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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Army **Date:** February 2016

Appropriation/Budget Activity 2040: <i>Research, Development, Test & Evaluation, Army / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602308A / <i>Advanced Concepts and Simulation</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	26.505	27.862	27.688	-	27.688	28.631	31.345	31.970	32.609	-	-
C90: <i>Advanced Distributed Simulation</i>	-	20.262	21.041	20.589	-	20.589	23.203	24.820	25.315	25.821	-	-
D02: <i>Modeling & Simulation For Training And Design</i>	-	6.243	6.821	7.099	-	7.099	5.428	6.525	6.655	6.788	-	-

A. Mission Description and Budget Item Justification

This Program Element (PE) investigates and designs enabling technologies to create effective training capabilities for the Warfighter and supports the underpinning technologies and understanding to establish architecture standards and interfaces necessary for realizing the Army vision of creating a realistic synthetic "electronic battlefield" environment for use across the spectrum of doctrine, organization, training, leader development, materiel, personnel, and facilities (DOTLM-PF). Project C90 focuses on advancing component technologies required for real time interactive linking within and among constructive, virtual, and live simulation and training by refining technologies for advanced distributed interactive simulation. Project D02 further develops concepts for immersive training and learning environments with the Institute for Creative Technologies (ICT) at the University of Southern California, Los Angeles, California.

Work in this PE complements and is fully coordinated with PE 0601104A (University and Industry Research Centers), PE 0602785A (Manpower/Personnel/Training Technology), PE 0602786A (Clothing & Equipment Technology), PE 0602787A (Medical Technology), PE 0603001A (Future Warrior Technology Integration), PE 0603007A (Manpower, Personnel and Training Advance Technology), PE 0603015A (Next Generation Training & Simulation Systems) and PE 0603710A (Night Vision Advanced Technology).

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

Work in this PE is performed by the Army Research Laboratory, Human Research and Engineering Directorate, Simulation and Training Technology Center (STTC), Orlando, FL.

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B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	27.423	27.862	28.288	-	28.288
Current President's Budget	26.505	27.862	27.688	-	27.688
Total Adjustments	-0.918	0.000	-0.600	-	-0.600
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.918	-			
• Adjustments to Budget Years	-	-	-0.600	-	-0.600

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Army **Date:** February 2016

Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602308A / <i>Advanced Concepts and Simulation</i>				Project (Number/Name) C90 / <i>Advanced Distributed Simulation</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
<i>C90: Advanced Distributed Simulation</i>	-	20.262	21.041	20.589	-	20.589	23.203	24.820	25.315	25.821	-	-

A. Mission Description and Budget Item Justification

This project investigates and designs enabling technologies for advancing distributed simulation and training (live, virtual and constructive) environments. This includes networking of models representing complex human behavior, complex data interchange between simulations, synthetic natural environments, medical training simulations, ground platform training, adaptive tutoring for individuals and teams, and collaborative training. The project researches the ability to create a virtual representation of combined arms environments, with the Warfighter-in-the-loop that constructive (event driven) simulations cannot simulate.

Efforts in this program element support the Army science and technology Soldier/Squad portfolio.

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

Work in this project is performed by the Army Research Laboratory (ARL), Human Research and Engineering Directorate, Simulation and Training Technology Center (STTC), Orlando, FL.

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

	FY 2015	FY 2016	FY 2017
Title: Live, Virtual, Constructive (LVC) Simulations	7.912	8.124	6.975
Description: This effort develops and investigates LVC training technologies (tools and methods) to inform an interactive, seamless training environment. Live training refers to personnel and systems performing an exercise mission on real terrain; virtual training refers to personnel using simulators; and constructive training refers to computer based models representing real world behaviors that introduce a wider control of virtual forces. Develop methods and technologies that are transitioned to Program Element (PE) 0603015A/Project S29.			
FY 2015 Accomplishments: Developed the architecture for the Soldier-Centered Army Learning Environment (SCALE); investigated the next generation simulation architectures and environments for the integration and execution of LVC simulations to be employed by joint and coalition warfare forces during collective training and mission rehearsal exercises; completed and implemented component designs of natural and man-made synthetic terrain effects such as craters, building rubble, etc.; and assessed the training effectiveness of the attained levels of realism and immersion. The SCALE architecture integrated mobile and social media			

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>technologies to enhance the training effectiveness of individual Soldiers. The architecture development is consistent with the Army Learning Model (ALM).</p> <p>FY 2016 Plans: Investigate various component designs and developmental concepts of real world (physics-based) dynamic effects in terrain representation for use in the Army's One World Environment; research, develop and assess the use of the SCALE architecture in relevant use cases supporting the ALM; develop next generation simulation architectures and environments for the integration and execution of LVC simulations to be employed by joint and coalition warfare forces during collective training and mission rehearsal exercises; validate the effectiveness of select experimental tools and virtual environments on Soldier learning during joint and coalition training and mission rehearsal exercises; research the effect of technologies such as interoperable performance assessment, mobile application use, data analytics, and social media on the capability to conduct training and education on operational systems in support of United States Army Training and Doctrine Command (TRADOC) Army Learning Concept 2020-2040 goals; and develop a technique to measure, track, and manage general learning outcomes that will feed a continuous adaptive learning model.</p> <p>FY 2017 Plans: Will design and develop physics-based dynamic effect algorithms and synthetic terrain components to enable the Army's One World Environment for training; develop a cloud-based architecture to support adaptive training; develop prototype technologies, such as performance assessment, mobile application use, data analytics, and social media and assess impact on training and education for operational systems; validate methods to measure, track, and manage general learning outcomes that will feed a continuous adaptive learning model; and design and develop artificial intelligence algorithms to enable intelligent and believable behaviors of virtual characters that can be reused across virtual, constructive, virtual and gaming domains.</p>				
<p>Title: Modeling and Simulation Training Technologies</p> <p>Description: This effort investigates future simulation and training technologies across a variety of domains, requirements, and applications. It will include new technologies that can be applied to military domains such as live and medical training. Included in this effort will be the development of new medical training simulations to train medical personnel across all levels of care and the development of live training technology that can be applied across all military levels and training environments. The effort will address the training effectiveness of the simulation and training technologies being researched and how they will contribute to the overall effectiveness of new training capabilities.</p> <p>FY 2015 Accomplishments: Continued next generation Multiple Integrated Laser Engagement System (MILES) research in support of a live training program of record for home station and combat training center supporting Force-on-Force (FOF) training for Brigade Combat Teams (BCTs), battalions, companies, platoons, squads, crews and individuals; researched, measured, and characterized real human</p>		6.311	6.528	6.650

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>and simulated human tissue to derive performance requirements for future simulated tissue; researched embedded and external sensors to autonomously measure student performance inside and outside of the body; and investigated advanced three-dimensional (3D) visualization technologies and measured the impact on anatomical cognition for medical training.</p> <p>FY 2016 Plans: Design the laser component of the next generation MILES for a live training program of record at home stations and combat training centers supporting Force-on-Force training for BCTs; apply measured tissue properties to experimental simulations and validate its performance; apply sensors to simulated tissue to objectively measure human performance and validate tissue performance; research and develop immersive technologies to engage learners in game-based medical training.</p> <p>FY 2017 Plans: Will design and develop sensors and communication components to refine laser component design for next generation MILES capabilities; conduct research to characterize diseased and injured tissues to inform development of synthetic tissue; conduct research to simulate and model tissues in LVC platforms; investigate methods and technologies to assess human performance during training using high fidelity tissue/sensor solutions; and conduct research to assess human performance during medical training using various immersive hardware and software solutions.</p>				
<p>Title: Collaborative and Immersive Environment Technologies</p> <p>Description: This effort investigates adaptive tutoring and immersive learning environments with social simulations to conduct kinetic and non-kinetic training for individuals and teams.</p> <p>FY 2015 Accomplishments: Conducted research to develop best practices for automatically authoring, assessing, managing instruction, and deploying computer based tutoring systems (CBTS); designed and developed domain models (e.g., content, human interaction, and assessment standards); determined effectiveness for CBTS technologies; developed techniques and identified technologies that will lower the skills required to author CBTS (ALM); continued to incorporate research results in GIFT tutoring framework to enhance overall training effectiveness; and conducted follow-on efficacy studies on virtual world and game-based learning techniques for a blended learning approach to conduct kinetic and non-kinetic training.</p> <p>FY 2016 Plans: Conduct initial user validation studies of usage of CBTS authoring tools to supplement traditional classroom training with computer-guided tutoring per ALM; conduct research to expand intelligent tutoring system domain models to represent Army training domains; research, develop, and evaluate instructional models for unit-level team tutoring.</p> <p>FY 2017 Plans:</p>		5.056	5.189	5.764

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Will investigate the effectiveness of using realistic human driven avatars (puppeteering) in training applications on improving human performance; investigate effectiveness of current Army applied virtual distributed learning training; identify capability gaps in small team training as it relates to the Army's Synthetic Training Environment; develop automated authoring tools to supplement traditional classroom training with computer-guided tutoring per ALM; and mature intelligent tutoring system domain models to represent Army training domains; assess effectiveness of instructional models for unit-level team tutoring.</p> <p>Title: Soldier System Architecture</p> <p>Description: Research and develop simulation architecture to represent the Soldier as a System considering physiological effects, cognitive load, and Soldier culture in the context of Soldier-materiel interactions supporting training effectiveness, experimentation, and materiel development. The architecture will advance computational strategies to enable the integration and interaction of new and existing Soldier models into a seamless Soldier as a System simulation. This effort is coordinated with and complements PE 0602785/Project 790, PE 0602786/Project H98, PE 0602787/Project 869, PE 0603001/J50, and PE 0603710/Project K70.</p> <p>FY 2015 Accomplishments: Researched and designed a simulation architecture that supports the development of a Soldier as a System simulation; developed novel simulation solutions to link and synchronize models of human and system components; and established groundwork for implementing echelons of metrics to create trade space data for analyzing factors to include Soldier individual and team performance, system effectiveness, training requirements, and cost.</p> <p>FY 2016 Plans: Investigate the design of a simulation architecture that supports the development of a Soldier as a System simulation; investigate novel simulation solutions developed to link and synchronize models of human and system/equipment components; and develop metrics to analyze design tradeoffs between factors such as individual and team performance, system effectiveness, training requirements and cost.</p> <p>FY 2017 Plans: Will develop simulation components that link and synchronize models of human and system/equipment components to enable analysis within Soldier Systems Engineering Architecture; and investigate modeling & simulation framework limitations and propose remediation activities to enable cross-community/domain/user accessibility and re-use of modeling and simulation architectures.</p>		0.500	0.600	0.600
<p>Title: Future Autonomy – Optimizing Training Strategies</p> <p>Description: This effort will research and develop simulation architectures, tools, and models that can represent current and future semi and fully autonomous systems. The architecture, tools and models will enable the evaluation of the training impacts</p>		0.483	0.600	0.600

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>(i.e., cognitive, physiological, and team coordination) of future autonomous systems and technologies on individual, crew, and unit tasks. The training demands of systems that are increasingly complex, intelligent, and self-adaptive far exceed those of legacy systems that require training of primarily procedural tasks. This is compounded by parallel increases in autonomy and responsibility at lower echelons.</p> <p>FY 2015 Accomplishments: Researched and developed simulation architectures that represent current and future autonomous systems. The architectures incorporated current autonomous system attributes that enable the evaluation of their effects on individual and unit training.</p> <p>FY 2016 Plans: Research, develop and evaluate models, methods and tools to identify best practices for training with autonomous systems/ technology to assess the effectiveness of various training strategies consistent with Army doctrine.</p> <p>FY 2017 Plans: Will conduct experiments to assess effectiveness of best practice training strategies for autonomous systems.</p>				
Accomplishments/Planned Programs Subtotals		20.262	21.041	20.589
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				
E. Performance Metrics				
N/A				

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Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602308A / <i>Advanced Concepts and Simulation</i>				Project (Number/Name) D02 / <i>Modeling & Simulation For Training And Design</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
<i>D02: Modeling & Simulation For Training And Design</i>	-	6.243	6.821	7.099	-	7.099	5.428	6.525	6.655	6.788	-	-

A. Mission Description and Budget Item Justification

This effort transitions basic research into applied research. This project investigates and designs training applications to enable the Army to train any time and any place. Efforts include designing virtual humans that embody natural language, speech recognition in noisy environments, gesture, gaze, and conversational speech. Techniques and methods are assessed for integrating different sensory cues into virtual environments that result in enhanced training and leader development. The project leverages the capabilities of industry and the research and development community through the synthesis of creativity and technology, including work at the Army Research Institute and the Army Research Laboratory.

Efforts in this program element support the Army science and technology Soldier/Squad portfolio.

Developed technologies and techniques are transitioned for maturation and demonstration to Program Element (PE) 0603015A/Project S28 (Immersive Learning Environments).

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

Work in this project is performed by the Army Research Laboratory, Human Research and Engineering Directorate, Simulation and Training Technology Center (STTC), Orlando, FL.

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

	FY 2015	FY 2016	FY 2017
Title: Immersive Technology Environments	3.122	3.411	3.550
Description: Conduct applied research that enables responsive and reconfigurable environments that immerse human senses such as sight, sound, and touch in mixed reality environments to include physical elements providing touch and feel to simulate objects such as obstacles and walls.			
FY 2015 Accomplishments: Researched techniques for human spatial perception within virtual environment; investigated the effect of display configurations on social responses to virtual humans to increase immersive effects; and investigated outfitting displays with audio transducers and using psycho-acoustical effects methodologies to increase immersion and effectiveness during interactions with virtual humans.			
FY 2016 Plans:			

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Investigate the effect on trainee learning and emersion experience within a virtual environment when low-cost scanning sensors and data capture techniques are used to rapidly capture and insert avatars representing the appearance and behaviors of actual trainees; experiment with adding mobile communication devices to the virtual human architecture to examine long-term interactions with virtual coaches and mentors; and determine the effectiveness of using virtual humans for interviewing patients in support of assessing Post Traumatic Stress Disorder.</p> <p>FY 2017 Plans: Will investigate the use of reinforcement learning to adapt, modify and improve engagement strategies for virtual learning environments; improve and extend capabilities of online virtual support agents so that they can respond appropriately even when user inputs are only partially understood and can be used via mobile phone applications; and develop tools for simulated crowd generation.</p>				
<p>Title: Immersive Technology Techniques</p> <p>Description: This effort develops tools, techniques and technologies for improving the immersion of human senses within simulation environments and therefore creating enhanced realism.</p> <p>FY 2015 Accomplishments: Researched and evaluated situational authoring tools designed to enable non-technical users to create content for inclusion into intelligent tutoring systems; investigated new animation and natural language techniques for the development of web-based virtual humans to support on-line immersive learning environments; and explored techniques to rapidly recreate training scenario content.</p> <p>FY 2016 Plans: Conduct research to develop learner models for adaptive training environments focusing on strategies to increase learner attention and engagement; and investigate natural language computer processing techniques to translate real-world narratives into authorable interactive narratives for immersive environments.</p> <p>FY 2017 Plans: Will advance research on autonomous agents for capturing training performance of users in indoor environments, and investigate the capture of three-dimensional (3D) geometry from the robotic platform; investigate how real-world data can be acquired and incorporated into simulated environments to increase the degree of user immersion; investigate the use of reinforcement learning to adapt, modify and improve engagement strategies for virtual learning environments; and develop authoring tools to allow virtual humans to be created and maintained by collaborators and other external sources.</p>		3.121	3.410	3.549
Accomplishments/Planned Programs Subtotals		6.243	6.821	7.099

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C. Other Program Funding Summary (\$ in Millions) N/A		
Remarks		
D. Acquisition Strategy N/A		
E. Performance Metrics N/A		