Statement of Need

Title: Synthetic Training Environment (STE)

Technology Objective: Soldier/Team Performance and Overmatch

Technology Sub-Objective: Collective, Non-Systems Training Simulations

1.0 Background/Problem to Be Addressed/ Description of Requirement

The Training and Doctrine Command (TRADOC) Combined Arms Center for Training (CAC-T) as part of the initial development for Synthetic Training Environment (STE), the Army's next generation training environment, is seeking a comprehensive technology solution for reconfigurable virtual collective trainers that operate on a common Global Terrain capability. The current virtual Combined Arms Tactical Trainers require high-overhead; are mainly facilities based; and have a very limited global terrain capability. Current capabilities do not allow units to conduct training at the Point of Need (PoN)-where they train on the terrain they will fight on.

Problem Statement: The Integrated Training Environment (ITE) Training Aids, Devices, Simulators, and Simulations (TADSS) currently lack the ability to allow units and Soldiers to conduct realistic, multi-echelon, collective training, seamlessly from squad to Army Service Component Command (ASCC) echelons, anywhere in the world, and require significant training overhead (time, money, people) to utilize.

Description of Requirement and Strategy: Depending on their echelon and training objective, Soldiers will need many ways of participating in STE exercises that run on the Training Simulation Software supported by a Global Terrain or One World Terrain (OWT) capability.

CAC-T's overarching strategy is to accelerate development of these STE capabilities through an iterative technology demonstration approach, utilizing Other Transactional Authorities (OTAs) to enable the rapid creation of prototypes. These prototypes will be placed in the hands of operational units to gain user feedback and ensure our development efforts are meeting the user needs. This effort will follow a development operations (DEVOPS) methodology which is defined as warfighters and developers working together to enable rapid and frequent delivery of capabilities to the warfighter to inform a potential program of record.

The initial prototype effort will focus on the development of prototype capabilities for company level transportable and reconfigurable Virtual Trainers, Global Terrain, built upon a common Training Simulation Software, all delivered at the PoN. The intent of the Technical Demonstration is to place prototypes meeting these objectives into the hands of Soldiers NLT 1 July 2018 for user assessment and feedback.

2.0 Required Capabilities: The Common Synthetic Environment (CSE) is the unified simulation environment Units and Soldiers use for training. The CSE provides Soldiers and Units a realistic (e.g., physics-based effects), digital representation of the dynamic OE and the military capabilities in the

scenario; to support collective training from Squad through ASCC. Within the CSE, there are two conceptually different ways in which units in a virtual environment will need to interact with the STE:

Virtual Semi-Immersive User Interface and Hardware

Virtual Semi-Immersive interfaces are common 'keyboard and mouse' interfaces into a virtual three-dimensional (3D) representation of a training environment. While commonly referred to as 'keyboard and mouse', it may include additional peripherals, such as controllers and joysticks to enhance training, but are typically not intended to provide a full 'form, fit and function' representation of training conditions. This form of low-overhead reconfigurable training enables the crew/team through Brigade Combat Team to interact with the Common Synthetic Environment (CSE) and a digital representation of the Mission Command Information System (MCIS) interfaces and platforms for all Warfighting Functions (WfF) and a dismounted Soldier capability. The CSE is the unified simulation environment in which the training takes place. The interface will stimulate sight, sound and touch modalities. Sight allows the Soldiers to see the CSE (both two-dimensional [2D] overhead and 3D 1st/3rd person views), sound allows the Soldier to hear and provide voice input into the CSE, and touch allows the Soldier to interact with the CSE. The quality of stimulation is a low fidelity approximation of what the Soldier experiences in the live environment.

Virtual Immersive User Interface and Hardware

Virtual Immersive trainers will seek a higher level of 'form, fit, and function' for the training audience than the semi-immersive systems. These interfaces into the CSE replace the immersive Combined Arms Tactical Trainers (CATT) found in the Army inventory. However, unlike the large overhead of current CATT trainers, the STE will need low overhead, reconfigurable, and transportable trainers to facilitate training anytime, anywhere. To accomplish this, the STE will require the use of innovative Mixed Reality and Natural User Interface technologies to deliver the following capabilities:

- Software-centric implementation
- Capitalization on rapid advancements in commercial mixed-reality technologies
- Low sustainment and concurrency costs
- Scalable interfaces to support training, without disruption, at the PoN
- Rapid concurrency updates driven through software rather than hardware changes
- Immersive collective training experiences that support suspension of trainee disbelief
- Accurate visual and haptic system representation (e.g., sensors, weapons, survivability capabilities, communications) to prevent negative training transfer or habit formation
- Natural fields of view
- The breadth of tactical trainers supporting Ground and Air Simulation

Ground: This reconfigurable and transportable trainer enables ground platform crew/team through Battalion Task Force to interact with the CSE and a digital representation of the MCIS interfaces and platforms for all WfFs. The immersive trainer provides a motion tracking capability and select high-fidelity physical platform controls for crew members. The interface will stimulate sight, sound and touch modalities. Sight provides the Soldiers a natural field-of-view and allows the Soldiers to see the CSE from first person perspectives, sound allows the Soldier to hear and provide voice input into the CSE, and touch allows the Soldier to use physical and tactile controls of systems, subsystems, components, and

mission command information system interfaces to interact with the CSE. Key considerations for ground immersive training include:

- Vehicle Commander: Weapon system control and sensor controls.
- Driver capabilities: Steer vehicle, change gear (e.g., forward, reverse), accelerate vehicle, brake vehicle, and control/view dashboard.
- Gunner (combat vehicle): Weapon system control and sensor controls.
- Loader: Loader's periscope, loading main weapons systems, loader's weapons systems, radios.
- Gunner/Air Guard (wheeled vehicle): Grip, aim, fire, and reload weapon.

Air: This reconfigurable and transportable trainer enables aviation crew/team through Battalion Task Force to interact with a CSE, and a digital representation of the MCIS interfaces and platforms for all WfF. The immersive trainer provides a motion tracking capability and select high-fidelity physical platform controls for pilot, co-pilot, and non-rated crew members. The interface will stimulate sight, sound and touch modalities. An accurate representation of crew sensory inputs and feedback are critical. The relatively increased danger from crew error in aviation platforms necessitates an expectation of higher fidelity in Air immersive trainers. Flight, weapon controls, and non-crewmember controls must provide highly accurate tactile control and switch options relative to the aircraft's digital operational flight program (OFP) capabilities and be in the correct location relative to where the crew member is standing or sitting (e.g., collective is always on the left side, cyclic between the legs), to prevent negative training and habit transfer.

Pilot/Co-Pilot capabilities include dual flight controls to allow the pilot or co-pilot/gunner to fly the aircraft safely (Cyclic, Collective, Pedals). It also includes unique weapon systems interfaces (i.e., Target Acquisition and Display Sight (TADS) Electronic Display and Control (TEDAC) for Attack Helicopter [AH]). The TEDAC for the AH-64 is only for the co-pilot/gunner position.

Non-Rated Crewmembers capabilities include unique weapon interfaces (i.e. door gun) for the Utility Helicopter (UH) and Cargo Helicopter (CH); unique Intercommunications System (ICS) Switch and handheld push to talk capability (UH, CH); and unique hoist controls (UH and CH). Unique cargo hook view space (CH) hoist operations must provide a minimum level of tactile and visual feedback to ensure awareness of proper operations.

Unmanned Aircraft System (UAS) capabilities will include the realistic representation of unmanned systems, to include all kinetic and non-kinetic battlefield effects, as well as the appropriate affordances for user/operator interactions, in order to facilitate collective training.

Global Terrain/One World Terrain (OWT) Capability

The Global Terrain research effort is a demonstration of the global terrain capabilities needed to achieve the STE vision. This concept would ultimately include a cloud-based service that delivers a common synthetic representation of the whole Earth to include the air, land (includes subterranean), sea (includes undersea), space, and cyber domains that units will use for collective training. The STE's Global Terrain will be delivered over the network to training audiences at home station, while deployed, and at the institution. Global Terrain Capabilities include:

- A digital global with all terrain available to include full 2D, 3D and parametric information on all the buildings/structures, to include interiors and subterranean features, on the planet.

- Soldier-level fidelity of terrain available on a global scale.
- Training without boundaries that allows seamless integration of physical training areas into global scale wrap around exercises in the virtual and constructive training domains.
- Reuse and integration of a variety of data sources, from the reuse of existing training simulation terrain, such as Synthetic Environment - Core (SE-CORE) home station databases; to the importation of the Army's Standard Shareable Geospatial Foundation (SSGF), the use open source data, to the collection and processing of organic terrain collection data, such as drone-captured photogrammetry.
- The ability to export 3D mesh-based terrain to 2D vector- and raster-based terrain systems.

The Global Terrain Capability concept delivers a geographical representation of the entire 3D world in a geo-referenced ellipsoid representation of the Earth. The goal for data fidelity is to provide sub-centimeter resolution and accuracy in terrain, to support full live-synthetic entity interaction in a 'fair-fight' environment. OWT will need to provide the best available terrain representation, from geo-typical to geo-specific, based on authoritative data, while making use of innovative approaches in procedural terrain generation and sensor fusion to constantly improve the quality of the available global terrain.

Additionally, training units will need a capability that allows runtime editing of exercise specific environments to set conditions needed to meet training objectives. Configuring operational variables (Political, Military, Economic, Social, Information, Infrastructure, Physical Environment, and Time [PMESII-PT]) that represent the Operational Environment (OE) enables the CSE to represent unique OE complexities. This provides enhanced realism for a realistic training experience without artificial limitations.

Standards and Architecture

The STE will break new grounds in how simulation-based collective training is developed and conducted for the Army. To set the proper conditions for this desired innovation, latitude will be afforded in the internal architecture and standards of the STE systems, so as to allow the Army to take advantage of cutting edge technology in our training. The base requirement, however, is that this internal architecture will be extensible and employ a Modular Open System Architecture (MOSA) strategy.

Externally, however, the STE will not exist alone, but rather operate within the larger Army Enterprise. Most immediately, the STE will have to support interoperation with Mission Command Information Systems (MCIS), Live TADSS and the current Live Virtual Constructive - Integrating Architecture (LVC-IA) systems, as well as authoritative data sources such as the Army Training Information System (ATIS). The STE will also have to support interoperability with current Army and Joint systems, and be extensible to support future systems as they are deployed. These interfaces from the STE to other systems will have to adhere to applicable standards for interoperability consistent with these systems. Additionally, the STE will have to operate over Army networks and adhere to standards defined by the Army's Common Operating Environment (COE).

3.0 Milestones / Deliverables

The objective is to design, develop, and demonstrate OWT, Virtual Semi-Immersive User Interface and Hardware and Virtual Immersive User Interface and Hardware in July 2018. White paper submissions shall present an OWT capability that supports both air and ground for both semi-immersive and virtual

immersive capabilities. The estimated ROM shall be broken out for each capability (OWT, semi immersive ground, semi immersive air; virtual immersive ground, virtual immersive air) as the Government may initially fund only the capabilities.

CAC-T will hold a technology demonstration and user assessment of industry capabilities in July 2018. CAC-T will assess the ability of industry capabilities to meet the STE vision, and identify priorities to support research and development needed to close remaining technological gaps. Participants in the July 2018 technology demonstration and user assessment will, at a minimum, demonstrate:

- Four immersive, collective, reconfigurable and transportable, virtual trainers for mounted training.
- Twelve semi-immersive, dismounted collective trainers.
- Simulation software delivered to the Point of Need.
- Uses Global Terrain built on a standard sharable geospatial foundation for all training.
- Training Simulation Software that works across all trainers, all environment (i.e., virtual and constructive), handles at least 40,000 entities, and scales to over 2+ million entities. While architecture decisions may impact what constitutes an entity, we generally define entities as independent objects with complex behaviors and attributes (e.g., personnel, vehicles, complex munitions, and key communications devices).
- Risk Management Framework compliance assessment
- An analysis of network (bandwidth and latency) constraints.
- Must interoperate with the LVC-IA to facilitate bridging with current training systems.

The solution should include all hardware, software, technical documentation, and cyber security testing documentation that shows how the solution meets cyber security needs. The solution should interface with current MCIS interfaces and platforms for all WfF, and should operate with current and future game based training engines within an open architecture. NLT July 2018 the government will assess a solution with the capabilities defined above to determine if it is a viable solution to provide a capability to field as an interim virtual collective trainer capable of mitigating critical capability gaps, to include training at the PoN.

These limited objectives for July 2018 highlight minimum goals, given the timeline and current CAC-T assessment of technology readiness. Do not construe these minimum goals as limitations. We encourage demonstrators or interested parties who believe that current technology allows us to exceed these minimums to do so. Developing the STE in a timely and cost efficient manner requires close cooperation between the Army, Industry, and Academia. This July 2018 technology demonstration and user assessment is one step in a cooperative process to deliver a leap forward in Army collective training and readiness.

Appendix A: Glossary

Appendix B: STE Overarching Concept Paper

Appendix C: Iterative Approach

Appendix A: Glossary

Term	Definition	Acronym
After Action Review	A structured review or de-brief process for analyzing what happened, why it happened, and how it can be done better, by the participants and those responsible for the project or event.	AAR
Aggregate (unit)	A group of entities or a group of other aggregates considered as a single unit. The substitution of the word "unit" is used to avoid phrases like "aggregate -aggregate." (IEEE Std 1278.1-2012)	
Army Enterprise Network	cf., LandWarNet	
Army Requirements Oversight Council	The AROC, coordinated by DCS, G-3/5/7, Current and Future Warfighting Capabilities Division (DAMO-CIC), is responsible for advising the G-3 / VCSA in the assessment and prioritization of capabilities integrated across DOTMLPF-P, to include the disposition of MCDs. (HTAR 2015-2016)	AROC
Army Service Component Command	Command responsible for recommendations to the joint force commander on the allocation and employment of Army forces within a combatant command. Also called ASCC. (JP 3-31)	ASCC
Army Training Information System	ATIS provides training information to a training environment role-based, Common Operational Picture (COP), similar to the warfighting force, to more efficiently produce, manage, and disseminate Army training information. ATIS will provide the Training Environment COP equivalent to the Operational Environment COP. This allows individuals and leaders to train the way they fight, using doctrinal processes and tools to Plan, Prepare, Execute and Assess training. Executing a training plan is executing mission command training by providing Commanders the ability to plan, develop and schedule training in all three training domains - Operational, Institutional and Self-Development (O/I/SD). ATIS will provide the ability to track the individual training of Soldiers throughout their career and as a unit collective during Force Generation. ATIS will provide transparency of training resource utilization. ATIS supports tracking individual Soldier training records and status as they move from one unit to the next. ATIS complies with the Joint Information Environment (JIE) strategy of enabling every user to plug in and connect an approved device, anywhere they are -- at home, at work, or on the move -- and get the information they need in a secure, reliable fashion.	ATIS
Artificial Intelligence	The capacity of a computer to perform operations analogous to learning and decision making in humans, as by an expert system, a program for CAD or CAM, or a program for the perception and recognition of shapes in computer vision systems. The STE will use AI to replicate large unit level routines to increase realism of the operational environment, to support automated adaptive behaviors and free-thinking hybrid threats, to represent culturally aware virtual humans and small units, to mimic unit behaviors when they are not present, to support communication and interfacing techniques with the environment and other entities/agents, and to ease the application for a military user base.	AI
Big Data	Big Data refers to analytical techniques that make use of trend identification in sufficiently large data sets. Two primary techniques used for Big Data analytics are Clustering and Prediction. Clustering is a process of grouping like records or objects, frequently using Machine Learning. Prediction is the process of using similarity identified through clustering to predict potential future effects and benefits. The availability of data within the STE will be exploited by these analytical approaches to tailor training to optimize outcomes. In general, this will involve clustering similar collective training audiences (whether companies, platoons, or squads), and then making training recommendations based on what has been effective or beneficial training within a given unit's cluster.	BD

Term	Definition	Acronym
Cloud Computing	Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.	
Cloud Environment	cf., Cloud Computing	
Combined Arms Center – Training	Develops training requirements, fields training systems, delivers leader training and sustains training capabilities to support Army institutional and operational training of Soldiers, leaders, and units to successfully execute Unified Land Operations in complex, ambiguous environments.	CAC-T
Common Operating Environment	The COE is an approved set of computing technologies and standards applied across six Computing Environments (CE): Command Post, Mounted, Mobile/Handheld, Real Time/Safety Critical/Embedded, Sensor, and the Data Center/Cloud/Generating Force. As a strategic Army initiative, and as an integral part of the LandWarNet and the Joint Information Environment, the COE is a foundational component of the Army's modernization strategy. It aligns development and migration of Army programs to a common software baseline and a centralized hardware procurement process across the COE and within the Computing Environments.	COE
Common Synthetic Environment	The STE will leverage existing and emerging technologies to replace select stove-piped collective non-systems Training Aids, Devices, Simulators, and Simulations (TADSS). The STE will converge current gaming, virtual and constructive training capabilities into a common synthetic environment. A Common Synthetic Environment (CSE) will provide the core architecture that allows models to interface with each other, the STE Artificial Intelligence (AI) representations, the One World Terrain (OWT) and Big Data (BD). The CSE must also provide the capability to distribute its synthetic representations as required by the STE Point of Need (PoN) functionality.	CSE
Computing Environment	A logical grouping of systems with similar characteristics used to organize the COE (deployment /echelonment *(sic)*, environmental, transport dependencies, form factors, etc.). A computing environment comprises the necessary hardware, operating system, libraries and software required to run applications within the COE. (COE CCC IS-CDD DRAFT 5-Oct-2016)	CE
Concurrency	Concurrency is the state of a simulated system such that the capabilities, fidelity, and upgrades for it and its subsystems, components, ancillary devices, and peripherals match those of the real-world system.	
Constructive Training	Models and simulations that involve simulated people operating simulated systems. Real people stimulate (make inputs) to such simulations, but are not involved in determining the outcomes.	
Cross-Functional Team	A cross-functional team is a group of people with different functional expertise working toward a common mission and goal. The TCM will lead a team composed of a PM (O6 PM, best to receive someone not currently associated to a PoR), tester, cost analyst, contracting, S&T.	CFT
Department of Defense Information Network	The globally interconnected, end-to-end set of information capabilities for collecting, processing, storing, disseminating, and managing information on demand to warfighters, policy makers, and support personnel. The DoDIN includes owned and leased communications and computing systems and services, software (including applications), data, security services, other associated services, and National Security Systems (NSS). Non-DoDIN Information Technology (IT) includes stand-alone, self-contained, or embedded IT that is not, and will not be, connected to the enterprise network.	DoDIN

Term	Definition	Acronym
Developmental Operations	In the context of the CFT effort, the Developmental Operations (DevOps) approach is defined as warfighters and developers working together to enable rapid and frequent delivery of capabilities, to quickly inform a potential program of record. It embraces rapid prototype iteration and collection of feedback from the user to improve the product. The CFT may or may not make specific use of continuous software releases and automated toolchains traditionally associated with DevOps, but will embrace the philosophy of rapid releases and user feedback.	DevOps
Distributed Exercise	An exercise enabled by distributed simulation where the training participants are at different locations (i.e., different cities, countries or continents).	
Elastic	In cloud computing, elasticity is the measure of how well a system adapts to workload changes by provisioning and deprovisioning systems to match the demand as closely as possible.	
Environment	The texture or detail of the natural domain, that is terrain relief, weather, day, night, terrain cultural features (cities or farmland), sea states, etc.; and the external objects, conditions, and processes that influence the behavior of a system. [18]	
Experience	The process of doing and seeing things and having things happen to you.	
Extensible	An extensible system is one which takes future growth into consideration during implementation.	
Fair Fight	A Fair Fight is when the performance characteristics of two or more interoperating simulations are seamless, preventing discrepancies in simulation algorithms or environmental representation from effecting the outcome of cross environment simulation exercises.	
Fidelity	The degree to which a model or simulation represents the state and behavior of a real-world object or the perception of a real world object, feature, condition, or chosen standard in a measurable or perceivable manner; a measure of the realism of a model or simulation.	
Form, Fit and Function	Technical data (TD) pertaining to items, components, or processes for the purpose of identifying source, size, configuration, mating and attachment characteristics, functional characteristics, and performance requirements.	
Future Virtual Collective Trainer	The Future Virtual Collective Trainers are the set of semi-immersive trainers and immersive vehicle platform collective trainers for battalion and below formations. The level of immersion and fidelity experienced will vary based on the user interface.	FVCT
Gaming	Commercial and government-off-the-shelf computer generated environment for interactive, semi-immersive training and education.	
Global Terrain Capability	The Global Terrain Capability concept delivers a geographical representation of the entire 3D world in a geo-referenced ellipsoid representation of the Earth. The goal for data fidelity is to provide sub-centimeter resolution and accuracy in terrain, to support full live-synthetic entity interaction in a ‘fair-fight’ environment.	
Haptic	Refers to all the physical sensors that provide a sense of touch at the skin level and force feedback information from muscles and joints.	
Immersed	Sight, sound, and touch modalities are stimulated. The quality of stimulation approximates what the Soldier experiences in the Live Environment.	
Immersion	The placing of a human in a synthetic environment through physical and/or emotional means.	
Immersive	cf., Immersed	

Term	Definition	Acronym
Integrated Training Environment	The Army's Integrated Training Environment (ITE) is current array of Training Aids, Devices, Simulations and Simulators (TADSS) that enable Army Collective, Non-Systems Training. The ITE is a system of systems that, by design, combines and connects key training enablers in a persistent and consistent manner to accurately train Mission Command (MC) according to the Commander's training objectives within the appropriate Operational Environment. The ITE Implementation and Management Plan (I2MP) describes how the Army aligns ITE system of systems requirements, funding and solutions to create incremental ITE capabilities to support Home Station Training with a focus on Brigade and below by 2020. The plan is a living document developed cooperatively by the Deputy Commanding General, Combined Arms Center – Training and the Program Executive Officer, Simulation Training and Instrumentation. The plan covers the stakeholders; organizations; roles; responsibilities; high-level governance and systems engineering approaches; tasks; and schedules involved in developing incremental ITE capabilities.	ITE
Intelligent Tutoring	cf., Intelligent Tutoring System	
Intelligent Tutoring System	The mechanism or technologies (tools and methods) to provide tailored training and educational experiences; adaptive tutoring systems respond to changing states in the learner and changing conditions in the training environment to optimize learning; adaptive tutoring systems anticipate and recognize teachable moments. The STE will use ITS for Team and Unit Modeling, Automated Enterprise Hotwash and After-Action Review (AAR), Affective/Cognitive Modeling Capabilities, Training Effectiveness/Human Performance Measurement, Authoring Tools to Extend Applicability Across Training Domains, Domain Modeling across a range of dynamic military tasks, and elements of the Human Dimension to drive the cognitive, social, and physical skills of Soldiers over their career (Long-term Learner Modeling).	ITS
Interoperability	The ability of a model or simulation to provide services to and accept services from other models and simulations, and to use these exchanged services to operate effectively together. (SISO-REF-002-1999)	
LandWarNet	The LandWarNet (LWN) is the Army's application of cyberspace within the Global Information Grid (GIG). To support global expeditionary operations the LWN must be operationalized, achieve unity of effort, reduce complexity and establish a single Army Enterprise Network (AEN). The LWN supports Geographic Combatant Commanders by providing a global "plug and play" capability for Army and Joint, Interagency, Intergovernmental, and Multinational (JIIM) mission partners. The LWN ICD describes the direct and supporting capabilities of this enterprise network at and above the C/JTF or "outside of the tactical formation". The Network Enabled Mission Command (NeMC) ICD describes the network and information capabilities required to provide and extend warfighting and generating force functions below the C/JTF or "inside the tactical formation".	LWN
Live, Virtual, Constructive - Integrating Architecture	The Army's program of record that provides the common software, protocols, standards, and interfaces to facilitate interoperability of currently non-linked LVCG TADSS so that they can interoperate, share information, provide common views of the battlefield, and stimulate MC systems. The LVC-IA will be developed and fielded in increments (notionally two years) and is the key technical enabler foundation of the ITE. The Live, Virtual Constructive Integrating Architecture (LVC-IA) is the Program of Record that establishes initial interoperability and over time, the integration of Live, Virtual, Constructive and Gaming Simulations and Simulators and the stimulation of Mission Command Systems.	LVC-IA
Master Enumeration List	Provides a single source repository enumeration definitions.	MEL

Term	Definition	Acronym
Master Scenario Event List	The MSEL is a chronological list that supplements the exercise scenario with event synopses; expected participant responses; capabilities, tasks, and objectives to be addressed; and responsible personnel. It includes specific scenario events (or injects) that prompt players to implement the plans, policies, and procedures that require testing during the exercise, as identified in the capabilities-based planning process. It also records the methods that will be used to provide the injects (i.e., phone call, facsimile, radio call, e-mail).	MSEL
Mission Command	The exercise of authority and direction by the commander using mission orders to enable disciplined initiative within the commander's intent to empower agile and adaptive leaders in the conduct of full-spectrum operations; commander-led and blends the art of command and the science of control to integrate the warfighting functions to accomplish the mission. (ADP 6-0)	MC
Mission Command Information Systems	MCIS combines data and information from the warfighting functions to support common CP activities that contribute to the commander’s ability to understand, visualize, describe, direct, lead, and assess operations.	MCIS
Mixed Reality	cf., Mixed Reality Continuum	MR
Mixed Reality Continuum	A spectrum spanning between the physical reality and virtual reality according to the proportional composure of the physical and virtual data representations.	
Multi-Domain	Multi-Domain Battle allows US forces to outmaneuver adversaries physically and cognitively, applying combined arms in and across all domains. It provides a flexible means to present multiple dilemmas to an enemy and create temporary windows of localized control to seize, retain and exploit the initiative. Employing Multi-Domain Battle, Army and Marine forces with cross-domain capabilities provide a credible capability to deter adversary aggression, deny enemy freedom of action, overcome enemy anti-access and area denial (A2AD), secure terrain, compel outcomes, and consolidate gains for sustainable outcomes.	

Term	Definition	Acronym
One World Terrain	The One World Terrain (OWT) research effort is a demonstration of the global terrain capabilities needed to achieve the STE vision. This concept would ultimately include a cloud-based service that delivers a common synthetic representation of the whole Earth to include the air, land (includes subterranean), sea (includes undersea), space (up to geosynchronous), and cyber domains that units will use for collective training. The CSE will represent the complexities of the complex operational environment, providing enhanced realism for a realistic training experience without artificial limitations. The STE's Global Terrain will be delivered over the network to training audiences at home station, while deployed, and at the institution. These Global Terrain Capabilities include: · "Google Earth" like terrain availability that includes full 3D and parametric information on all the buildings/structures, to include interiors and subterranean features, on the planet. · Soldier-level fidelity of terrain available on a global scale. · Training without boundaries that allows seamless integration of physical training areas into global scale wrap around exercises in the virtual and constructive training domains. · Reuse and integration of a variety of data sources, from the reuse of existing SE CORE home station databases; to the importation of the Army's Standard Shareable Geospatial Foundation (SSGF), the use open source data, to the collection and processing of organic terrain collection data, such as drone-captured photogrammetry. · The ability to export 3D mesh-based terrain to 2D vector- and raster-based terrain systems The STE represents a concept in M&S that has not yet been realized -- a single system capable of simulating across the entire spectrum of capabilities seen in virtual, constructive, and game-based (VCG) systems. To achieve this, there is a need for a single, global planetary engine to drive the training and simulation requirements. Core to this engine is a global terrain database that is complete, updated regularly, and capable of being reasoned across the VCG continuum. However, achieving this vision involves investment across a variety of geospatial disciplines from collection to application. Currently only small portions of a global simulation database have been constructed, and even in areas with data, it is often only useful for a single type of system or simulation. Moving towards a more complete dataset is the immediate need, followed by the ability of the data to be reasoned on. This will be achieved by investing in all parts of the terrain pipeline -- Collection, Creation, Storage, Distribution, and Application.	OWT
Open Software Architecture	The Department of Defense's (DoD) modular open systems approach (MOSA) is to design systems with highly cohesive, loosely coupled, and severable modules that can be competed separately and acquired from independent vendors. This approach allows the Department to acquire warfighting capabilities, including systems, subsystems, software components, and services, with more flexibility and competition. MOSA implies the use of modular open systems architecture, a structure in which system interfaces share common, widely accepted standards, with which conformance can be verified. (ODASD)	
Operational Environment	(DOD) A composite of the conditions, circumstances, and influences that affect the employment of capabilities and bear on the decisions of the commander. Also called OE. See ADRP 3-0 and ADRP 6-0.	OE
Other Transactional Authority	Other transactions Authority (OTA) is the term commonly used to refer to the 10 U.S.C. 2371 (Prototyping) / 10 U.S.C. 2373 (Research) authority to enter transactions other than contracts, grants or cooperative agreements.	OTA

Term	Definition	Acronym
Point of Need	The STE PoN concept provides a collective training capability to training audiences of all components at home stations (e.g., installations, combat training centers [CTCs], armories, reserve centers, Regional Collective Training Centers [RCTC], etc.), while deployed, and at the institution. The STE Point of Need functional area has five task groups: Networking and Cloud Technology, Exercise Control / Synch and Scenario Generation / Initialization, User Interface / Contextual Input and Support for Various Platforms, Single Client Install or Web Application Access Gateway to access entire training system / environment (elimination of federated training systems), and Common Risk Management Framework that links to Mission Command.	PoN
Realism	Fine Arts. Treatment of forms, colors, space, etc., in such a manner as to emphasize their correspondence to actuality or to ordinary visual experience.	
Scalable	The capacity to be changed in size or scale.	
Semi-Immersed	Sight, sound, and touch modalities are stimulated. The quality of stimulation is a low-fidelity approximation of what the Soldier experiences in the Live Environment.	
Semi-Immersive	cf., Semi-Immersed	
Synthetic Environment	The integrated set of data elements that define the environment within which a given simulation application operates. The data elements include information about the initial and subsequent states of the terrain including cultural features, and atmospheric and oceanographic environments throughout an exercise. The data elements include databases of externally observable information about instantiable entities, and are adequately correlated for the type of exercise to be performed. Also known as virtual world. (IEEE Std 1278.1-2012) [10] Virtuality Continuum: “The Virtuality Continuum is a continuous scale ranging between the completely virtual, a virtuality, and the completely real, reality. The reality-virtuality continuum therefore encompasses all possible variations and compositions of real and virtual objects.” [2] Virtual: An entity or data that is derived from a modeled or simulated representation of the actual or anticipated system.	SE

Term	Definition	Acronym
Synthetic Training Environment	The Training and Doctrine Command (TRADOC) Capability Manager Integrated Training Environment (TCM ITE) is the STE capability developer. The TCM ITE vision is to converge current Gaming, Virtual, and Constructive training capabilities into a STE that integrates with the Live training environment. The army will use the STE for collective mission command and combined arms training in the operational and institutional training domains. The black border in Figure 1 represents the STE capability. The blue dashed border represents the STE in the context of a joint, live, and synthetic training event. The STE will provide three major capabilities: • Training Design and Management: These capabilities enable Commanders, Staffs, and support personnel to plan, prepare, execute, and assess collective training events. • Training Simulation: The Training Simulation provides a realistic, physics-based digital representation of the dynamic operational environment and the military capabilities in the training scenario. The Training Simulation adjudicates the interaction of Soldiers, Units, computer-generated forces (CGF), environmental effects, weather, weapons effects, and operations to ensure "fair fight" outcomes. The Training Simulation will provide aggregate, entity, and common services to create the Single Synthetic Environment (SSE). • Synthetic Collective Trainer: The Synthetic Collective Trainer (SCT) provides the training audience with the set of platform and collective trainers to interact with the SSE. The output of the Training Simulation is the Single Synthetic Environment (SSE). Soldiers see and interact with the SSE using Synthetic Collective Trainers, Mission Command Information Systems (MCIS), Live Instrumentation, and Augmented Reality. The black filled boxes around the center graphic show the primary alignment of the market research areas to the STE capability. For example, terrain aligns to both the Training Design and Management capability (preparation of simulation ready terrain data) and the Training Simulation capability (run time rendering of the synthetic environment to the training audience). Another example is delivery from the cloud and data storage (envisioned in the cloud). These apply to the entire STE capability based on the Point of Need vision.	STE
Technology Readiness Level	Technology Readiness Levels (TRL) are a method of estimating technology maturity of Critical Technology Elements (CTE) of a program during the acquisition process. They are determined during a Technology Readiness Assessment (TRA) that examines program concepts, technology requirements, and demonstrated technology capabilities. TRL are based on a scale from 1 to 9 with 9 being the most mature technology. The use of TRLs enables consistent, uniform, discussions of technical maturity across different types of technologies. Decision authorities will consider the recommended TRLs when assessing program risk.	TRL
Training Aids, Devices, Simulators, and Simulations	Training aids, devices, simulators, and simulations (TADSS) replicate OE complexities (training role-players, IED simulators, MILES, small arms) to a low-fidelity environment (low fidelity as defined by Army training directives).	TADSS
Training Effectiveness	Evaluation of the impact of training and educational tools and methods on usability, learning, comprehension, performance, retention, reasoning, and transfer of knowledge and acquired skills to the operational environment.	
Training Simulation	cf., Training Simulation Software	
Training Simulation Software	The Training Simulation Software (TSS) is the simulation software engine within which the synthetic environment operates. The TSS provides Soldiers and Units a realistic (e.g. physics-based effects), Single Synthetic Environment (SSE); a digital representation of the dynamic operational environment and the military capabilities in the scenario; to support collective training from squad through Army Service Component Commands (ASCC).	TSS

Term	Definition	Acronym
Unified Action Partners	Unified action partners are those military forces, governmental and nongovernmental organizations, and elements of the private sector with whom Army forces plan, coordinate, synchronize, and integrate during the conduct of operations.	UAP
US Army Training and Doctrine Command	Recruits, trains, and educates the Army's Soldiers; develops leaders; supports training in units; develops doctrine; establishes standards; and builds the future Army (AR 10-88)	TRADOC
Universal Joint Task List	The UJTL defines tasks and functions performed by Army elements operating at the operational and strategic levels of war. The UJTL provides an overall description of joint tasks to apply at the national strategic, theater strategic, operational, and tactical levels of command. The UJTL also provides a standard reference system used by United States Army Training and Doctrine Command (TRADOC) combat developers for analysis, such as front-end analysis of force element capabilities. Each military Service is required to publish its own tactical task list to supplement the UJTL. (FM 7-15)	UJTL
Unmanned Aircraft System	An unmanned aircraft system (UAS), sometimes called a drone, is an aircraft without a human pilot onboard – instead, the UAS is controlled from an operator on the ground. (Federal Aviation Administration)	UAS
Virtual Human	Virtual entities which replicate U.S., Allies, enemies, and non-combatants to facilitate individual and unit training in ambiguous and complex environments. (ACTE ICD). Virtual humans are intended to mimic a broad range of human behaviors and characters for these domains, they must integrate a diverse set of graphics, AI technologies, and domain knowledge. (Building Interactive Virtual Humans for Training Environments, USC ICT, I/ITSEC 2007)	
Virtual Training	A simulation involving real people operating simulated systems. Virtual simulations inject human-in-the-loop in a central role by exercising motor control skills, decision skills, or communication skills.	
Visualization	The formation of an artificial image that cannot be seen otherwise. Typically, abstract data that would normally appear as text and numbers is graphically displayed as an image. The image can be animated to display time varying data. (SISO-REF-020-2007) [10] World View: The view each simulation entity maintains of the simulated world from its own vantage point, based on the results of its own simulation and its processing of event messages received from all external entities. See: entity perspective.	
Warfighter Training Support Package	A WTSP is a complete, detailed, exportable package integrating training products, materials, and information necessary to support operating force training. WTSPs provide the actual details for securing the materials, training venues, and other necessary resources identified in each Unit CATS training event supporting the HQDA-approved METLs for designated units. A WTSP is a product that uses ADDIE.	WTSP
Warfighting Function	A group of tasks and systems (people, organizations, information, and processes), united by a common purpose that commanders use to accomplish missions and training objectives. (ADRP 3-0)	WfF

Appendix B: Synthetic Training Environment (STE) Concept

What is the Synthetic Training Environment (STE)?

The STE is the Army's next generation collective training system. FM 7-0 highlights the need for tough, realistic, and challenging training, while the enduring requirement for responsible stewardship of Army resources demands training tools as efficient, effective, and adaptable as possible to maximize limited time and resources. The STE simultaneously increases the realism and availability of training opportunities while streamlining their costs. The Army will use the STE to meet the demands of the future strategic, operational, and tactical environments.

The STE fields the Army's first truly converged simulation capability, allowing commanders to conduct the multi-echelon, combined arms training that our Units need to win in a complex world. The STE will support exercises from operational training at the ASCC level to tactical training at the Squad and platoon level. The STE must support this range of training simultaneously as well as in discrete training events at each echelon. To accomplish this, the STE will need to allow Units to train not only across the constructive and virtual training environments, but across live and synthetic training environments as well. The interaction across these environments need to support real-time, entity-level interactions without latency, and without the need for artificial boundaries between environments to hide and prevent fair fight issues. This will enable Soldiers and Units to train as they fight against a wide array of opposing forces.

Another key feature of the STE is the ability of Soldiers and Units to access its wide range of training capabilities, Operational Environment (OE) representation, anytime, anywhere. Active, Reserve and Guard Units and civilians will all use the STE for multi-echelon, collective training at the point-of-need (PoN) in the Operational and the Institutional training domains. PoN includes home stations (e.g., administrative buildings, motor pools, training buildings, local training areas [LTAs], combat training centers [CTCs], armories, reserve centers, Regional Collective Training Centers [RCTC]), while deployed, and at training and educational institutions. The STE concept envisions delivering training content from the cloud to the PoN using the Department of Defense Information Network (DoDIN) and operational networks.

Additionally, the STE will need to provide unprecedented ease-of-use. It needs to enable Commanders, Staffs, and support personnel the ability to plan, prepare, execute, and assess training events with minimal overhead support. The STE should provide a sustainable, easy-to-use, low overhead, and intuitive training capability that empowers Units to take control of their training and increase exercise iterations. This builds readiness faster and delivers a force capable of conducting multi-domain operations, essential to success on the modern battlefield. Increased Unit mission readiness will increase overall Army Readiness and reduce operational risk for a globally responsive and regionally engaged force. Realistic and repeatable collective training on combined arms maneuver and mission command is a key to entering live training at higher levels of proficiency and building operational readiness faster.

Overarching Strategy to Achieve STE:

In July 2017, the Army Requirements Oversight Council (AROC) Capabilities Board (ACB) approved the training gap, the STE concept, and requirement. The capability gap examined by the ACB is that the Army has fallen behind in the realm of synthetic technology. Specifically, there is a gap in the ability to conduct and integrate multi-echelon and distributed synthetic (virtual, gaming, and constructive) training either as a stand-alone capability or integrated into the live training or real world mission

rehearsals delivered at the PoN. The Army requires a converged Live, Virtual, Constructive, and Gaming common synthetic environment that allows Units to train as they will fight, with whom they will fight, and where they will fight. It will provide Units the repetitions required to achieve mastery of the diverse individual through collective tasks necessary to win decisively in Multi-Domain Battle.

The ACB determined that the Army required a new STE approach that keeps pace with commercial virtual, gaming, and constructive simulation technologies, which we currently lag behind. STE requires cost-effective synthetic training capabilities that make positive contributions towards assisting Commanders in preparing our Soldiers and formations to win in combat.

To execute this new approach to STE, the Army will form a CFT, led by CAC-T, to develop approaches which accelerate the development of the STE through industry collaboration and early user feedback. This CFT approach will allow for early prototyping, experimentation, and user feedback to better inform the STE requirement; allow for a better assessment of technology maturation (especially in Virtual and Gaming); and provide the opportunity to develop a better costing methodology for the STE.

Our overarching strategy to develop the STE will rely on employing a version of the developmental operations (DevOps) philosophy, utilizing Other Transactional Authorities (OTAs) to accelerate the development and testing of prototypes. These prototypes will be frequently placed in the hands of operational Units to gain user feedback and ensure our development efforts are meeting the user needs. In the context of the CFT, the DevOps methodology is defined as warfighters and developers working together to enable rapid and frequent delivery of capabilities to the warfighter to inform a potential program of record.

The initial focus is on the development of prototype capabilities for Company level Combined Arms Transportable Reconfigurable Virtual Trainers, One World Terrain, and a Simulation Engine, all delivered at the Point of Need. The intent is to have prototypes in the hands of Units NLT 1 July 2018 for user assessment and feedback.

Follow on efforts will focus on expanding Combined Arms Transportable Reconfigurable Virtual Trainers to BN/ BDE level; Point of Need capability; and Exercise Design and Training Management Tools (e.g., Intelligent Tutors, Artificial Intelligent, Intuitive, Big Data).

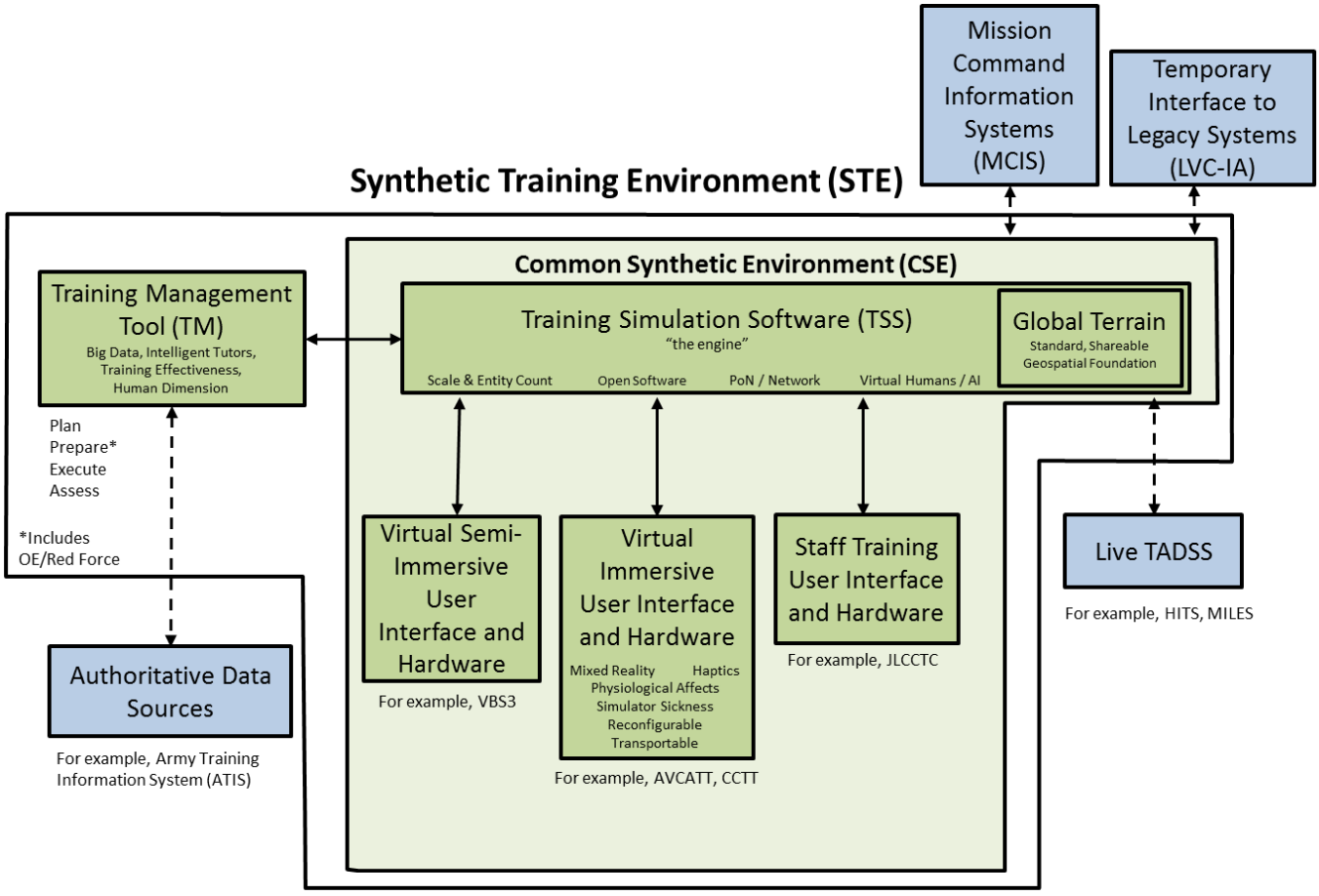
The STE shall include the following Critical Operational attributes

- A single common shareable geospatial representation of the world.
- Common Synthetic Environment (CSE) that represents multi-domain battle from Soldier to Corps fidelity.
- Realistic, real-time training at the PoN (home station, armory, CTCs, deployed locations).
- Reduced training resources (time, manpower, cost).
- Re-configurable, transportable trainers.
- Reduced exercise and training scenario design timelines.
- Software enabled updates to trainers.
- Increased training throughput.
- Elastic and composable training capability.
- Seamless stimulation of mission command (MC) workstations and platforms.

- Full Live-Synthetic convergence, allowing real-time entity fidelity interactions across the simulation domains (Live, Virtual, Constructive).
- Accessible Army-wide using DoDIN, operational networks and infrastructure.
- Reduced new equipment train up time.
- Open Software Architecture built with Government Use Intellectual Property.

Attributes and Functions of the STE

The following sections will lay out the conceptual framework for the STE, as illustrated in Figure 1. At the highest level, the STE may be considered to have two primary capabilities, the Training Management Tool and the CSE. This framework is not intended to constrain the architecture of any future development of the STE, but rather to articulate the breath of capabilities needed to achieve the STE vision.



This framework only helps to visualize the requirement, it is NOT meant as a solution or to constrain the development

Figure 1

Common Synthetic Environment (CSE) capability

The CSE is the unified simulation environment Units and Soldiers use for training. The CSE provides Soldiers and Units a realistic (e.g., physics-based effects), digital representation of the dynamic OE and the military capabilities in the scenario; to support collective training from Squad through ASCC.

The CSE is the holistic end state of the convergence of the Live, Virtual, Gaming and Constructive training environments. The STE's CSE will operate from the cloud and over the DoDIN and Army Enterprise Network with the ability to stimulate mission command systems, providing enhanced realistic training for Soldiers and Units, whether it is at Home Station, Armories, during professional military education, Combat Training Centers, or deployed. The STE's open architecture will allow the seamless and cost effective integration of new technology advances, ensuring that the Army can conduct multi-echelon collective training with our Joint and Unified Action Partners in preparation to conduct unified land operations. Furthermore, this convergence will help overcome the challenges of multiple terrain databases, and reduce costly hardware at fixed sites with a solution that has the right levels of affordable fidelity and realism.

Training Simulation Software (TSS)

The TSS is the simulation software engine provides the synthetic environment. In commercial terms, it is the 'game engine' at the heart of the STE. The TSS works across all trainers, all environments (i.e., virtual and constructive), handles at least 40,000 entities, and scales to over 2+ million entities. While architecture decisions may impact what constitutes an entity, we generally define entities as independent objects with complex behaviors and attributes (e.g., personnel, vehicles, complex munitions, and key communications devices). This engine provides authoritative adjudication of all interactions for all entities, whether they are trainee participants or autonomous and semi-autonomous forces. Credible artificial intelligence (AI) and Virtual Humans with high fidelity Human Behavior Representation will be a critical part of the STE to create realistic autonomous or semi-autonomous Units (e.g., Blue Forces, Opposing Forces, and Role Players) that enable high quality training while reducing the overhead manpower requirements necessary to run an exercise. It also represents the effects of the environment, weather, and weapons on the operation. The TSS needs to enable training from the Squad to ASCC level, which means it must break ground with novel ways of supporting seamless, believable, real-time interactions of high entity counts between constructive, virtual, and live training environments. TSS capabilities include:

- High fidelity battle damage.
- All Warfighting Functions (WfF) (Mission command, Movement and Maneuver, Intelligence, Fires, Sustainment, and Protection).
- Represent all aspects of the multi-domain battlefield.
- Sufficient entity count to support training at the ASCC level, to include environmental representation of Dense Urban Terrain (DUT) and Megacities. Initial estimates require at a bare minimum 2.6 million entities, depending on software implementation decisions.
- Represent current and future force structure, weapons effects, warfighting function, Joint, Interagency, Multinational (JIM) capabilities and near peer capabilities.
- Provide the rules, behaviors, effects, adjudication algorithms/models, 2D/3D visual models, movement models, to represent the contemporary operating environment as the CSE.
- Create the CSE with initialization data.
- Provide all STE training user interfaces and hardware, as well as MCIS, a representation of the CSE, including a correlated, synchronized COP
- Provide a correlated, synchronized ground truth to tech control.

- Provide each Soldier in a training event will the same representation of the OE in the CSE based on the Soldier's role and activities.
- Represent operational variables (political, military, economic, social, information, infrastructure, physical environment, and time [PMESII-PT]) in the CSE.
- Provide realistic:
    - Effects on Soldier and platform movements in the battlespace.
    - Effects on munitions (to include precision guided munitions), communications, cover & concealment, and line of sight.
    - Runtime deformation from weapons effects and traffic (e.g., building rubble, road degradation, collapsed bridges and tunnels, etc.).
    - Lighting effects on the terrain to include global time zone effects (day, night, and levels of night-time illumination based on celestial objects).
    - Atmospherics, including light scattering, air pressure and turbulence, and their impact munitions, platforms, aircraft flight dynamics, and visibility.
    - Seasonal and weather effects on terrain, infrastructure, and vegetation.
    - Authoritative Probability of Hit/Probably of Kill (Ph/Pk) for munitions and weapons that are common for both Synthetic and Live exercises.
- Incorporate social considerations, emerging military capabilities such as operations in the cyber domain, the use of directed energy weapons, and military operations in DUT.
- Track all Live and Synthetic Forces (entities and aggregate Unit icons) and battlefield objects in the CSE.
- Provide a single authoritative master enumeration list (MEL) that is input, processed, and output by all synthetic army training capabilities. Parametric (e.g., PH/PK, Vehicle/Platform/Weapon Attributes, etc.); Naming Convention.

To offer Soldiers and Units the ability to train as they fight, the TSS will need to provide information to and receive information from the Common Operating Environment (COE), MCIS (e.g., Operational Flight Program (OFP), Joint Battle Command – Platform (JBC-P), Aviation Mission Planning System (AMPS), and platforms. This will facilitate mission command and collective training of all WfF from Squad through ASCC in accordance with Army published training strategies and models.

To facilitate the potential for long term convergence into future web/widget based Mission Command Information Systems (MCIS), the TSS requires compliance with mission command COE capabilities/standards and the six Computing Environments (CE): Enterprise CE (i.e., cloud processing/hosting), Command Post CE, Mobile / Handheld CE, Sensor CE, Mounted CE, and Real Time Safety Critical Embedded CE.

User Interface and Hardware capabilities

Depending on their echelon and training objectives, Soldiers will need several ways of participating in STE exercises that run on the TSS. There are three conceptually different ways in which Soldiers and Units need to interact with the STE: Virtual Semi-Immersive User Interface and Hardware, Virtual Immersive User Interface and Hardware, and Staff Training User Interface and Hardware.

Virtual Semi-Immersive User Interface and Hardware

Virtual Semi-Immersive interfaces are common 'keyboard and mouse' interfaces into a virtual three-dimensional (3D) representation of a training environment. While commonly referred to as 'keyboard and mouse', it may include additional peripherals, such as controllers and joysticks to enhance training, but are typically not intended to provide a full 'form, fit and function' representation of training conditions. This form of low-overhead reconfigurable training enables the crew/team through Brigade Combat Team to interact with the Common Synthetic Environment (CSE) and a digital representation of the Mission Command Information System (MCIS) interfaces and platforms for all Warfighting Functions (WfF) and a dismounted Soldier capability. The CSE is the unified simulation environment in which the training takes place. The interface will stimulate sight, sound and touch modalities. Sight allows the Soldiers to see the CSE (both two-dimensional [2D] overhead and 3D 1st/3rd person views), sound allows the Soldier to hear and provide voice input into the CSE, and touch allows the Soldier to interact with the CSE. The quality of stimulation is a low fidelity approximation of what the Soldier experiences in the live environment.

Virtual Immersive User Interface and Hardware

Virtual Immersive trainers will seek a higher level of 'form, fit, and function' for the training audience than the semi-immersive systems. These interfaces into the CSE replace the immersive Combined Arms Tactical Trainers (CATT) found in the Army inventory. However, unlike the large overhead of current CATT trainers, the STE will need low overhead, reconfigurable, and transportable trainers to facilitate training anytime, anywhere. To accomplish this, the STE will require the use of innovative Mixed Reality and Natural User Interface technologies to deliver the following capabilities:

- Software-centric implementation
- Capitalization on rapid advancements in commercial mixed-reality technologies
- Low sustainment and concurrency costs
- Scalable interfaces to support training, without disruption, at the PoN
- Rapid concurrency updates driven through software rather than hardware changes
- Immersive collective training experiences that support suspension of trainee disbelief
- Accurate visual and haptic system representation (e.g., sensors, weapons, survivability capabilities, communications) to prevent negative training transfer or habit formation
- Natural fields of view
- The breadth of tactical trainers supporting Ground and Air Simulation

Ground: This reconfigurable and transportable trainer enables ground platform crew/team through Battalion Task Force to interact with the CSE and a digital representation of the MCIS interfaces and platforms for all WfFs. The immersive trainer provides a motion tracking capability and select high-fidelity physical platform controls for crew members. The interface will stimulate sight, sound and touch modalities. Sight provides the Soldiers a natural field-of-view and allows the Soldiers to see the CSE from first person perspectives, sound allows the Soldier to hear and provide voice input into the CSE, and touch allows the Soldier to use physical and tactile controls of systems, subsystems, components, and mission command information system interfaces to interact with the CSE. Key considerations for ground immersive training include:

- Vehicle Commander: Weapon system control and sensor controls.

- Driver capabilities: Steer vehicle, change gear (e.g., forward, reverse), accelerate vehicle, brake vehicle, and control/view dashboard.
- Gunner (combat vehicle): Weapon system control and sensor controls.
- Loader: Loader's periscope, loading main weapons systems, loader's weapons systems, radios.
- Gunner/Air Guard (wheeled vehicle): Grip, aim, fire, and reload weapon.

Air: This reconfigurable and transportable trainer enables aviation crew/team through Battalion Task Force to interact with a CSE, and a digital representation of the MCIS interfaces and platforms for all WfF. The immersive trainer provides a motion tracking capability and select high-fidelity physical platform controls for pilot, co-pilot, and non-rated crew members. The interface will stimulate sight, sound and touch modalities. An accurate representation of crew sensory inputs and feedback are critical. The relative increase in danger from crew error in aviation platforms necessitates an expectation of higher fidelity in Air immersive trainers. Flight, weapon controls, and non-crewmember controls must provide highly accurate tactile control and switch options relative to the aircraft's digital operational flight program (OFP) capabilities and be in the correct location relative to where the crew member is standing or sitting (e.g., collective is always on the left side, cyclic between the legs), to prevent negative training and habit transfer.

Pilot/Co-Pilot capabilities include dual flight controls to allow the pilot or co-pilot/gunner to fly the aircraft safely (Cyclic, Collective, Pedals). It also includes unique weapon systems interfaces (i.e., Target Acquisition and Display Sight (TADS) Electronic Display and Control (TEDAC) for Attack Helicopter [AH]). The TEDAC for the AH-64 is only for the co-pilot/gunner position.

Non-Rated Crewmembers capabilities include unique weapon interfaces (i.e. door gun) for the Utility Helicopter (UH) and Cargo Helicopter (CH); unique Intercommunications System (ICS) Switch and handheld push to talk capability (UH, CH); and unique hoist controls (UH and CH). Unique cargo hook view space (CH) hoist operations must provide a minimum level of tactile and visual feedback to ensure awareness of proper operations.

Unmanned Aircraft System (UAS) capabilities will include the realistic representation of unmanned systems, to include all kinetic and non-kinetic battlefield effects, as well as the appropriate affordances for user/operator interactions, in order to facilitate collective training.

Global Terrain/One World Terrain Capability

The OWT research effort is a demonstration of the global terrain capabilities needed to achieve the STE vision. This concept would ultimately include a cloud-based service that delivers a common synthetic representation of the whole Earth to include the air, land (includes subterranean), sea (includes undersea), space (up to geosynchronous), and cyber domains that units will use for collective training. The STE's Global Terrain will be delivered over the network to training audiences at home station, while deployed, and at the institution. Global Terrain Capabilities include:

- A digital global with all terrain available to includes full 2D, 3D and parametric information on all the buildings/structures, to include interiors and subterranean features, on the planet.
- Soldier-level fidelity of terrain available on a global scale.
- Training without boundaries that allows seamless integration of physical training areas into global scale wrap around exercises in the virtual and constructive training domains.

- Reuse and integration of a variety of data sources, from the reuse of existing SE CORE home station databases; to the importation of the Army's Standard Shareable Geospatial Foundation (SSGF), the use open source data, to the collection and processing of organic terrain collection data, such as drone-captured photogrammetry.
- The ability to export 3D mesh-based terrain to 2D vector- and raster-based terrain systems

The Global Terrain Capability concept delivers a geographical representation of the entire 3D world in a geo-referenced ellipsoid representation of the Earth. The goal for data fidelity is to provide sub-centimeter resolution and accuracy in terrain, to support full live-synthetic entity interaction in a 'fair-fight' environment. OWT will need to provide the best available terrain representation, from geo-typical to geo-specific, based on authoritative data, while making use of innovative approaches in procedural terrain generation and sensor fusion to constantly improve the quality of the available global terrain.

Additionally, training units will need a capability that allows runtime editing of exercise specific environments to set conditions needed to meet training objectives. Configuring operational variables (Political, Military, Economic, Social, Information, Infrastructure, Physical Environment, and Time [PMESII-PT]) that represent the Operational Environment (OE) enables the CSE to represent unique OE complexities. This provides enhanced realism for a realistic training experience without artificial limitations.

Staff Training User Interface and Hardware

During large scale Mission Command training, Staffs will use their organic MCIS. The MCIS will interface with the CSE, which will stimulate the MCIS to represent ongoing operational events and conditions. Staff training interfaces allow training enablers (i.e. "pucksters") to easily create the realistic operational environments in which Staffs training occurs. In this mode, commonly referred to as 'constructive simulations', the primary training audience will not directly use this interface, but will instead interact solely through their organic MCIS. To represent the large-scale operations needed to stimulate these staff exercises in compelling ways, personnel tasked as training enablers will need to realistically maneuver large forces. The same capability requirements will also apply to automated opposing forces, as well as civilian and allied representation. The interfaces to control these forces will require intuitive user experiences, credible automated behaviors, and scalable force representation.

Staff trainers typically require one operator to control many entities comprising entire formations of the military hierarchy. The quality of the user interface directly correlates to the ease with which one user can control many entities. If the interface is difficult to use, then the training exercise will require additional personnel, time, and technical support, bloating the overhead cost of the training exercise and reducing a commander's ability to execute repeated iterations of the exercise. The STE will need highly intuitive interfaces allowing a few personnel to run large formations in a realistic manner without constant technical support.

Credible automated actions taken by the automated forces must occur together with intuitive user experiences. Highly believable human behavior representation will reduce the requirement for operators to micromanage the actions of the many forces they are expected to control. The need for credible behaviors applies to all automated entities on the battlefield, whether they are red, blue, green or gray. By improving the quality of the automation, we can reduce the requirement for support while creating a more immersive and realistic training environment for Units.

In the larger context of the STE, this automation requires higher fidelity because these automated forces will need to interact seamlessly with virtual and live training audiences. To support this core function of

the STE, the 'constructive' interface will need to address novel ways of representing these behaviors and states at the entity fidelity level. Historically, constructive simulations employed aggregation to represent the large numbers and sizes of forces needed. However, disaggregation and the translation of aggregate effects to entity fidelity remains a significant technical challenge. Resolving this challenge requires novel approaches, either by increasing entity count so that aggregated formations truly simulate each constituent entity separately or developing new algorithms, models, and paradigms to validate the effects of aggregate interactions at the entity level.

Training Management Tool

Training management is a wrap-around capability that enables operational Units to more quickly plan collective training, set up training scenarios and prepare exercises, execute and monitor their execution, assess the results, and use those results to plan the next training events. This capability must tightly integrate with the Army Training Information System (ATIS). ATIS is not an organic component of the STE, but will be an authoritative source of data that will feed training management. The STE must interoperate seamlessly with ATIS.

The convergence of training capabilities, will open new opportunities for enterprise management of Army collective training. It will allow greater visibility of objective metrics on training, which will support Objective-T and the Sustainable Readiness Training management. Management capabilities enable commanders, staffs, and support personnel to plan, prepare, execute, and assess training events consistent with the Army Operations Process found in FM 7-0 (Training to Win in a Complex World). To do so, the STE will also support the breadth of training activities consistent with the **Plan**, **Prepare**, **Execute**, and **Assess** framework.

Plan. Units will need greater control over planning their own training exercises, without external support. This will require a tool that includes planning, resource scheduling, and scenario and exercise design capabilities that allows commanders, staffs, and support personnel to plan training events. The planning phase identifies the training objectives and designs an exercise scenario that will meet the objectives. Inputs to this planning will include operational variables to describe the OE, and capabilities will access, query, and receive data from authoritative data sources to create the initialization data that is consistent with the scenario and training event design. This capability will exchange information with Enterprise Training Management systems and use Unit and Soldier performance training record metrics to initialize the training scenario. To exercise control over their training, users will need an intuitive edit capability to supplement or modify authoritative data as required for specific training requirements. Plan capabilities include:

- The use of enterprise Army training development capabilities that provide the ability to develop and coordinate training events.
- Identification of task, condition, and standards of Mission Essential Tasks, Army Universal Task Lists (AUTL), and Universal Joint Task List (UJTL) relevant to the training objectives.
- The display of Mission Essential Tasks, AUTL, and UJTL and recommendations on tasks the Unit should train, retrain, or train in more complex conditions.
- Access to Unit training records using Army enterprise training management capability.
- The use of enterprise Army learning content management capability that provides centralized access to collective training content anytime and anywhere. This capability shall enable users to search existing collective training content and provide recommendations on applicability of existing training content to the training event the user is developing.

- The ability to access and manage planning for collective Unit training.
- The use of enterprise Army training development capabilities that develop and coordinate training support packages (TSP) (TP 350-70-1 Training Development in Support of the Operational Domain) and scenarios that meet training objectives.
- The ability for the user to manage scenarios and training events:
    - Search, view, and select an existing scenario and training event.
    - Create new scenario and training event:
        - Design new scenario and training event.
        - Clone and modify an existing scenario and training event.
    - Upload and store scenarios and training events.
    - Archive scenarios and training events.
    - Delete scenarios and training events.
- The ability to receive the training support packages (TSP) information from the Army enterprise training development capabilities; and autonomously develop simulation initialization data for a training event.
- The ability to manage data:
    - Retrieve data (e.g., access, query and obtain data from authoritative data sources).
    - Transform data (e.g., create training simulation initialization data from the scenario & training objectives).
    - Distribute training simulation initialization data.
    - Store/archive data for reuse and training effectiveness analysis.
- Tools that:
    - Allow users to modify the physical environment (e.g. adding obstacles) and the information/social environment to maintain consistency with Live training events.
    - To make local on-demand adjustments to terrain and man-made features to support specific training needs.
    - Allow users to modify the common synthetic environment (e.g., add obstacles, rubble infrastructure, modify building features, etc.) during any time of the Scenario design, creation, and execution process.
- A collaborative capability to generate (plan, create, test, and deploy) content for items that do not have authoritative data. This includes military forces, military equipment, visual models, behaviors, terrain, and the environment.
- A collaborative training event and scenario design capability that allows concurrent training design from different locations, e.g. Ft Benning and Ft Rucker can design a common exercise at the same time.
- A wizard that assists the training developer to design STE training events.

Prepare. The prepare capabilities provide leaders and designers a roadmap to ensure accomplishment of exercise elements (e.g., training objectives and scenarios). This includes facilitating coordination for resources outside of STE simulations. The prepare phase also creates an exercise assessment plan that specifies areas and elements to assess. This capability enables mission rehearsal to ensure the scenario works as desired. Prepare capabilities include:

- The ability to access and manage preparation activities for collective Unit training.
- The use of Army provided training resource management capabilities that provide an ability to manage availability/sustainability of the TSS, Future Virtual Collective Trainer, and existing non-system Training Aids, Devices, Simulators, and Simulations (TADSS).
- A tailorable and open ended checklist creation and management ability that allows exercise managers and coordinators the flexibility to create and use any number of checklists to help ensure necessary pre-execution events are accomplished in the Prepare phase.
- A wizard that assists the Training Audience and Trainers how to use the STE.

Execute. The execute capabilities provide training event tools that allows Unit leaders/trainers, exercise/training directors, and the support staff (technical control) to begin the exercise event and then monitor the status of the STE and the progress of the training event. It also provides a data management process and capabilities that implement a data warehousing strategy to support post-training event analysis and activities. The training audience executes a training event using the Common Synthetic Environment, but the Training Management Tool will facilitate that execution. Execute capabilities include:

- The ability to access and manage execution activities for collective Unit training.
- A training event and technical control capability to initiate, monitor, control, facilitate participant communication, and make on demand modifications to the ongoing event.
- Training event and technical control capabilities that are accessible through a dashboard.
- A checkpoint / restore capability.
- A capability for users to make on-site and on demand changes to operational variables in the CSE (e.g., scenario, authoritative data, obstacles, modifying information / social aspects).
- A Master Scenario Event List (MSEL) capability.
- Capability for Unit trainers, exercise/training directors to adjust in real-time the exercise parameters, scenarios and missions to be able to adjust the intensity of the training event to maximize the effect of training on the audience.

Assess. Assessment is more than the then capability provides an automated after action review (AAR) capability that includes replay, data analytics, and data visualization. Assessment is an ongoing capability throughout the entire Training Management Cycle. Recommendations and feedback should be provided to the user throughout the Plan, Prepare, Execute and Assess phases. During the Plan and Prepare phases, training management tools should provide the user with feedback on way to complete the Plan and Prepare products. During the Execute Phase, real-time assessment of the training audience should be provided to allow the training to be able to adjust the training exercise parameters to challenge the training Unit and maximize training outcomes. And finally, the Assess Phase include automated AAR capabilities and the necessary tools for the Units to assess the effectiveness of the training event and recommendations on future training needs or remediation events. The assessment is key in providing

the training audience for each event with useful feedback that will help them improve and plan future training events. It also is key in feeding Big Data analysis efforts to measure training effectiveness and make enterprise-wide recommendations on improvements to training. Units access their training event AAR from the Future Virtual Collective Trainer capabilities and training support computers. After the training event, the Training Design and Management capabilities will allow commanders to update Unit performance training records in Training Management systems, and will make the outcomes of the training available for wider analysis across the Army. Assess capabilities include:

- The ability to record training event and training event data for user controlled playback and assessment of data to support AAR.
- An automated, graphical capability to track collective task (e.g., Combined Arms Training Strategies [CATS]) performance and provide a capability to allow Commanders to provide a training readiness assessment in support of training objectives.
- An automated, capability to track collective task performance.
- An automated data collection and analysis to enable the Commander to make assessments on crew and Unit mission performance.
- The ability to deliver the AAR to the point of training, or distributable to other locations using MCIS.
- The ability to play back (play, pause, step, skip), zoom in, zoom out, freeze, and print capability for individual engagements with various human and platform sensors (e.g., head tracking/Soldier worn sensor, direction of view, weapon sensors, radio frequency, multi-functional displays) synchronized Unit audio content and instructor networks.
- Standard and user configurable reports in MS Office formats to facilitate AARs and the Unit take home package.
- The ability to provide AAR materials in less than or equal to 30 minutes from the end of the training event for standard reports.
- The ability for Commanders to provide updated Unit performance training records to the Army Enterprise Training Management systems.
- An AAR Intelligent Tutor that provides:
    - The observer/controller a Unit performance assessment dashboard.
    - The Soldier informal individual performance feedback.
    - The Commanders/Leaders informal Unit performance feedback.
    - The trainer automated formal AAR materials.

Interoperate with Live Training Aids, Device, Simulators, and Simulations (TADSS)

To achieve full convergence across the live, virtual and constructive environments, the STE must be prepared to interoperate with live training systems, which will be part of the Army Tactical Engagement Simulation System (ATESS). Engineers must continue close coordination between ATESS and STE development to ensure these programs work together to deliver high quality training. Current training systems cannot present realistic two-way interactions between virtual and constructive domains and the live environments. Additional technical developments in instrumentation and mixed reality presentation

will ultimately facilitate the desired converged training end state. Implementation of STE concepts must bear this long-term goal in mind.

Interoperate with MCIS

Whether trainees are operating in virtual immersive, semi-immersive, staff training, or live portions of STE exercises, they will all need to be able to train on and stimulate real and simulated MCIS. To do so, the COE compliant STE will bi-directionally communicate information with Unit MCIS, to include platform specific software (e.g., OFP, Joint Battle Command – Platform [JBC-P], Nett Warrior, and other mission planning software). Mission Command is a fundamental part of collective training, and all implementations of STE training must effectively train, interface with, and/or stimulate the appropriate MCIS.

Temporary Interface to Legacy Systems

As part of a bridging strategy to deliver the best available training to Units, the requirement to interface with current Programs of Record remains while fielding STE. Primarily accomplished through the Live Virtual Constructive - Integrating Architecture (LVC-IA), this tool creates consistent Common Operating Pictures between exercises conducted in different training environment, but faces challenges with entity level interactions. The conceptual architecture of the STE facilitates bridging to LVC-IA and similar training simulation interfaces, as its TSS contains all the relevant information needed for multi-domain interaction.

Architecture and Standards

The STE will break new grounds in how collective training simulations are created and developed for the Army. To set the proper conditions for this desired innovation, latitude will be afforded in the internal architecture and standards of the STE systems, so as to allow the Army to take advantage of cutting edge technology in our training. The base requirement, however, is that this internal architecture will be extensible and employ a Modular Open System Architecture (MOSA) strategy.

Externally, however, as described in the preceding sections on interoperability and integration, the STE will not exist alone. The STE must operate within the larger Army Enterprise. Most immediately, the STE will have to support interoperation with Mission Command Information Systems (MCIS), Live TADSS and the current Live Virtual Constructive - Integrating Architecture (LVC-IA) systems, as well as authoritative data sources such as the Army Training Information System (ATIS). The STE will also have to support interoperability with current Army and Joint systems, and be extensible to support future systems as they are deployed. These interfaces from the STE to other systems will have to adhere to applicable standards for interoperability consistent with these systems. Additionally, the STE will have to operate over Army networks and adhere to standards defined by the Army's Common Operating Environment (COE).

Conclusion

The STE revolutionizes training to build Army readiness. By rebuilding the Army's collective training simulation capabilities from the ground up, the STE reduces the overhead associated with conducting high quality, high return training, while enabling new ways of training and managing training in manners previously not possible. The STE will make training easier to plan, prepare, execute and assess by streamlining the simulations used in training. This, in turn, takes training from the hands of external organizations and installation personnel, and returns it to the commanders and their staffs. The STE will

provide the enhanced realistic training environment that our future forces will use to achieve and maintain their readiness objectives.

Appendix C: Iterative Approach

Follow-on technology demonstrations and user assessments will be scheduled, based on the successes and failures in the July 2018 demonstration. Based on CAC-T assessment, once a sufficiently viable prototype demonstration has been achieved, that capability will be spun-out to move rapidly into procurement and life-cycle management. This process will be repeated, as required, to achieve the STE concept.

	Scalable from Squad to ASCC
Training Framework	• **Training audiences: Squad to ASCC** • **Staff training audiences: Battalion to ASCC** • **HICON capability: Company to ASCC** • **Immersive virtual capabilities from platform through Battalion for Armor, Infantry, Stryker, Aviation, and Combat and Combat Support formations** • **Semi-immersive capabilities from dismounted Soldier through ASCC** • **Integrates with Live training through the current live Instrumentation systems** • **Enables "fair fight" across training environments**
Simultaneous Exercises	**50 simultaneous independent exercises using virtual capabilities; Expanded to 70+ simultaneous exercises using all Virtual and Live instrumentation capabilities; at the Point of Need to include, Homestation, Armory, CTC and deployed**
Scalability & Entity Count	**Common Synthetic Environment scalable capability from 40,000 entities to 2.6M entities (including virtual, current constructive and live instrumented entities)**
Operational Variables	**Represent all Operational Variables (Physical Environment, Military, Economic, Social, Infrastructure, Information, Political, and Time)**
Interoperability	**Interoperable with Mission Command Information Systems, Common Operating Environment, Authoritative Data Sources, Legacy Training Devices, Army Enterprise Networks, Emerging Army data consolidation policies, Joint and Multi-national systems**