	1.587
Description: This effort will extend current tunnel detection and perimeter security systems beyond austere environments for application in variable terrain, and complex geologic environments, such as mountains, and hard rock geology common in the western pacific. Extended current tunnel detection and perimeter security systems beyond austere environments for application in variable terrain, and complex geologic environments, such as mountains, and hard rock geology common in the western pacific.			
FY 2023 Plans: Will conduct experiments to determine the feasibility of legacy tunnel detection and perimeter security technologies in variable terrain, and complex geologic environments, such as mountains, and hard rock geology common in the western pacific.			
FY 2022 to FY 2023 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CX6 / Subterranean Detection and Monitoring Apl Tech

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
Funding realigned from PE 0603463A (Network C3I Advanced Technology) / Project AT3 (Subterranean Detection and Monitoring Adv Tech) representing the planned lifecycle progression to a shift in research focus to hard rock geology.			
Accomplishments/Planned Programs Subtotals	-	-	1.587

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army **Date:** April 2022

Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CZ6 / Assured PNT Enabling Applied Technology
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COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
<i>CZ6: Assured PNT Enabling Applied Technology</i>	-	-	-	3.661	-	3.661	3.332	2.306	2.257	2.121	0.000	13.677

Note

In Fiscal Year 2023 (FY23), this Project is realigned from Program Element (PE) 0602146A (Network C3I Technology) / Project CK1 (Assured PNT Enabling Technologies).

A. Mission Description and Budget Item Justification

Assured Positioning Navigation and Timing (APNT) Enabling Technologies project investigates and matures technologies for Space-Based and High Altitude applications for Army tactical ground forces. Efforts include the development of sensors and electronic components for communications, signal and information processing, target acquisition, quantum based communications and sensing, and threat warning for small spacecraft and high altitude applications. Investigations leverage other Department of Defense (DoD) space science and technology applications to support Army space force enhancement and cooperative satellite payload development.

Research complements Program Element (PE) 0603463A (Network C3I Advanced Technology) / Project CJ8 (Assured PNT Communications Advanced Tech).

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

Research in this Project is performed by the United States Army Space and Missile Defense Command (USASMDC) in Huntsville, AL.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022	FY 2023
Title: Assured PNT Enabling Applied Technology	-	-	3.661
Description: This effort supports validation of hardware and software components and models to further Space/HA sensor or Deep Sensing capabilities, payload design and development.			
FY 2023 Plans: Will continue to design, develop, and implement an advanced laboratory testbed that will be utilized to mature payloads for APNT, ground launched assets and optical/quantum secure communications on multiple simulated platforms simultaneously with hardware and software in the loop. The testbed will be applicable to high altitude (HA), space based, and ground based platforms utilizing quantum secured communications. Hardware will be developed to optimize transmission of data across multi-domain environments and optimized for Army Program Executive Office (PEO) requirements.			
FY 2022 to FY 2023 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army		Date: April 2022
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CZ6 / Assured PNT Enabling Applied Technology

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
Funding realigned from PE 0602146A (Network C3I Technology) / Project CK1 (Assured PNT Enabling Technologies).			
Accomplishments/Planned Programs Subtotals	-	-	3.661

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army										Date: April 2022		
Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research				Project (Number/Name) CZ7 / Convergent CEMA Technical Effects			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
<i>CZ7: Convergent CEMA Technical Effects</i>	-	-	-	5.611	-	5.611	5.448	5.542	5.544	5.543	0.000	27.688

Note

In Fiscal Year 2023 (FY23), this Project is realigned from Program Element (PE) 0602182A (C3I Applied Research) / Project CM9 (Convergent CEMA Deception).

A. Mission Description and Budget Item Justification

This Project investigates, designs, and develops hardware and software to enable cyber and radio frequency (RF) technical effects 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 will investigate and develop methods to protect blue platforms from adversarial detection and attack. This research is critical to counter near-peer adversary ability to geo-locate and put indirect fires onto blue force positions.

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

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

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022	FY 2023
Title: RF-Enabled CEMA Sensing and Technical Effects	-	-	3.300
Description: This effort develops technologies to avoid geolocation of blue force 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 2023 Plans: Will develop techniques for heterogeneous and distributed signal transmission; will develop signals and waveforms for RF emissions on wideband reconfigurable transceivers and perform proof-of-concept validation; will design and implement wideband reconfigurable RF transceiver hardware interoperable with compact antennas, RF frontend hardware, and data converters; will develop non-RF integrated breadboard communication demonstrator and assess general capabilities of this system external to the laboratory environment.			
FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned from PE 0602182A (C3I Applied Research) / Project CM9 (Convergent CEMA Deception).			
Title: Convergent Networking and CEMA Effects	-	-	2.311
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. Research also investigates			

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Army	Date: April 2022
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Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602182A / C3I Applied Research	Project (Number/Name) CZ7 / Convergent CEMA Technical Effects
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
<p>methods of adaptive networking using unconventional communication channels and active tactical cyber defense methods to anticipate adversarial activities and effective responses.</p> <p>FY 2023 Plans: Will develop intelligent networking protocols for controlling novel methods for covert communication; will conduct experiments on the use of unconventional spectrum and techniques for covert communications; will explore the integration of developed covert networking techniques with multi-domain technical effects; will investigate the use of game theory approaches to achieve cyber misrepresentation on tactical networks; will build attack graphs to comprehend the interdependencies among vulnerabilities and to analyze the attacker's potential course of action; will use game theory for an optimum decoy allocation framework that causes network reconnaissance to be difficult, allows detection of an attacker, and detains the attacker.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Funding realigned from PE 0602182A (C3I Applied Research) / Project CM9 (Convergent CEMA Deception).</p>			
Accomplishments/Planned Programs Subtotals	-	-	5.611

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A