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 0602783A *I Computer and Software 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	-	13.452	14.041	14.958	-	14.958	15.235	15.521	15.822	16.138	0.000	105.167
Y10: *Computer/Info Sci Tech*	-	13.452	14.041	14.958	-	14.958	15.235	15.521	15.822	16.138	0.000	105.167

A. Mission Description and Budget Item Justification

This Program Element (PE) develops and characterizes information and communications processing software that automates the delivery of information used in planning, rehearsal, and execution by ground commanders. Efforts develop communication/network architectures, software, and the information fusion software necessary to simplify the understanding and interactions from humans to humans, humans to computers, and computers to humans. Research enables enhanced understanding of many information sources and accelerates the decision cycle time for commanders and leaders operating in the mobile, dispersed, highly networked environment envisioned for the future force.

Work in this PE is fully coordinated with PE 0603008A (Command, Control, Communications Advanced Technology), PE 0603772A (Advanced Tactical Computer Science and Sensor Technology), PE 0603008A (Command, Control, Communications Advanced Technology), and PE 0603794A (Command, Control and Communications Advanced Technology).

This PE supports Army Science and Technology efforts in the Command, Control, Communications, and Intelligence portfolio.

The cited work is consistent with the Assistant Secretary of Defense, 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)

B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	13.811	14.041	10.074	-	10.074
Current President's Budget	13.452	14.041	14.958	-	14.958
Total Adjustments	-0.359	0.000	4.884	-	4.884
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.354	-			
• Adjustments to Budget Years	-	-	4.884	-	4.884

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 0602783A *I Computer and Software Technology*

• FFRDC	-0.005	-	-	-	-

Change Summary Explanation

In FY 2019, this effort was increased from realigned funds 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 to support artificial intelligence.

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 0602783A / *Computer and Software Technology*	Project (Number/Name) Y10 / *Computer/Info Sci 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
Y10: *Computer/Info Sci Tech*	-	13.452	14.041	14.958	-	14.958	15.235	15.521	15.822	16.138	0.000	105.167

A. Mission Description and Budget Item Justification

This Project develops and characterizes information and communications processing software to automate the delivery of information for planning, rehearsal, and execution by ground commanders. Efforts develop communication/network architectures, software, and the information fusion software necessary to simplify the understanding and interactions from humans to humans, humans to computers, and computers to humans. Research enables enhanced understanding of many information sources and accelerates the decision cycle time for commanders and leaders operating in the mobile, dispersed, highly networked environment envisioned for the future force.

Work in this Project is fully coordinated with Program Element (PE) 0603008A (Command, Control, Communications Advanced Technology), PE 0603772A (Advanced Tactical Computer Science and Sensor Technology), PE 0603008A (Command, Control, Communications Advanced Technology), and PE 0603794A (Command, Control and Communications Advanced Technology).

This Project supports Army Science and Technology efforts in the Command, Control, Communications, and Intelligence portfolio.

The cited work is consistent with the Assistant Secretary of Defense, 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: Multi-Media Information Processing and Exploration	1.762	1.888	1.906
Description: This effort develops and characterizes fusion software to improve the completeness and timeliness of decision-making for Mission Command. The goal of this effort is to develop software applicable to the Distributed Common Ground Station ? Army (DCGS-A) architecture (an integrated architecture of all ground/surface systems) and for next generation analytic capabilities.			
FY 2018 Plans: Design and develop methods to extract information from multi-source data, predict adversarial intent, and provide indications and warnings of adversarial action for use in intelligence analysis and tactical operations; investigate collective-intelligence techniques to enhance Soldier understanding of political, military, economic and social conditions in tactical environments.			
FY 2019 Plans: Will investigate theoretically grounded approaches for uncertainty quantification and propagation in multi-scale, multi-source data and models; will develop methods for computational learning and reasoning that operate on shorter time scales and/or where			

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 0602783A / *Computer and Software Technology*	**Project (Number/Name)** Y10 / *Computer/Info Sci Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
there may be few or no guarantees of convergence and are amenable to adaptive learning and optimization; and will develop self-organizing, self-managing, self-adapting, self-maintaining, self-protecting properties in heterogeneous complex-systems that facilitate interoperability, just-in-time human interactions, and the implementation of local-adaptation functionality in self-organizing, complex human and agent systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Slight increase to support evaluation of multi-scale, multi-source data and models			
Title: Cyber Security & Information Assurance ***Description:*** This effort designs and characterizes software for the protection of information and networks in wireless tactical environments. The goal is to develop software algorithms that detect and defeat malicious activities of adversaries in bandwidth-constrained tactical networks. ***FY 2018 Plans:*** Investigate and develop network-based trust models and metrics for the control and evolution of network behavior to enable more secure tactical networks and prevent adversarial disruption; explore and implement techniques for providing covert authentication of wireless communications links at the physical layer. Explore the capacity of Extremely Lightweight Intrusion Detection system-constructed weight vectors with respect to the number of signatures they can contain. Create intelligent agents that reflect actual behaviors and model them on a test-bed for human-in-the-loop experimentation, and create methods to disrupt and degrade the effectiveness of adversaries operating within a computer network. ***FY 2019 Plans:*** Will explore and implement network and physical layer based approaches for evolving network behavior to improve network resilience in the presence of adversarial disruption based on mission and information requirements; will investigate methods for machine learning (ML) with incomplete information and ambiguous guidance and applications to detect and thwart adversarial ML; will investigate generation after next applications for intrusion detection and active defense; investigate applications in threat intelligence as well as attribution of malicious code; will investigate identification of malicious activity via network sessions attributes; and will investigate techniques to secure cyber physical systems that do not have integrated security built-in. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increased investments in cyber security to improve network resilience	3.873	4.050	4.925
Title: Context-Based Information Exchange ***Description:*** This effort investigates techniques that integrate local and external information sources, and it applies text and video analytic approaches to support automated intelligence analysis and decision making.	2.216	2.334	2.342

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Extend user context models to incorporate continuous learning to improve performance and fit of models of individual solders over time; based on context models, investigate algorithms to foresee mission-related information requirements prior to manual requests in anticipation of soldier situational awareness gaps; develop algorithms to generate computable descriptions of location imagery captured by battlefield visual sensors. ***FY 2019 Plans:*** Will develop approaches for adversarial learning that is resilient to continuous learning threats and maximizes Soldier and agent situational awareness; will develop methods and models for complex event processing, with compact representations, efficient pattern evaluation, and mission-centric focus to accelerate reasoning and decision making; and will conduct experiments to determine methods that support diverse, nonlinear, and emergent system behaviors or tractable optimization strategies in non-stationary systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Slight increase to support development of approaches for adversarial learning			
Title: Multi-Lingual Computing ***Description:*** This effort develops and assesses computational multilingual algorithms and software frameworks to enable commanders and troops to bridge language barriers in order to counter adversaries and collaborate with allies. In Fiscal Year (FY) 2019, funds from this effort are realigned to support the Army science and technology (S&T) Modernization priorities. ***FY 2018 Plans:*** Develop semi-supervised analysis and deep learning methods for automated information extraction from multilingual sources; develop generalized methods for the automatic processing of document images containing multilingual handwritten and printed text; and assess human-in-the-loop methods for leveraging semantic representations of domain data to achieve high quality translations to and from low-resource languages. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** This effort was zeroed to support development of machine learning with constrained resources.	2.576	2.597	-
Title: Network Theories and Models ***Description:*** This effort investigates and designs theory based software models to characterize and validate emerging network protocols and structures. The goal of this effort is to develop software algorithms that maintain effective communications in networks in spite of disruptive effects such as task reorganization, mobility of friendly forces, and adversarial attacks on friendly networks. In FY 2019, funds from this effort are realigned to support the Army science and technology (S&T) priorities as identified	1.345	1.453	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
at the December 2016 S&T Army Requirements Oversight Council by the Chief of Staff of the Army (shifted to Machine Learning with Constrained Resources). ***FY 2018 Plans:*** Develop techniques for the distributed management & control of cognitive radio networks; implement the adaptive algorithms for robust and efficient tactical communications using cognitive and dynamic spectrum access techniques investigated and created in PE 0601102A Project H48 / Battlespace Info & Comm Rsc; and explore and implement models for influencing the evolution of communication networks in spite of mobility and adversarial attacks. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** This effort was zeroed to support development of machine learning with constrained resources			
Title: Heterogeneous Computing and Computational Sciences ***Description:*** This effort researches and develops software algorithms to allow information processing across different computing hardware platforms. The goal of this research is to provide high performance computing (HPC) / processing capabilities to the Soldier on the battlefield. ***FY 2018 Plans:*** Design algorithm development and programming methodologies to fully utilize domain-specific processor/processing architectures (custom-engineered for size, weight and power based on task); implement middleware that enables reuse of existing code to take advantage of next generation processing capabilities; and determine scalability toward exascale (billion, billion calculations per second) capability of low-power next generation processing. ***FY 2019 Plans:*** Will investigate computational capabilities and new enabling applications for domain-specific, coupled, and heterogeneous architectures; will advance computing capabilities amid fundamental limitations in exponential growth of Moore?s law via algorithmic innovations; and will develop methods to address planning, reasoning, and uncertainty at the tactical edge enhanced with heterogeneous computing resources. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Slight increase to address planning, reasoning, and uncertainty at the tactical edge enhanced with heterogeneous computing resources.	1.680	1.719	1.726
Title: Machine Learning with Constrained Resources ***Description:*** This effort will research new machine learning data sets and reinforcement learning methods to address issues of statistically mismatched and incomplete information which must be annotated, collected, classified and used for rapid decisions	-	-	4.059

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
by autonomous intelligent agent (IA) and joint IA-Human teams. In addition, multi-modal communication approaches will be investigated to ensure effective communications and understanding of intent. The goal of this research is enable joint human-intelligent agent decision making, optimizing the strengths of each in the decision process and creating an adaptive, agile team. This work applies research conducted in 61102/H48/16. In FY19, this effort was developed from realigned funds in support of 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 2019 Plans:*** Will develop methods for system-self-awareness of space, time and power characteristics and their relation to requirements of active/pending system missions, with additional ability to degrade or self-destruct gracefully; will design approaches that balance the trade-off between accuracy of computation required to answer queries of users, security concerns and mission criticality/ relevance; will investigate the use of reinforcement learning to develop resilient behaviors and learn effective strategies for accomplishing Soldier relevant mission tasks in complex environments; and will develop approaches that learn from human input develop a scalable technique for performing machine learning online, in complex Army environments, and at operational tempo. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Effort begins in FY19			
Accomplishments/Planned Programs Subtotals	13.452	14.041	14.958

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A