Embedded Training: A Future Combat System Live Training Use Case

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ABSTRACT

The Future Combat Systems (FCS) program is a Family of Systems (FoS) that will provide the basis for transforming the Army's current forces. It will be a networked, multifunctional, multi-mission re-configurable system of systems designed to maximize joint interoperability, strategic transportability, and commonality of mission roles. The Future Combat Systems will develop the capability to rapidly project a dominant ground force anywhere in the world within days. This strategically deployable, tactically superior and sustainable force will provide a quick reaction capability to conflicts arising in the 21st century. This requisite capability requires advanced technologies, a revolution in both strategy and tactics, and innovative industrial teaming. FCS is on the leading edge of implementing embedded training, where individual, crew, and collective training is available "any time and any where." FCS is an enabler for our future Soldiers; giving them a full spectrum of capability across the range of conflict operations, from major engagements to stability operations, with an embedded training system that is customized to handle immediate threats. Through their embedded training capabilities, FCS Brigade Combat Teams will be able to train in homestation configurations, without the aid of external training systems, and to interact with live training ranges, without the use of external instrumentation. To accomplish this, FCS is reusing existing training software to produce a set of Training Common Components. This paper describes how the TCCs are being used to provide a core set of embedded live training capabilities that will be supplied to all FCS platforms. In addition, this paper describes the challenges associated with supporting FCS embedded collective training capabilities at the Live Training Ranges.

ABOUT THE AUTHORS

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Paul Walker is the chief engineer for the CTIA FCS TCC development program, where he is responsible for reusing software from the U.S. Army Common Training Instrumentation Architecture (CTIA) to realize as FCS Training Common Components (TCC). He has been in lead positions on a variety of U.S. Army live, virtual and constructive training programs including CCTT, WARSIM, OneSAF, and CTIA. Mr. Walker started his career with IBM Federal Systems Division in Manassas, VA, and is now with Lockheed Martin Simulation, Training & Support in Orlando, Florida. Mr. Walker earned a BS in Electrical Engineering from the University of Kentucky and an MS in Software Systems Engineering from George Mason University.

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INTRODUCTION

To maintain military supremacy in the future Operational Environment (OE), the U.S. Army must be a more strategically responsive, deployable, agile, versatile, lethal, survivable, and sustainable force, effective in all situations from major combat operations (MCO) to homeland security. These seven characteristics form the Army Vision and are the foundation for the development and evolution of Army organizations, their operational concepts, required capabilities, and missions (TRADOC Pamphlet 525-3-90 O&O). Today we have a superb fighting force; the best army conducting combat operations in the world. But this force will gradually lose its decisive edge against modernizing, adaptive forces that are designing strategies and systems to overmatch our current capabilities. We must develop new organizational and operational concepts optimized for offensive combat operations over the next several decades. The goal is to construct a fully capable ground force designed for rapid deployment and operations across the full spectrum of war.

To achieve this goal, the Army Future Force (FF) will incorporate active and reserve components as part of a joint and coalition team that is decisive in any operation, against any threat, in any environment. This team requires a force projection Army that is strategically and operationally responsive; an Army that can deploy a Future Combat Systems (FCS) equipped Brigade Combat Team (BCT) in a timely manner using a mix of air, sea, and land movement and pre-positioned equipment. This FCS-equipped BCT represents a capability critical to the FF and the accomplishment of the goals of the Joint Vision and Army Vision.

FCS is a Family of Systems (FoS) that will be a networked, multifunctional, multi-mission re-configurable system of systems (SoS) designed to maximize joint interoperability, strategic transportability, and commonality of mission roles. This requisite capability requires advanced technologies, a revolution in both strategy and tactics, and innovative training capabilities. By requiring that training capabilities be designed into the system "up front," the FCS program has ensured that it is on the leading edge of embedded training, where individual, crew, and collective training is available "any time and any where." FCS will be an enabler for our future Soldiers with an embedded training system that can be customized to handle immediate threats. Through their embedded training capabilities, FCS BCTs will be able to train in homestation configurations without the aid of external training systems, and to interact with live training ranges, without the use of "strap on" instrumentation.

To accomplish these embedded training goals, FCS is reusing existing training software from Army base programs to develop a core set of Training Common Components (TCC) that can be used by all FCS platforms. This paper describes how software from the live training domain base programs, namely Common Training Instrumentation Architecture (CTIA) and One Tactical Engagement Simulation System (OneTESS), will be reused to produce TCCs that provide a core set of embedded live training capabilities for all FCS platforms. In addition, this paper describes the challenges associated with supporting FCS embedded collective training capabilities at the Live Training Ranges.

BACKGROUND

Live, Virtual, and Constructive Training

The FCS TCC development effort is focused on providing a training solution that spans the live, virtual and constructive training domains. A live simulation, used for live training, involves live forces, acting in a real environment, using their organic equipment to execute a training exercise or scenario. A virtual

simulation involves a live trainee interacting with a simulated environment. Proficiency trainers, such as driving or flight simulators, use virtual simulations. Constructive simulations involve simulated actors interacting in a simulated environment; live role players or controllers may give input to the simulation, but do not determine the outcomes. Constructive simulations are used to create a layer of reality around a trainee. For example, in leadership training, an organic Tactical Operations Center (TOC) could interact with a constructive simulation that represents the upper- and lower-echelon forces with which the TOC interacts. From the point-of-view of the trainees in the TOC, the forces the commander and staff are receiving orders from, or giving orders to, are real.

Live Collective Training

Live training range systems provide the means to plan, prepare, execute and provide training feedback for Force-on-Force (FOF) and Force-on-Target (FOT) training. Live collective training exercises at these ranges are characterized by the following:

- Live, organic Soldier/vehicle activity on physical terrain under simulated combat conditions,
- FOF weapon engagement with instrumented targets via a Tactical Engagement Simulation (TES),
- FOT with physical targets and live fire,
- Tracking the position of the training audience is done through an Instrumentation System (IS),
- Training analysts link observations, events, and training reports to build Cause and Effect reports
- Alerts (training-related) and alarms (safety-related) can be triggered when Soldiers or vehicles cross control measures or enter restricted areas
- Human- and IS-implemented real and simulated visual and sound effects for battlefield events (e.g., vehicle kill indicators, smoke, pyrotechnics, barricaded bridges, etc.).

Live Training Transformation (LT2)

A primary source of software reuse for FCS TCC development is the Live Training Transformation (LT2) program. LT2 is an Army initiative to develop a product line for live training ranges that improves the efficiency of live collective training exercises and yields significant cost avoidance over the training range life cycle. The LT2 product line is centered on a common architecture shared across the product line – the CTIA – and a set of reusable LT2 components that are designed to provide specific live training capabilities and interact via the CTIA (Dumanoir, Rivera 2005). LT2 components can be "mixed and matched" to satisfy specific live training needs. Systems built from LT2 components and using the CTIA are composed using a "toolbox of components" approach that maximizes software reuse and provides common functionality, interfaces and standards across the various Army training ranges. LT2 training systems, known as the LT2 – Family of Training Systems (LT2-FTS), will also provide interfaces to virtual and constructive training domain systems, the Army's C4ISR infrastructure systems, FCS platforms, and to components of the Joint National Training Capability (JNTC).

FCS Embedded Training (ET)

The FCS FoS has a requirement to provide embedded individual and collective training that supports live, virtual, and constructive (L-V-C) training environments. To provide this capability, FCS will embed full task and tactical engagement simulation systems that provide Soldiers and leaders with a readily available system for planning, executing and assessing tasks with subordinate units in any combination of L-V-C environments. The system will provide feedback through a training management interface to existing Army knowledge databases and will allow leaders to modify a Training Support Package (TSP) to adjust difficulty during training. Embedded L-V-C training is the cornerstone of networked Embedded Training (ET) and will satisfy an FCS Key Performance Parameter (KPP#6), which states "The FCS Family of Systems (FoS) must have an embedded individual and collective training capability that supports live, virtual, and constructive training environments."

FCS Embedded Training (ET) is being designed at the start of the program to ensure it is developed in conjunction with the other FCS SoS components. To do otherwise would lead to needless duplication of software development, potential negative training as a result of inevitable baseline divergence (as training tries to keep pace with operational software functionality) and additional space/weight/power claims for training. To fulfill its Operational and Organizational (O&O) concepts, the SoS must be capable of supporting operations, mission rehearsal and training of separate audiences (Soldiers, units, leader/staff teams) simultaneously. (FCS Fact Files, 2006)

FCS TRAINING COMMON COMPONENTS (TCCs)

The FCS training systems will be based on a set of eight TCCs that will be developed by reusing software from existing Army training programs. There are two strategic reasons for FCS to leverage training capabilities currently being developed by PEO STRI: (1) reduce FCS training development costs by taking advantage of existing Army training program investments, and (2) ensure that the FCS emergent training capability is consistent and interoperable with Army current force training environments. The TCC effort is being managed by the FCS Training Integrated Product Team (IPT), co-chaired by a PEO STRI Project Manager Future Force Simulation (PM FFS) and FCS Training lead developer – (SAIC). The PEO STRI "base" training programs that are providing core training capabilities to the TCC development (see individual web site references) are:

- CTIA
- OneTESS
- OneSAF Objective System (OOS)
- Army Training Information Architecture (ATIA)

FCS TCCs provide the ET "starter kit" which supplies a basic training architecture that can then be customized by specific FCS systems (e.g., Manned Ground Vehicles (MGV), Unmanned Ground Vehicles (UGV), Unattended Ground Sensors (UGS), etc.) to meet their unique ET requirements. Although the TCCs will function together as a subsystem, they are not intended to satisfy all FCS training needs; rather they will facilitate specific platform training requirements. The TCC development effort is focused on reusing and rehosting contributing program functionality and integrating existing training capabilities with the FCS System of Systems Common Operating Environment (SOSCOE). The TCCs will address both vertical integration of existing training capabilities with the FCS SoSCOE as well as horizontal integration of the base programs' software into a common set of LVC capabilities. Figure 1 provides an architectural layer diagram of the TCCs within an FCS system. The eight TCCs provide the following functional capabilities necessary to support embedded training:

Training Management. The Training Management TCC is the repository for all individual, crew and collective training activities. TSPs, which describe a given training event, are provided by the Training Management TCC. At the conclusion of a training exercise, it can collect training data and store it in an Army training database for further analysis. The

primary sources of reuse for the Training Management TCC are the OOS, ATIA, and CTIA programs.
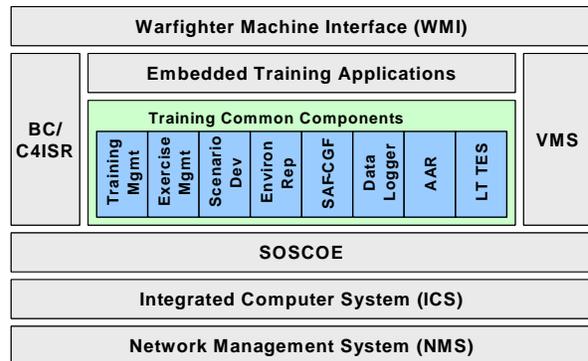

Figure 1. Training Common Components within a FCS layered Architecture View

Exercise Management. The Exercise Management TCC provides automated and manual management and control of a training exercise. Users can assign training exercise resources and roles. Operators can control and manage the preparation, initialization, execution, monitoring, and termination of FCS embedded training exercises; monitor an exercise's execution; and perform simulation management functions (e.g., start, stop, pause, resume, checkpoint save, and checkpoint restore a constructive simulation). The primary sources of reuse for the Exercise Management TCC are the CTIA and OOS programs.

Scenario Development. The Scenario Development TCC supports the creation of military and simulation-based scenarios to be used for embedded training exercises. The primary sources of reuse for the Scenario Development TCC are the OOS and CTIA programs.

Environmental Representation. The Environmental Representation TCC provides the synthetic natural environment for simulation-based embedded training. It allows a user to perform some modifications to environmental features either before or during the exercise. The primary source of reuse for the Environmental Representation TCC is the OOS program.

Semi-Automated Forces ─ Computer Generated Forces (SAF-CGF). The SAF-CGF TCC provides the ability for the embedded training system to simulate surrounding forces, both friendly and enemy, and to allow the trainee to participate in engagements using

his own tactical equipment and vehicle. In live training, the SAF-CGF TCC will wrap the training audience with simulated forces to allow the trainees interaction with a much larger simulated exercise. The primary source of reuse for this TCC is the OOS program.

Data Logger. The Data Logger TCC is the repository for CTIA runtime services and CTIA database services, making this component key for embedded live training and compatibility with CTIA-compliant live training ranges. In addition, the Data Logger TCC provides services for the collection of simulation-based training data. The Data Logger TCC supports all of the data types identified in the FCS Brigade combat Team Information Model (BCTIM). The primary sources of reuse for the Data Logger TCC are the CTIA and OOS programs.

After Action Review (AAR). The AAR TCC allows users to specify the data to be collected in an exercise, analyze the exercise data, and prepare and conduct after action review at any time and any place during or after the exercise. Users control data logging, including starting, stopping and changing of the data to be collected while the training exercise is ongoing and mission time is advancing. The AAR TCC supports automatic and manual user production of presentations from logged simulation data, including audio and video data. AAR products and results can be uploaded via the Training Management TCC to Army training databases to be used for training analysis. The primary sources of reuse for the AAR TCC are the CTIA and OOS programs.

Live Training Tactical Engagement Simulation (LT TES). The LT TES TCC tracks all live entities, adjudicates live and integrated L-V-C direct and indirect fire engagements, and stimulates dual use operational hardware and Range Instrumentation Systems. It facilitates real-time, precision, combined arms FOF and FOT training, providing the ability to engage existing target systems. The primary sources of reuse for the LT TES TCC are the OneTESS and CTIA programs.

FCS TCCs AND LIVE TRAINING

All FCS live training must be capable of being conducted without the support of an external (non-FCS) training system. Thus an FCS BCT must be able to plan, execute, assess, and report the results of live training at its homestation or when deployed while using only its embedded systems. When training at a live training range, such as the National Training Center (NTC) (see Figure 2), FCS systems would be expected to interact with the range's CTIA-compliant training systems without the need for extra "strap-on" instrumentation.

Figure 2. Live Training Range

Live Training Range Use Case Development

In order to support the development of live training use cases in the FCS environment, the FCS team has focused on the two main live training scenarios: when an FCS unit is training at homestation or deployed, and when an FCS unit is training at an instrumented live training range. These two use cases, documented in the Future Combat Systems (FCS) Platoon Thread documents, are being used to derive the majority of the FCS live training requirements.

Homestation/Deployed. In this use case, an FCS unit conducts infantry platoon-level tasks at homestation. This is a formal training event and formal training feedback in the form of AARs is provided back to the platoons. All planning, management, control, data collection, analysis, assessment, and feedback will be accomplished using the training systems embedded in the FCS vehicles.

The unit commander is the Senior Trainer for a training event. His subordinate controls the exercise. The unit provides additional staff support in logistics and technical matters (information, computers, instrumentation). Observer/controllers (O/C) and training analysts, all organic to the unit, will support this event. Units not being evaluated in this event provide the OPFOR and role players.

The training environment is a contemporary operational environment (COE) with civilians on the battlefield (COB), governmental and non-governmental organizations. Training tasks are integrated into the scenario and will be observed and evaluated by the O/Cs. The Exercise Controller (EXCON) will direct the Master Scenario Events List (MSEL) for the exercise.

The exercise is initialized using a TSP, which was previously created using the Scenario Development TCC, that describes the scenario, participants, and resources needed to perform the training. The TSP is acquired using the Training Management TCC. The Exercise Management TCC instances on each vehicle then continue to initialize and prepare for the exercise. The EXCON's vehicle will host the master controlling instance.

If the exercise requires a wrap-around constructive simulation (e.g., the training units need to coordinate with a remote artillery battalion), the SAF-CGF and Environmental Representation TCCs must be invoked. This simulation will be distributed and contained within the FCS vehicles in the training exercise without external support. Note that for training to be effective, the simulated entities must never share line-of-sight with the live trainees. However, there will be training instances where constructive entities may be transformed into live participants.

All observations will be recorded by the O/Cs, either through the FCS Warfighter Machine Interface (WMI) in their vehicles or via hand-held CTIA-compliant tablets that can communicate with their FCS vehicles. All position and tracking data for the training audience will be automatically captured from their operational systems and passed to the Data Logger TCC via the LT TES TCC and SOSCOE. Simulated or real fires will be captured, assessed, adjudicated and logged by the LT TES TCC. Analysts will analyze the training data, determine cause and effect, and present AARs using only the FCS-provided interfaces in the AAR TCC. Soldiers can receive a distributed AAR from the workstation in their FCS vehicle. Training data and results can then be uploaded to Army training databases via the Training Management TCC.

Instrumented Live Training Range. In this use case, an FCS unit is conducting a planned unit rotation at the NTC. This is also a formal training event and formal training feedback in the form of AARs will be provided back to the units. In this case, most of the planning, management, control, data collection, analysis, assessment, and feedback will be accomplished using the CTIA-compliant instrumentation systems installed at the training range. However, the FCS vehicles will be able to interact with those systems without the use of external "strap on" instrumentation via the LT TES and Data Logger TCCs.

As in the homestation use case, the training environment is a contemporary operational environment (COE) with civilians on the battlefield (COB), governmental and non-governmental organizations. Training tasks are integrated into the scenario and will be observed/evaluated by the O/Cs. The Exercise Controller (EXCON) will direct the Master Scenario Events List (MSEL) for the exercise.

All observations will be recorded by the O/Cs either through the FCS WMI in their vehicle or via a hand-held CTIA-compliant tablet that can communicate with range's CTIA-compliant training system. All position and tracking data for the training audience will be automatically captured from their operational systems and passed to the Data Logger TCC via the LT TES TCC and SOSCOE. Data will be analyzed, cause and effect assessed, and AARs given using either the FCS-provided interfaces in the AAR TCC – which will likely happen when the AAR is being conducted for the FCS unit in-place and in real time -- or using the instrumented range's AAR capabilities. Training data and results can then be uploaded to Army training databases via the Training Management TCC or via the range's system.

CHALLENGES AND PATH FORWARD FOR FCS LIVE TRAINING

There are many challenges and opportunities involved in implementing embedded live training in the FCS environment. The following section discusses several key challenges being faced by the FCS live training communities.

Communications Network. Live range training environments typically have many ground-based wireless nodes. There are many different types of data that need to be collected and transmitted (e.g. digital, voice, video). The ranges have a substantial investment in their communications infrastructure. One of the FCS objectives is to use operational/tactical communications network to conduct all FCS communications to include training. In order to accomplish this objective the FCS Training IPT is working closely with the FCS C4ISR segment teams to clearly define the communications network requirements that need to be satisfied in order to conduct live collective training. This will allow FCS

developers to find a communications network solution that can be embedded on the vehicles, using operational networks, and satisfy the training communications requirements.

Simulated vs. live forces. Using the wrap-around computer-generated forces will be another challenge for FCS in the live domain. Because the SAF-CGF and Environmental Representation TCCs will have to interact with real Soldiers on real terrain, the TCCs will have to be able to accurately reflect the current ground conditions, obstacles, and weather. For example, rather than the simulation telling the trainee what the current weather conditions are – as typically happens in a constructive or virtual training event – the simulation will have to absorb the actual current conditions and reflect those in the simulation. Similarly, if the SAF-CGF TCC would like to fly aircraft, but the current actual weather conditions will not support real aircraft, the simulation will have to be adjusted. The FCS Training IPT is currently analyzing these issues and how they may impact areas such as Battle Damage Assessment (BDA) and the "fair fight" aspect of a training.

Application-specific Interoperability. Although not a specific "live" training challenge, it is an existing challenge with the Live training software being integrated as part of the TCCs since some of the LT2 component software being used is Microsoft Windows based. This issue exists with some of the virtual, and constructive software as well. In the case of some of the LT2 component software, it was developed as a Microsoft Office application to provide a user friendly environment and interface which is very familiar to the Soldier in the field. Interoperability of these systems with Linux and the WMI will be required. A trade study is in progress to determine the best way to accomplish interoperability.

Live-Constructive Interoperability. FCS developers are currently working to integrate more closely the live and constructive base program reusable components of the TCCs. This capability is leveraged from a CTIA-OOS base program interoperability initiative prototyped in 2005. The current focus is on producing proxy objects and events that allow live forces and constructive (simulated) forces to detect each other and allow limited FOF weapon engagements. This effort is based on allowing the SAF-CGF TCC (OOS) to interface directly with the CTIA Object model. This direct interface is expected to allow improved interoperability in support of the following use cases:

- o Send weapon fires and detonations

- o Receive and respond to weapon fires and detonations,
- o Control Measures (2-D Display, Fire Zone, etc.),
- o Adjudicate constructive minefield interaction with live forces,
- o Analyze data for consistency,
- o Initiate and adjudicate NBC events,
- o Adjudicate geometric pairing based indirect fire (LT TES),
- o Exercise Control - Start, stop, pause, resume (Exercise Mgmt TCC / CTIA).

Live, Constructive, and Virtual Interoperability. The initial FCS embedded training capability will be a coordinated effort between the live (LT2/CTIA), and constructive (OneSAF) training communities, and the FCS developer communities (e.g., MGV, BC, and UAV/UGV/UGS). Currently, a requirements gap analysis among the communities is clarifying what must happen to make the communities operate successfully as one team to develop an embedded system, and in particular what the FCS platform developers need as a "core" software training capability to allow them to provide a feasible and efficient embedded training capability. The FCS Training community is also currently assessing what pieces of the virtual product line known as Synthetic Environment CORE (SE CORE) might be integrated into the TCCs. One key TCC that is being influenced by the SE CORE base program is the Environmental Representation TCC, since the current work being done by OOS base program on that TCC, will transition to SE CORE as the main source for synthetic environment representation for training simulations. In the long term, the FCS Training IPT TCC effort will provide key pieces to the LVC training environment puzzle for the Army and the JNTC.

Joint Interoperability. The FCS Training community will have to interoperate in a Joint environment with other live training ranges from other services and test ranges. The JNTC has chosen the Test and Training Enabling Architecture (TENA) as the main architecture to use for this type of inter-range interoperability. The CTIA base program has integrated TENA software with the CTIA services so that CTIA provides TENA compatibility. This capability allows all the LT2 family of training systems to interoperate with other Joint live ranges through TENA. The FCS Training IPT is currently coordinating with JNTC to define how SoSCOE will provide similar capabilities independent of CTIA base program effort. Once TENA compatibility is achieved by FCS it will allow the FCS platforms to use the common TENA for inter-range

communications between all Future Force Live ranges for training and testing.

 Embedded Tactical Engagement Simulation System (E-TESS). Although adding a new TCC – the LT-TES TCC to the original seven TCCs was a great advancement in support of Live Training for FCS, there still remain several challenges related to the TESS area. These challenges require the development of a cohesive and comprehensive TCC integration and technology transition plan that enables the smooth transition from current TESS technology, such as Multiple Integrated Laser Engagement System (MILES), to the use of OneTESS technology in support of FCS E-TESS. In addition, this integration and technology transition plan should address a phased approach required to append and/or embed TESS solutions and meet the desire to implement dual use operational equipment.

CONCLUSION

The FCS Training IPT has adopted a revolutionary approach for providing core training capabilities to the FF in support of the FCS embedded training requirements. In addition, the Army is achieving significant cost avoidance by leveraging efforts from existing "base" programs that are developing capabilities for the FF. These efforts are providing the synergy necessary to afford our Soldiers decisive superiority through training and interoperability with Battle Command Systems and other Army training systems of the future. Although there are many obstacles to overcome, the Army, and its future training capabilities are on a worthy course to provide Soldiers innovative solutions for embedded training.

ACKNOWLEDGEMENTS

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