Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Army											Date: May 2017	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602716A *I Human Factors Engineering Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	23.220	23.671	24.127	-	24.127	25.160	25.365	25.877	26.408	-	-
H70: *Human Fact Eng Sys Dev*	-	23.220	23.671	24.127	-	24.127	25.160	25.365	25.877	26.408	-	-

A. Mission Description and Budget Item Justification

This Program Element (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.

Efforts in this PE support the Army Science and Technology Soldier/Squad portfolio.

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 Assistant Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work is performed by the Army Research Laboratory (ARL), Aberdeen, MD.

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Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*		**R-1 Program Element (Number/Name)** PE 0602716A / *Human Factors Engineering Technology*			
B. Program Change Summary ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	23.681	23.671	24.034	-	24.034
Current President's Budget	23.220	23.671	24.127	-	24.127
Total Adjustments	-0.461	0.000	0.093	-	0.093
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.461	-			
• Civ Pay Adjustments	0.000	0.000	0.093	-	0.093

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army			Date: May 2017
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602716A / *Human Factors Engineering Technology*	Project (Number/Name) H70 / *Human Fact Eng Sys Dev*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
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A. Mission Description and Budget Item Justification

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Interfaces for Collaboration and Decision Making	2.658	2.699	2.756
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 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.			
FY 2016 Accomplishments: Identified and investigated aspects of information displays and interfaces that best support the effective conduct of tactical intelligence; validated the effectiveness of interface type and information presentation techniques in experimental decision aids			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Army		Date: May 2017
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602716A / *Human Factors Engineering Technology*	**Project (Number/Name)** H70 / *Human Fact Eng Sys Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
such as the Warfighter Associate; and conducted research to identify elements critical to information display and presentation for the development of future decision aids applicable to civil-military, tactical (Company level), and cyber security. ***FY 2017 Plans:*** Will conduct fact extraction and analysis of data from complex networked teams (including civil-military), to inform development of technology for enhanced decision-making; and conduct research on data-to-decisions and decision-support technologies for cyber security, mission command and understanding of big data domains to enhance decision-making and collaborative performance. ***FY 2018 Plans:*** Will develop metric approach to quantify digital performance in human-system interactions; leverage current networking technology and recent advances in wearables and computer-mounted sensor technologies to collect and analyze large volumes of data to characterize behavioral, physiological, task-based and environmental factors influencing task performance and decision making of individuals and teams; develop cyber-security ontologies and scenarios to characterize human dynamics in the cyber domain using approaches such as game theory, artificial intelligence, cognitive modeling, multi-agent simulation, and online platforms for investigation.			
Title: Human Performance Modeling ***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. Efforts are coordinated with Program Element (PE) 0602786A/H98 (Clothing and Equipment Technology). ***FY 2016 Accomplishments:*** Enhanced the analytic capabilities and usability of current human performance modeling tools by incorporating cognitive distraction driving scales, updating military specialty lists and improving reporting and visualization capabilities; expanded human figure digital library by developing three-dimensional (3D) models of Air Soldier clothing and equipment items to perform early human figure modeling assessments of future aviation platform designs; investigated the importance of coping style and working memory capacity for improved prediction of cognitive performance while driving; and investigated the feasibility of incorporating Soldier Systems Engineering Architecture (SSEA) drawings and Human View concepts into the Improved Performance Research Integration Tool (IMPRINT) to improve system design predictions and drive design requirements early in acquisition. ***FY 2017 Plans:***	2.620	1.128	0.506

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will incorporate new cognitive demand scales and update micromodels within IMPRINT; and investigate the effects of physical and cognitive stress such as dehydration or vigilance on Soldier performance, and transition results to models. ***FY 2018 Plans:*** Will maintain and improve IMPRINT reporting and visualization capabilities; update new performance shaping functions within IMPRINT; research trustworthiness effects within communities and develop methods of using human performance modeling tools as a hybrid modeling architecture; and enhance accommodation modeling tools with improved H-point seated posture positioning for human figure modeling analysis.			
Title: Brain-Computer Interaction ***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 characterizing Soldier brain activity in operational contexts; real-time techniques to integrate neurally-based information into systems designs. ***FY 2016 Accomplishments:*** Investigated novel approaches for image analysis that fuse computer vision and brain-computer interaction technologies for enhanced target identification capabilities.capabilities. ***FY 2017 Plans:*** Will develop novel techniques that enable co-adaptation of multiple computer vision and brain-computer interface systems for distributed processing of large-scale image data. ***FY 2018 Plans:*** Will develop and integrate novel neural classification algorithms that enable brain-computer interaction technologies for image analysis to be used without requiring a calibration to the individual user.	3.273	2.288	3.540
Title: Dismounted Soldier Performance ***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. ***FY 2016 Accomplishments:*** Investigated the effects of cognitive stress on physical performance; developed techniques to employ basic science principals discovered in highly controlled laboratory experiments in more operationally relevant environments using more militarily relevant physical and cognitive stressors to enhance research results; conducted research to inform guidelines for equipment developers	6.221	7.507	5.256

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
and the Research and Development Centers that will enhance Soldier and small team performance; investigated the effects of small arms recoil on shooter performance and transition results to research and development centers and the United States (U.S.) Army Marksmanship Unit. ***FY 2017 Plans:*** Will examine the tradeoffs between ballistic armor coverage area, armor plate design and mobility to quantity the effect to Soldier performance; conduct research to provide a greater understanding of the effects of physical augmentation (such as exoskeleton devices) on Soldier performance; examine the effects of physical load mitigation technologies on physical performance; investigate the effects of motivation on cognitive performance for individuals and small teams; and examine the effects of prolonged physical stress on physical and cognitive performance. ***FY 2018 Plans:*** Will work to understand the underlying mechanisms by which physical load (equipment mass, physical fatigue, etc.) affects dismounted Soldier performance; investigate the effects of team interaction on operationally relevant cognitive and physical tasks; work to quantify the effect of human variability on the performance of small arms shooting accuracy, and determine ways of mitigating negative effects.			
Title: Human-Robot Interaction ***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). ***FY 2016 Accomplishments:*** Developed concepts for efficient Soldier-robot interaction and teaming, multimodal bidirectional communication between Soldiers and autonomous systems, and trust and transparency between Soldier and robot; and investigated the impact of social-cultural context on usage of autonomous systems in coordination with the ARL Autonomous Systems Enterprise partners. ***FY 2017 Plans:*** Will develop and assess multimodal bidirectional communication solutions, including natural language, gesture, and tactile methods, for effective Soldier-agent interaction and teaming; and develop models of trust and transparency as basis for human-centered design requirements for intelligent, autonomous systems. ***FY 2018 Plans:*** Will refine multimodal bidirectional communications solutions, including natural language and language-based methods, for effective Soldier-agent interaction and teaming; enhance models of trust and transparency to serve as basis for human-centered	2.965	2.998	3.054

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
design requirements for intelligent, autonomous systems; both bidirectional communications and trust and transparency will be considered in a variety of applications, including multi-human, multi – intelligent agent, distributed systems.			
Title: Understanding Socio-cultural Influence ***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. This work complements and is coordinated with PE 0602784A/T41 (Socio/Cultural Behavior) and PE 0602785A/790 (Personnel Performance & Training Technology). ***FY 2016 Accomplishments:*** Conducted experiments on the effectiveness of information presentation using the socio-culturally informed design principles; integrated cognitive framework into select experimental decision support and training tools and validated tools with experiments designed to determine if relevant socio-cultural information is presented effectively to enhance Soldier decision making in diverse environments. ***FY 2017 Plans:*** Will develop metrics and supporting models to map the effect of socio-cultural factors on Soldiers' decision-making, and improve asymmetric threat forecasting to inform battlefield operations; and develop representative algorithms of social-cultural variables to integrate into models that will predict adversary behavior. ***FY 2018 Plans:*** Will validate new social cultural representation models integrating civil affairs and intelligence social-cultural expertise into the US Army's Common Operating Picture to augment the Commander's military decision making process; identify sociocultural influences that facilitate teaming amongst socio-cultural diverse groups; develop an ontological framework of these influences and interactions to obtain a better understanding of cause and effect and to support predictive model development.	1.980	2.029	2.060
Title: Continuous Multi-Faceted Soldier Characterization for Adaptive Technologies ***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. ***FY 2017 Plans:***	-	1.600	2.259

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Will develop techniques to integrate behavioral, physiological, environmental, and task-based sensors to enable continuous low resolution multi-faceted monitoring of an individual. ***FY 2018 Plans:*** Will demonstrate capability for real-time performance assessment using novel techniques for aggregation, storage and access of individual specific, low-resolution, longitudinal data from a combination of behavioral, physiological and task domains.			
Title: Soldier Sensory Performance ***Description:*** Conduct Soldier-oriented research to understand the attentional and cognitive challenges of interpreting unaided and aided tactile signals, visual imagery, and auditory events in complex, dynamic battlefield environments. Results are used for enhancing sensory performance by providing the materiel development community with the knowledge necessary to effectively design systems that maximize mission effectiveness and survivability of the dismounted Soldier. ***FY 2016 Accomplishments:*** Conduced Soldier-centric research on personnel-borne improvised explosive device (IED) detection technologies to characterize operator/system strengths and constraints, and maximizing IED detection performance; conducted research on enhancements to night-vision goggle technologies, including studies designed to optimize processing parameters (e.g., image latency and frame rate) for electronically coupled night-vision and thermal detection systems; continued to support equipment development by providing human auditory performance data to Research Development and Engineering Centers (RDECs) in order to develop evaluation standards that are tied to the impact of auditory capabilities on operational requirements; conducted a study to examine the efficacy of two-way tactile communication to support squad-level communications; explored the integration of bone conduction technology communication systems into chemical, biological, radiological and nuclear protective masks to improve Soldier communication and validate their effectiveness in a field environment. ***FY 2017 Plans:*** Will develop models of target saliency and concepts for training methodologies to enhance IED detection performance; validate concepts of integrating bone conduction communications systems into chemical, biological, radiological and nuclear protective masks as an improvement to Soldier communication and performance; and characterize operator/system performance capabilities of night vision devices (NVDs) to support development of digital sensor technology.	1.444	1.485	-
Title: Training Effectiveness Research ***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	0.980	0.937	0.932

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
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. This effort leverages research from PE 0601102A/74A (Human Engineering) and will be transitioned to PE 0603015/S29 (Next Generation Training and Simulation Systems). ***FY 2016 Accomplishments:*** Identified user skills that are critical to interacting with intelligent, autonomous systems and appropriate methods for measuring the user's skill level; and identified and matured approaches for evaluating the effectiveness of various types of training to conduct select human operator tasks. ***FY 2017 Plans:*** Will develop automated performance measurement capabilities for use in evaluating the effectiveness of training; and conduct research on the integration of multi-sensor data (e.g. accuracy, communications, psycho-physiological, and/or movement/location) for automated measurement of critical training outcomes and perform validation studies assessing metrics (algorithms) of training performance in virtual test-bed and live training environments. ***FY 2018 Plans:*** Will refine research-based integration of multi-sensor data (e.g. accuracy, communications, psycho-physiological, and/or movement/location) for automated measurement of critical training outcomes; conduct research to validate training performance assessment algorithms for virtual test-bed and live training environments; refine and validate automated performance measurement capabilities for use in evaluating the effectiveness of training.			
Title: Soldier System Architecture ***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. This research supports the development of the SSEA and is coordinated with PE 0602786A/H98, 0603015A/S28, PE 0603710A/Project K70, PE 0602308A/C90, PE 0602787A/869, and 0603004A/232. ***FY 2016 Accomplishments:*** Developed model-based predictive analyses of Dismounted Infantry (DI) missions that will provide Department of Defense (DoD) leadership with analytic data to inform requirements development and trade-off decisions as early as Milestone A. These	1.079	1.000	1.004

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
analyses will integrate Human Systems Integration and Systems Engineering inputs to generate critical tasks combinations that provide the necessary analytical data to support cognitive workload measurement, MOEs, and MOPs for DI. ***FY 2017 Plans:*** Will develop an analysis methodology and proof of concept front end analysis tool for SSEA; and develop operational scenarios to examine cognitive, physical, and social aspects of performance to exercise within SSEA. ***FY 2018 Plans:*** Will conduct experiments on Soldier Resilience (arousal) and Effects of Stress on Soldier performance to shoot, move, and communicate. Purpose is to collect output data informing future model development and supporting SSEA scenarios at the tactical level of warfare. Will validate SSEA analysis methodology and proof-of-concept front-end analysis tool in a military relevant context.			
Title: Rapid Soldier Capability Enhancement ***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 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. ***FY 2018 Plans:*** Will investigate augmentation application, including timing, amplitude, and duration relative to biological and environmental signals, to understand functionality in varied and complex environments. Model performance and adaptation to augmentation agents in order to predict capability enhancement; investigate individual variability and short and long term adaptation to augmentation agents. Plan to investigate the extension of methods and metrics developed for single augmentation agent to the quantification of Soldier performance while using a system of augmentation agents.	-	-	2.760
Accomplishments/Planned Programs Subtotals	23.220	23.671	24.127

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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E. Performance Metrics

N/A