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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army **Date:** March 2019

Appropriation/Budget Activity 2040: <i>Research, Development, Test & Evaluation, Army / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602716A / <i>Human Factors Engineering Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	-	23.813	24.121	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	47.934
H70: <i>Human Fact Eng Sys Dev</i>	-	23.813	24.121	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	47.934

Note
 In Fiscal Year (FY) 2020, this Program Element (PE) is realigned with continuity of effort to the following PEs:
 * PE 0602143A Soldier Lethality Technology
 * PE 0602145A Next Generation Combat Vehicle Technology

A. Mission Description and Budget Item Justification

This PE conducts applied research on human factors to maximize the effectiveness of Soldiers in concert with their equipment. The resulting data are the basis for weapon systems and equipment design standards, guidelines, handbooks, and Soldier training as well as manpower requirements to improve equipment operation and maintenance. Application of this research will yield reduced workload, fewer errors, enhanced Soldier protection, user acceptance, and allows the Soldier to extract the maximum performance from the equipment.

Major efforts research sources of stress, potential stress moderators, and intervention methods, and identify and quantify human performance measures and methods to address current and future warrior performance issues. Individual efforts exploit adaptive learning methods and strategies, enhance and validate human performance modeling tools; investigate integration of advanced concepts in crew stations designs, optimizes interfaces for information systems and improves human robot interaction (HRI) in a full mission context.

Results of these efforts are transitioned to the Research, Development, and Engineering Centers, the Program Executive Offices (PEO) & Program Managers, Army Training and Doctrine Command (TRADOC), Army Medical Command (MEDCOM), Human Systems Integration (HSI) Directorate (Army G1), and Army Test and Evaluation Command (ATEC).

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 PE is performed by the United States Army Futures Command (AFC).

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B. Program Change Summary (\$ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	24.127	24.131	24.596	-	24.596
Current President's Budget	23.813	24.121	0.000	-	0.000
Total Adjustments	-0.314	-0.010	-24.596	-	-24.596
• Congressional General Reductions	-0.006	-0.010			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.308	-			
• Adjustments to Budget Years	-	-	-24.596	-	-24.596

Change Summary Explanation

FY20 decrease related to science and technology financial restructuring.

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COST (\$ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
H70: <i>Human Fact Eng Sys Dev</i>	-	23.813	24.121	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	47.934

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
 Program Element (PE) 0602143A Soldier Lethality Technology
 * Project AY6 Soldier Squad Small Arms Armaments Technology
 * Project BB7 Exoskeleton: technology for Man-Machine Interface
 * Project BC3 Soldier Decision Making & Comms Performance Tech
 * Project BE8 Synthetic Training Environment (STE) Technology
 PE 0602145A Next Generation Combat Vehicle Technology
 * Project BF6 Crew Augmentation and Optimization Tech

A. Mission Description and Budget Item Justification

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Major efforts research sources of stress, potential stress moderators, and intervention methods, and identify and quantify human performance measures and methods to address current and future warrior performance issues. Individual efforts exploit adaptive learning methods and strategies, enhance and validate human performance modeling tools; investigate integration of advanced concepts in crew stations designs, optimizes interfaces for information systems and improves human robot interaction (HRI) in a full mission context.

Results of these efforts are transitioned to the Research, Development, and Engineering Centers, the Program Executive Offices (PEO) & Program Managers, Army Training and Doctrine Command (TRADOC), Army Medical Command (MEDCOM), Human Systems Integration (HSI) Directorate (Army G1), and Army Test and Evaluation Command (ATEC).

Efforts in this Project support the Under Secretary of Defense for Research and Engineering Science and Technology priorities and the Army Modernization Strategy.

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

	FY 2018	FY 2019	FY 2020
Title: Interfaces for Collaboration and Decision Making	2.656	2.800	-
Description: This effort looks at the study of how networks influence, and are influenced by, human behavior in the context of military decision making. The studies, which range from computational modeling to networked simulations in a laboratory			

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
environment, to large-scale simulation exercises, will investigate the effects of technology on information flow, cognitive workload, team collaboration, organizational effectiveness, situational awareness, and decision making.				
<p>FY 2019 Plans: Develop initial capability for real-time empirical assessment of human cyber performance to include leveraging human digital behaviors (i.e. keystrokes, mouse-clicks, tool use, screen recordings); identify specifications for Soldier cyber security training needs in tactical environments; develop techniques and measures to assess cyber team effectiveness; create behavioral models of Soldier situation understanding and defense of enterprise-level networked operational environments; continue development of capabilities for dynamic human/agent cyber experimentation using cyber test-range for on-site and remote human-in-the-loop experiments with authoring and execution of repeatable cyber scenarios.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: This research effort was realigned to PE 0602143A (Soldier Lethality Technology) / Project BC3 (Soldier Decision Making & Communications Performance Tech) in FY20 as part of financial restructuring.</p>				
<p>Title: Human Performance Modeling</p> <p>Description: Enhance human performance modeling tools to enable system analysis that will inform system design early in the acquisition process. These tools will allow the identification of design flaws that can be mitigated to reduce workload and human errors and increase user acceptance of developing technologies allowing the Soldier to extract the maximum performance from the equipment. Collect and analyze empirical data on human perception (vision and hearing) to support human and system performance models used for equipment design and training.</p> <p>FY 2019 Plans: Investigate the use of Human Systems Integration (HSI) tools to validate the effects of autonomous systems on operator workload and mission performance; conduct human performance modeling tool maintenance, development, and support; continue to extend development of human accommodating analysis to quantify human resource costs in terms of manpower, personnel and training; develop training videos to support the HSI practitioners; explore the development of human agent assisted tools for supporting HSI evaluations and assessments.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: This research effort was realigned to PE 0602143A (Soldier Lethality Technology) / Project BC3 (Soldier Decision Making & Communications Performance Tech) in FY20 as part of financial restructuring.</p>		0.506	1.025	-
<p>Title: Brain-Computer Interaction</p> <p>Description: Investigate the use of neurophysiological and behavior-based technologies for enhancing the interaction between Soldiers and systems such as autonomous systems and advanced crew stations. Implement guidelines for algorithms for</p>		3.530	1.230	-

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
<p>characterizing Soldier brain activity in operational contexts, and real-time techniques to integrate neurally-based information into systems designs.</p> <p>FY 2019 Plans: Develop novel multiclass rapid-serial visual presentation brain-computer interaction paradigms for improved integration with deep-learned computer vision; develop novel approaches for determining the optimal allocation of images across hybrid teams of computer vision and brain-computer interface-using humans for enhancing efficiency of image analysis.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: This research effort was realigned to PE 0602145A (Next Generation Combat Vehicle Technology) / Project BF6 (Crew Augmentation and Optimization Tech) in FY20 as part of financial restructuring.</p>				
<p>Title: Dismounted Soldier Performance</p> <p>Description: Investigate equipment design standards and human performance measures and create guidelines for maneuver team information systems solutions that improve situational understanding and decision cycle time; identify, mature, and quantify human performance limitations to address future warrior performance issues.</p> <p>FY 2019 Plans: Determine the performance thresholds associated with individual and small team performance as a function of physical and cognitive constraints; examine the distinctions between equipment configurations, including novel system interface approaches designed to improve performance metrics (e.g., timing, accuracy, mobility); continue to investigate the effects of human variability on the performance of small arms shooting accuracy, and will determine ways of mitigating negative effects; conduct studies that relate characteristics of individual Soldier weapon systems, ancillary equipment, and ammunition to dismounted Soldier shooting performance (accuracy and precision).</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: The effort ends in Fiscal Year (FY) 2019.</p>		5.156	1.375	-
<p>Title: Human-Robot Interaction</p> <p>Description: Design human-centered design requirements and technologies for supervision and Soldier interaction with multiple semi-autonomous unmanned vehicles in urban and unstructured environments. This research will be transitioned to U.S. Army Tank Automotive Research Development and Engineering Center (TARDEC).</p> <p>FY 2019 Plans: Extend advances in multimodal, bidirectional communications models, including natural language solutions for small teams, to enhance Soldier collaborations with multiple heterogeneous agents in a distributed operational environment; enhance models</p>		3.054	3.075	-

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
<p>of trust and transparency to include adaptive roles for both humans and agents and serve as basis for human centered design requirements in multi-agent systems; explore applications for bidirectional communication and trust and transparency to include both mounted and dismounted operations.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: This research effort was realigned to PE 0602145A (Next Generation Combat Vehicle Technology) / Project BF6 (Crew Augmentation and Optimization Tech) in FY20 as part of financial restructuring.</p>				
<p>Title: Understanding Socio-cultural Influence</p> <p>Description: Investigate and model cognitive aspects of socio-cultural influences on Soldier/Commander decision making and communication to enhance Soldier performance with systems, within teams and in the mission context. Extend models of individual and teams to societal levels to support regional understanding, training, mission rehearsal, and influence.</p> <p>FY 2019 Plans: Continue to quantify the processes and proficiencies that are selected for and taught by practitioners who collect, process, and distribute sociocultural information within the Army; develop a predictive model of group behavior based on religion to augment Civil Affairs decision making; conduct preliminary experiments to explore methods for improving situational understanding and decision making when visualizing sociocultural information in virtual reality; leverage theory from cognitive science to inform experimentation.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: In FY19 this effort ends.</p>		2.060	2.025	-
<p>Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies</p> <p>Description: This effort will investigate technologies that provide the foundation for future Army systems to adapt to individual Soldier's states, behaviors, and intentions in real-time. Develop novel approaches to individualize adaptive systems through enhanced interfaces, interactions, or interventions that capitalize on prediction methods; and decrease time-to-train, augment physical, cognitive, and social performance, and improve human-network interactions.</p> <p>FY 2019 Plans: Develop techniques and algorithms to collect, synchronize and integrate high resolution behavioral, physiological, environmental, and task-based sensor information with existing low-resolution multi-faceted assessment capability to enable continuous monitoring of an individual across a variety of timescales; develop capability for real-time group-based performance assessment incorporating multi-faceted individual metrics and social dynamics through integration of multiple, pervasive data sources.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement:</p>		2.159	1.600	-

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
This research effort was realigned to PE 0602145A (Next Generation Combat Vehicle Technology) / Project BF6 (Crew Augmentation and Optimization Tech) in FY20 as part of financial restructuring.				
<p>Title: Training Effectiveness Research</p> <p>Description: Novel technologies and their implementation in Army systems may result in demands on Soldiers that exceed their knowledge, skill, or memory capacity. When demands cannot be remediated by human systems integration, training may enable the demands to be met. This effort will identify human operator tasks in complex, intelligent, and emerging systems critical to mission employment of new technologies. The aspects (particularly knowledge and skill) of those tasks will be determined through experimentation and analysis to inform development of training and simulation technologies, fundamental research on the effectiveness of training regimes, and simultaneous task combinations that must be trained.</p> <p>FY 2019 Plans: Conduct experiments with refined research-based integration of multi-sensor data (e.g. accuracy, communications, psycho-physiological, and/or movement/location) for automated measurement of critical training outcomes; explore and identify training effectiveness measures for collective training (mixed reality and live); explore and identify multi-sensor data for automated measurement of effective collective training outcomes.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: This research effort was realigned to PE 0602143A (Soldier Lethality Technology) / Project BC3 (Soldier Decision Making & Communications Performance Tech) and Project BE8 (Synthetic Training Environment (STE) Technology) in FY20 as part of financial restructuring.</p>		0.932	0.992	-
<p>Title: Soldier System Architecture</p> <p>Description: Soldier performance is affected by mission demands, environment, human characteristics, equipment, and technology. System development requires considering tradeoffs among these factors and sufficient data about them on which to base analyses. This effort will identify and develop human performance measures of effectiveness (MOEs) and measures of performance (MOPs) critical to performing individual and team tasks in a mission text. Tools and techniques for analysis of these tradeoffs will also be developed. Empirical data will be mined from existing sources or collected where gaps exist to inform the interaction among factors affecting Soldier mission performance for emerging technologies.</p>		1.000	-	-
<p>Title: Rapid Soldier Capability Enhancement</p> <p>Description: Research the relationship of augmentation agents and Soldier performance & behavior. Investigates the effects of augmentation agents (perceptual, cognitive, and/or physical), used either individually or coupled as a system of agents, on Soldier</p>		2.760	2.760	-

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
performance, resilience, and training during operationally relevant tasks. Development of guidelines and models for designing and employing augmentation agents. Implementation of guidelines will enhance augmented Soldier performance.				
<p>FY 2019 Plans: Investigate augmentation applications, to understand functionality in mounted and dismounted operational environments; enhance models of performance and adaptation to facilitate more robust prediction of capability enhancement including short and long term adaptations and factors related to individual variability; enhance metrics for quantifying Soldier performance while using a system of augmentation agents in complex environments.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: This research effort was realigned to PE 0602143A (Soldier Lethality Technology) / Project BC3 (Soldier Decision Making & Communications Performance Tech) and Project BE8 (Synthetic Training Environment (STE) Technology) in FY20 as part of financial restructuring.</p>				
<p>Title: Tools for Assessing Human/Intelligent Team Performance</p> <p>Description: Develop tools for verifying and validating Soldier interactions and overall human-system performance of mixed Soldier-intelligent agent teams, while providing the foundation for a generalizable tool for a broad range of Human-System Integration (HSI) assessments. Focus on flexible, tailor-able analysis tools for laboratory grade, high-resolution assessment of dismount-robot interactions in complex environments.</p> <p>FY 2019 Plans: Develop portable, ?plug and play? analysis toolkit that enables individualized assessment of a single human interacting with an intelligent agent in pseudo-controlled environments.</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement: This research effort was realigned to PE 0602143A (Soldier Lethality Technology) / Projects AY6 (Soldier Squad Small Arms Armament Technology) in FY20 as part of financial restructuring.</p>		-	1.000	-
<p>Title: Explainable Intelligence Underlying Efficient Integration of Cognitive Assist Agents</p> <p>Description: This effort will develop novel methods for joint human / intelligent agent learning and decision making to capitalize on the individual strengths of humans and intelligent agents to improve emergent group performance; and enable rapid, cooperative decision making and learning utilizing machine learning approaches.</p> <p>FY 2019 Plans:</p>		-	2.050	-

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020
Develop novel machine learning approaches for learning the optimal allocation of tasks across hybrid teams of humans and artificial intelligent agents; develop novel approaches to deep neural networks based on the underlying geometry of the data. FY 2019 to FY 2020 Increase/Decrease Statement: This research effort was realigned to PE 0602145A (Next Generation Combat Vehicle Technology) / Project BF6 (Crew Augmentation and Optimization Tech) in FY20 as part of financial restructuring.				
Title: Soldier Focused Neurotechnologies Description: Neurotechnologies for Soldier use are limited by a lack of sufficient tools and methodologies capable of interpreting brain data in real world environments. Research will focus on the development of novel user-transparent data acquisition systems that are comfortable and non-invasive and on the development of robust tools that account for high levels of variance and noise expected in recorded brain data in real-world environments. FY 2019 Plans: Determine and develop efficacy of novel materials for use in advanced validation tools for mobile brain-recording hardware; develop a framework describing the relationship between computational neural data features and the performance of corresponding neural state classifiers within non-ideal, noisy environments. FY 2019 to FY 2020 Increase/Decrease Statement: This research effort was realigned to PE 0602145A (Next Generation Combat Vehicle Technology) / Project BF6 (Crew Augmentation and Optimization Tech) in FY20 as part of financial restructuring.		-	2.330	-
Title: Exoskeleton Description: Accelerates Soldier lethality and mobility capabilities through exoskeleton systems with improved Soldier compatibility and reduced training requirements. Advances innovative assessment and analysis techniques and metrics that inform hardware design, system control and technology use case objectives. Identifies and matures fundamental assessment protocols for transition to Army Test and Evaluation community. FY 2019 Plans: Identify and validate initial surrogate tasks and associated performance metrics against an anticipated urban terrain scenario; identify key quantitative measures and model their relationship to performance outcomes; characterize human movement variability in performance of and transitions between component tasks and responses to perturbations within movement through complex urban environment scenario. FY 2019 to FY 2020 Increase/Decrease Statement:		-	1.500	-

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2018	FY 2019	FY 2020
This research effort was realigned to PE 0602145A (Next Generation Combat Vehicle Technology) / Project BB7 (Physical Augmentation Tech) in FY20 as part of financial restructuring.			
Title: FY 2019 SBIR / STTR Transfer Description: FY 2019 SBIR / STTR Transfer FY 2019 Plans: FY 2019 SBIR / STTR Transfer FY 2019 to FY 2020 Increase/Decrease Statement: FY 2019 SBIR / STTR Transfer	-	0.359	-
Accomplishments/Planned Programs Subtotals	23.813	24.121	-

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

Remarks

D. Acquisition Strategy
N/A

E. Performance Metrics
N/A