LVC Interoperability: Where is the best place to start?

Paul Dumanoir
U.S. Army PEO STRI
Orlando, Florida
paul.dumanoir@us.army.mil

Robert Parrish
U.S. Army PEO STRI
Orlando, Florida
robert.parrish@us.army.mil

Harry A. Sotomayor
U.S. Army PEO STRI
Orlando, Florida
harry.sotomayor@us.army.mil

ABSTRACT

Live, Virtual, Constructive (LVC) interoperability can be defined as the ability for assets, models, and effects from one training environment to be seen, affect, and be affected within the rest of the training environment. LVC interoperability has been implemented in a number of different ways for a number of years where most of the approaches integrate LVC assets through defined protocols, various gateways or translators, and a set of messaging collection tools. To a much lesser extent, some implementation approaches also develop a common object model and middleware, and use a set of system engineering and business practices that drive a given particular LVC solution. The U.S. Army Program Executive Office (PEO) Simulation Training and Instrumentation (STRI) is taking those basic principles and practices and applying them on specific, relatively new Live, Virtual, and Constructive simulation product lines attempting to influence their design early in their development cycle by exploring options that could yield a more robust, systematic LVC interoperability solution set. This paper provides an overview of several LVC assets within the PEO STRI product lines and their respective Live, Virtual, and Constructive domain common components, and how they are being integrated to address current and future LVC training needs by the Army and DOD. In particular, the paper will focus on the Army "Live" training product line, and describe how interfaces, standards, and training methodologies are being developed to support specific LVC use cases required by the "Live" training community. This paper will also provide lessons learned, challenges encountered, and recommended way ahead from a "Live" perspective.

ABOUT THE AUTHORS

Paul Dumanoir is the chief engineer for Live Training Transformation (LT2) and responsible for product line engineering of Live training range systems at U.S. Army PEO STRI. He has 20 years experience working in DOD simulation and training programs as both project director and systems/software engineer. He is current interests include component-based product-line engineering, embedded training, and net-centric warfare training applications. He earned his B.S. in Electrical Engineering from the University of South Alabama in 1987 and his M.S. in Computer Systems from the University of Central Florida in 1991.

Robert Parrish is the Deputy Director for Live Simulation Systems at U.S. Army PEO STRI. He has 24 years of experience working in the DOD acquisition community. He worked 10 years with the Navy and 14 years with the Army as a systems/project engineer for both virtual and live training systems. His current interests include Systems Engineering, test and training technologies, LVC interoperability, and M&S. He earned his B.S. in Electrical Engineering from the Georgia Institute of Technology in December 1982.

Harry A. Sotomayor is the Chief Engineer for the Warrior Trainer Integration (WTI) Office at the U.S. Army PEO STRI responsible for the Live Virtual Constructive Integrating Architecture (LVC-IA). He has 20 years of acquisition experience working on Live, Virtual and Constructive training and simulation programs. His current interests include service oriented architecture (SOA) and LVC interoperability in support of Army training. He earned a Bachelor of Science in Electrical Engineering from the University of Puerto Rico in 1986, and a Master of Science in Operations Research (Stochastic Simulation) from The George Washington University in 1993.

LVC Interoperability: Where is the best place to start?

Paul Dumanoir
U.S. Army PEO STRI
Orlando, Florida
paul.dumanoir@us.army.mil

Robert Parrish
U.S. Army PEO STRI
Orlando, Florida
robert.parrish@us.army.mil

Harry A. Sotomayor
U.S. Army PEO STRI
Orlando, Florida
harry.sotomayor@us.army.mil

INTRODUCTION

Army doctrine remains the foundation for training and readiness in the 21st century. Doctrine dictates, "The commander selects the tools that will result in the unit receiving the best training based on available resources." It also permits the commander to "select the right mix" of Live, Virtual, Constructive (LVC) components to support training and progressively enhance unit readiness using an "Initial-Proficiency-Sustainment" approach (FM 7.0, 2002). Commanders prepare for training by assessing their unit's readiness and establishing a training program that will move the unit from "Initial" readiness to readiness "Proficiency" and enable it to "Sustain" readiness.

Within this training foundation, a LVC-Training Environment (LVC-TE) encompasses the products, components, processes, technology, services, and resources needed to provide a realistic and authoritative simulation of the Warfighter's operational battlespace. Within the Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) LVC portfolio there are five main functional areas required for the successful employment of a LVC-TE. Figure 1 is an adaptation of a Joint LVC-TE view (JCD JLVC-TE, 2005), and provides an overview of how these functional areas are applied as key ingredients of the PEO STRI approach to LVC interoperability and integration. The five functional areas are:

- An integrating architecture which allows for the easy and rapid construction of secure synthetic battlespaces tailored to a particular need or application.
- Synthetic battlespace representations that allow for the full range of military operations to be realistically exercised in training or mission rehearsed.
- Integration and stimulation of operational systems so Warfighters can train and mission rehearse on the systems they actually use. In particular, allow the synthetic battlespace within which Warfighters train and mission rehearse to receive, process, and transmit operational system information.
- User services which allow for the collaborative planning, preparation, execution, and After Action Review (AAR) of training and mission rehearsal events.
- Technology refresh enhancements which ensure the synthetic battlespace used for training and mission rehearsal remains current, relevant, and able to adapt to emerging operational requirements and training technologies.

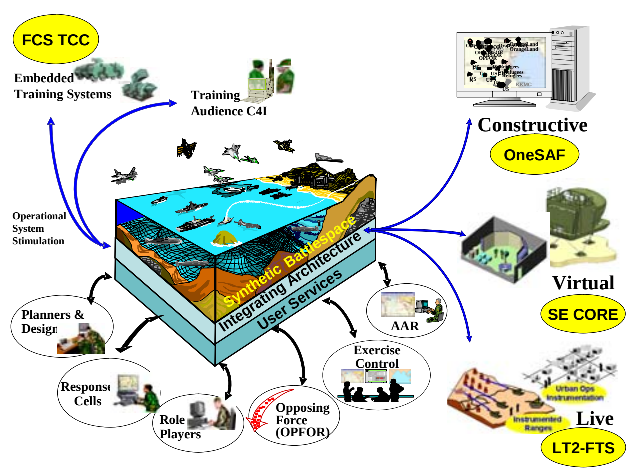

Figure 1. LVC-TE Notional View

The paper provides an overview of some of the core LVC assets within the PEO STRI Product Line (PL) portfolio, how the product line architectures, common services, and components provide capabilities within the five main functional areas described above, and goes on to describe how these assets are being used to address the current Army and the DOD LVC training needs.

LVC INTEROPERABILITY AND INTEGRATION (LVC I2)

PEO STRI's objective of achieving efficient LVC Interoperability and Integration (I2) is based on a shift from a "program based organization" to a "capabilities based organization". It includes establishing common interoperability standards, common products, tools and repositories to facilitate the PEO to achieve his I2 objectives. This objective capitalizes on current Army investments in training by leveraging the individual L, V, and C PLs as well as the FCS Embedded Training programs.

Within PEO STRI's training portfolio, a set of integrated architectures exists for each of the L, V, and C product lines. These integrated architectures are based on product line engineering concepts that use common architecture services, interfaces, standards, and software components to provide specific training functions across each respective domain. Interfaces include connections to external systems such as tactical systems or other Live, Virtual, and/or Constructive simulations. A brief overview of the functions these PLs provide within their respective L, V, and C domains is described in subsequent sections of this paper.

A 2nd tier of interoperability and level of integration is required to bring these separate L, V, and C product line architectures together to provide the training users the expected LVC-TE results. This is the essence of the LVC I2, which is in the conceptual stage at PEO STRI. One of the main objectives of this LVC I2 effort will be to grow an integrated architecture framework concept, based on existing individual L, V, and C PL architecture frameworks, which describes how, and what common architecture services, interfaces, standards, and software components from the individual PLs are used and integrated to facilitate rapid integration of LVC components. These LVC components will include synthetic representations of the battlespace, operational systems (e.g., Battle Command Systems) interfaces, and user services required for the conduct of training and mission rehearsal events and tailored for a particular application. This LVC-TE integrated architecture framework concept should define and facilitate the quick integration of LVC components in a "plug and train" approach where components will interoperate with each other with no or minimal modification to their interfaces.

To help enable future LVC I2 efforts, PEO STRI is establishing a training support system infrastructure within the PEO. This initiative is supported by the Department of the Army Management Office - Training Simulations (DAMO-TRS) and the initial effort has been endorsed for funding in FY 07 through the mid-year review process in order to procure resources to conduct an initial assessment of an I2 path forward. This effort will be led by an I2 Advisory Board (I2 AB) which will assist the PEO in achieving its I2 objectives by leveraging the existing PEO internal resources and processes and focus on best business practices to achieve product (non-system & system training devices) portfolio interoperability. The PEO continues to work with the Army leadership to establish an annual funding line to work LVC I2 activities, such as defining key standards, interfaces, protocols, and common products/ components, which are a key part of the LVC I2 effort. As part of its initial focus the I2 AB will evaluate the best approaches in order to establish and baseline the first instantiation of an LVC-TE based on fielded training systems which are part of the PEO STRI portfolio. This first LVC-TE instantiation will evolve from an integrated set of training systems currently in the fielded inventory, to an integrated set of objective training simulations. This integrated set of objective training simulations will implement lessons learned from previous LVC-TE instantiations. These lessons learned and integrated solutions will be shared with the testing community to influence I2 across functions/ domains.

OBJECTIVE LVC TRAINING SIMULATIONS AND THEIR ASSETS

A LVC-TE can be conceptually divided into the following subsystems.

- A data communications network that carries the simulation data, simulation technical control data, command and control data, and tactical voice/data.
- A set of simulations that compute the behavior of the natural environment, Blue Forces, Red Forces, bystanders, and civil, economic, political, and social behavior of the populations in theater.
- A set of command and control equipment used by the training audience, Blue Cell, and Red Cell to monitor and direct the operations of the Blue Forces and Red Forces separately.
- Command and control equipment as required to direct additional sides in multisided exercises.
- A set of data acquisition equipment that acquires the behavior of the simulated forces for analysis and review. This includes both data acquisition from the simulation and the command and control system historical data collection and review features.
- A set of analysis tools that the training facilitators use to review and critique the exercise.
- A set of equipment that allows the inclusion of live forces into the exercise. The command and control audiences are one group of live participants. A second group includes land, air, and sea vehicles operating on one or more training ranges.

Within the PEO STRI training portfolio there are three main PLs – one for each of the L, V and C domains, which provide functions that support the aforementioned subsystems. The Live domain has the Live Training Transformation Family of Training Systems (LT2-FTS). The Virtual domain has the Synthetic Environment CORE (SE CORE). The Constructive domain has the One Semi-Automated Forces (OneSAF), for entity level constructive simulations, and Warfighters Simulation (WARSIM) for aggregate level constructive simulations.

In addition to these three individual L, V, and C PLs, there are two other important Army programs that will provide key LVC-TE capabilities in the areas of centralized training management for the Army and Future Combat Systems (FCS) Embedded Training (ET). The Army Training Integrated Architecture (ATIA) is being developed as a means to centralize all the Army training management functions (ATIA, 2007). The FCS ET product line, known as the FCS Training Common Components (TCCs), provides a core LVC ET capability for the FCS. The remainder of this section provides an overview of the three main L, V, and C PLs, and how the FCS TCC program is developing an instantiation of a core LVC capability, based on solutions from the three individual L, V, and C PLs.

Live (L) Domain

The Live Training Transformation (LT2) Product Line focuses on live training domain requirements, with the objective to maximize component reuse, reduce fielding time, minimize programmatic costs, and enhance training benefits afforded to the Soldier (Dumanoir, Rivera, 2005). The LT2 Family of Training Systems (LT2-FTS) is an Army program (TRADOC, 2005) to develop a live training product line that provides capabilities centered on a common architecture, known as the Common Training Instrumentation Architecture (CTIA). CTIA is a component-based, Service Oriented Architecture (SOA) that enables a structure of common, reusable components, their relationships, and the standards and guidelines governing their design and evolution over time. CTIA provides the technical framework to implement various LT2 product instantiations for the Army's instrumentation ranges at combat training centers, homestation, and deployed.

Figure 2 provides an architectural overview of the LT2 product-line, which provides assets through the LT2 Portal (2007). In this architectural view the bottom layer represents the architecture infrastructure functions provided by CTIA. The next layer up represents the common software components that plug into that architecture to provide the specific user services for live training range applications. Software components within these two bottom layers provide the "tools" required to compose functional capability groups that support the different phases of Live training. Different compositions of these functional capability groups provide different functional capabilities to support the different live training exercise needs in a Combat Training Center (CTC), in Home Station Training Ranges and/or while deployed.

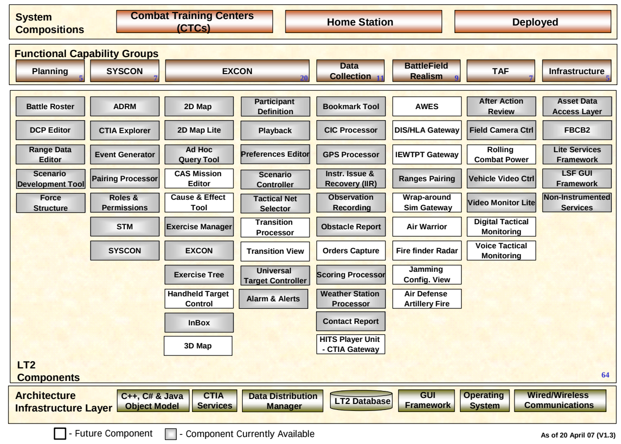

Figure 2. LT2 Product Line Architecture Framework View.

The set of LT2-FTS product integrated architectures describe how the live training systems within this product line plan, prepare, execute and provide training feedback for Force-On-Force (FOF) and/or Force-On-Target (FOT) training. These architectures also describe interfaces to virtual and constructive training domain systems, the Army's Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) infrastructure systems, Future Combat System (FCS) platforms, and to Joint National Training Capability (JNTC) components.

The LT2-FTS product integrated architectures also provide a set of architectural services that facilitate common user functions within a live training range. They basically provide interfaces that isolate components from underlying hardware and operating systems. This set of LT2-FTS domain specific architecture services, which are a key element of the LT2-FTS domain Services Oriented Architecture construct, can be grouped into 3 main categories.

- <u>Exercise Independent Services</u> includes services such as Registration Agent Service, Component Service, Exercise Management Service, and GPS Correction Service.

- Exercise Specific Services includes services such as Event Dispatch Service, Event Query Service, Event Subscription Service, Object History Service, Object Management Service, Rule Service, (Situation Awareness (SA) Region Management Service, Tactical Message Service, Tracking Control Service, Tracking Data Query Service, Meta Data Service, Test/Training Enabling Architecture (TENA) Services, and Environment Runtime Component (ERC) Update Management Service.

- Implementation Services include services such as Exercise Management Object (EMO) Routers, Database Services, and File System Services.

Virtual (V) Domain

The Synthetic Environment Core (SE Core) PL provides a Common Virtual Environment (CVE) to link virtual training simulation devices using a common integrated architecture, with common services and components (SE Core Web Site, 2007). SE Core will provide a fair fight capability that is sufficient for Mission Rehearsal and Global War on Terror (GWOT) training. There are two primary initiatives under the SE Core program: the Architecture and Integration (A&I) and the Database Virtual Environment Development (DVED)

The SE Core A&I effort's primary mission is architecture analysis and development of the Virtual Simulation Architecture (VSA) to provide a CVE that links system and non-system virtual simulations into a fully integrated and interoperable training capability. The VSA utilizes a PL approach that emphasizes systematic reuse and interoperability and provides the foundation and guidelines for developing Common Virtual Components (CVCs), which are designed to enable plug-and-train operation. The CVCs' extensibility will support the fulfillment of future training needs. The CVCs can be linked to a plug-and-train environment, thus reducing redundancy, leveraging reuse, and facilitating the integration of the LVC training environments.

Figure 3 provides an architectural overview of the VSA product-line in which the bottom layers represents the Virtual simulation platforms and the VSA services. Next layers up represent a logical grouping of reusable software components and set of products and sub products which represent the deployable applications. These products are the elements that provide the functions that meet the virtual training operational needs, which in turn are incorporated within virtual training systems segments.

The SE Core integrated architecture is based on a set of services which provide interfaces that access commonly reused functions across the virtual training domain. The following set of 7 initial SE Core domain specific architecture services are currently in development.

- Distributed Object State Services
- Composition Services
- Simulation Execution Services
- Interoperation Services
- Data Services
- Coordinate Services
- Environment Services

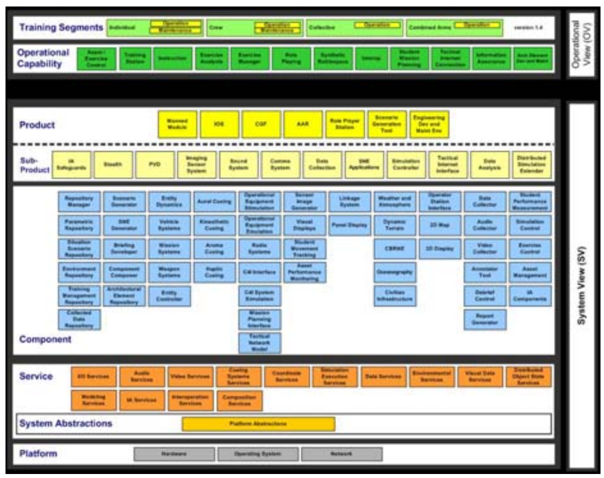

Figure 3. SE Core Product Line Architecture Framework View.

The SE CORE DVED effort's primary mission is to rapidly generate correlated runtime databases for simulation systems. Using a DVED defined software architecture and processes along with a suite of commercial and Government off-the-shelf database development software tools, a master Synthetic Environment (SE) database is populated from a union of multiple authoritative data sources. From this master SE database and with simulation system vendor developed database formatters, runtime databases are then produced that meet the Warfighters' objectives for training, mission rehearsal, and mission planning. The DVED architecture and tools will enable the generation of master SE database content and runtime simulation databases in hours or days, instead of the current production time of months. The Army will initially establish five database production centers around the world that will serve as centralized facilities for the production of all virtual runtime databases created under the SE Core program. The database production centers will create correlated, runtime databases for use by ground, aviation, and joint forces using virtual systems such as the Close Combat Tactical Trainer (CCTT), Aviation Combined Arms Tactical Trainer (AVCATT), FCS and the supporting OneSAF databases. The DVED effort will also develop common virtual vehicle models, common virtual sensor simulation software, and the virtual simulation component of dynamic environment, atmospheric effects, and Chemical, Biological, Nuclear, Radiological, Nuclear and Explosive (CBRNE) simulations. The DVED standard database architecture with its resulting increase in speed and efficiency, will allow up-to-date intelligence and surveillance data to be inserted rapidly into virtual databases, thus providing the most effective training and mission rehearsal systems to our Warfighters.

Constructive (C) Domain

The Joint Land Component Constructive Training Capability (JLCCTC) is a federation of Constructive simulations/models and the associated software tools required to compose, initialize, operate, tune, and maintain a synthetic operational environment to support the conduct of collective command and staff training. JLCCTC is the Army's command and control Constructive training federation that will evolve from the current training systems in the inventory to an integrated set of objective training simulations.

The two main constructive simulations that are part of the PEO STRI portfolio are the Warfighter Simulation (WARSIM) aggregate level simulation and the One Semi Automated Forces (OneSAF) entity level simulation. Out of these two constructive simulations, the OneSAF simulation was developed using a product line approach (Wittman Harrison, 2001). Although neither WARSIM nor OneSAF are fully integrated into the JLCCTC today, they are considered an important piece of any LVC-TE. In particular, the OneSAF simulation is considered an important element in the future of LVC since it is the common entity –level Computer Generated Forces (CGF) simulation being integrated across several products within the PEO STRI portfolio.

OneSAF is the Army's a composable, next-generation, entity-level CGF simulation designed for brigade and below combat and non-combat operations (OneSAF Web Site, 2007). Being a semi-automated forces (SAF) model, it provides intelligent, doctrinally-correct behaviors to increase the span of control for workstation operators. It was built to represent the modular and future force and to represent entities, units, and behaviors across the spectrum of military operations in the contemporary operating environment. OneSAF is unique in its ability to model unit behaviors from fire team to company level for all units, and employs appropriate representations of the physical environment and their effects on simulated activities and behaviors. With requirements ranging from closed-form analytical support to command level human in the loop training, it provides a common CGF solution for a broad range of user requirements, based on a common architecture framework to which includes common services and common components.

The OneSAF Product Line Architecture Framework (PLAF), shown in figure 4, supports a hierarchical composition process to create specific system configurations based on software components and is intended to identify basic products, components, and interfaces that support the entirety of the OneSAF user domain requirements.

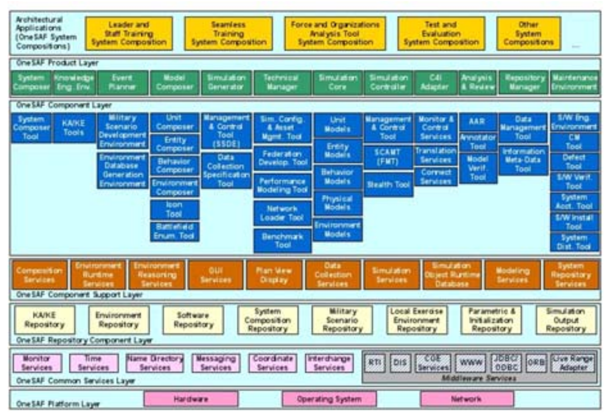

Figure 4. OneSAF Product Line Architecture Framework View

At the highest level, products are combined to create the system configurations, identified in the system compositions layer, which provides configured end-user functionality for operational use within the Advanced Concepts and Requirements (ACR), Training, Exercises, and Military Operations (TEMO), and Research, Development, and Acquisition (RDA) domains. The product layer includes all of the OneSAF products that will be configured to support the mission area applications. These are the top-level building blocks within the OneSAF architecture which provide the specific functionality that makes up a part of setting up, executing, and analyzing simulation results. The component layer contains the components that are to be developed independently in support of the products contained in the product layer. The PLAF supports multiple implementations of each of these components in order to support a specific product for a specific composition; however, a single component implementation may support multiple products, multiple same kind products, and multiple compositions. The component support layer holds the software services that are used by more than one of the components. The repository layer represents an electronic storage mechanism that keeps all of the information, data, and meta-data for one logical area pertaining to OneSAF. The common services layer includes those services that are commonly available as COTS, such as database management, operating system time synchronization services and network distribution services. Included in common services layer are the middleware services, which provide support for middleware solutions to gain distributed interoperable simulation and software services.

LVC Embedded Training Domain

The FCS program is a family of systems that will provide the basis for transforming the Army's current forces. It will be a networked, multifunctional, multi-mission re-configurable family of systems designed to maximize joint interoperability, strategic transportability, and commonality of mission roles. This strategically deployable, tactically superior and sustainable force will provide a quick reaction capability to conflicts arising in the 21st century. FCS is on the leading edge of implementing embedded individual, crew, and collective training to support the concept of "any time and any where" training. To accomplish these Embedded Training (ET) objectives, FCS is reusing existing training software from Army base programs to develop a core set of Training Common Components (TCCs) that can be used by all FCS platforms (TCC Web Site, 2007). This TCC software reuse is drawn from the LT2-FTS PL for the live training domain, and the OneSAF PL for the Constructive domain. The TCC software reuse from the SE CORE PL is mainly from a synthetic environment and environmental representation standards perspective. The ATIA is also being leveraged to provide Army specific training management functions. Key elements are being integrated from each of these PLs to provide a core set of ET capabilities for all FCS platforms (Dumanoir, Pemberton and Walker, 2006).

The FCS TCCs provide an 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 re-hosting contributing program functionality and integrating existing training capabilities with the FCS System of Systems Common Operating Environment (SOSCOE). SOSCOE is the middleware that provides all the common services to the various FCS operational components as well as the TCCs. 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 6 provides an architectural layered view of the TCCs within an FCS system.

Out of the 8 TCCs the Data Logger TCC is the repository for CTIA and OneSAF runtime services and CTIA database services. Since this TCC captures the main training architecture services, it is one of the key components for embedded 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 and supports all of the data types identified in the FCS Brigade Combat Team Information Model (BCTIM).

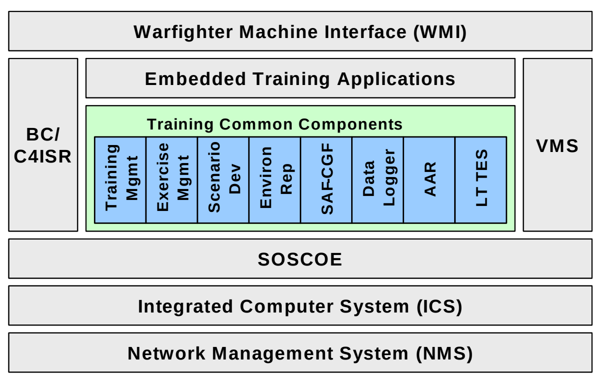

Figure 6. FCS TCC Product Line Architecture Framework View.

Although the FCS TCC effort has proven invaluable in exploring and addressing LVC I2 issues, several challenges still remain to achieve the desired LVC-TE state. The following section provides an overview of some of these challenges.

LVC I2 INITIATIVES, LESSONS LEARNED AND CHALLENGES

Although LVC training has been done for years, PEO STRI continues to explore new and innovative ways to improve the effectiveness and seamlessness of the LVC-TE. The basis for these innovations are lessons learned from previous LVC experiences which have been using existing interoperability methods such as DIS, HLA, and/or TENA. This section provides an overview of some of these initiatives being undertaken to achieve improved LVC I2.

Common Standards, Products, Architectures and/or Repositories (CSPAR). One of the building blocks of the LVC I2 effort is a policy which defines the designation and use of common products and the identification of communication and interface standards, data models, and architectures which facilitate and ultimately reduce the cost of the integration and interoperability of L,V, and C capabilities across PEO STRI. This policy, known as the CSPAR, establishes a set of common components, architectures/ frameworks, standards, interfaces, data interchange formats, repositories and data/object models, which should be evaluated for adoption and use by any and all acquisitions which have requirements that fall within their boundaries. The intent is to evolve assets identified in this policy by taking the existing PL assets and extending them to support a LVC-TE as required. One example is taking existing architecture services and evolving them to support common and unique training needs within a LVC-TE. Another example is evolving existing AAR components from the different PLs into a common set of AAR components that can meet individual PL needs as well as combined LVC AAR needs.

I2 Maturity Model (I2MM). Another LVC I2 building block is an I2MM which helps define levels of interoperability. This I2MM is similar to the old DOD Levels of Information Systems Interoperability (LISI) Model, in that it identifies the stages through which PEO STRI systems should logically progress, or "mature," in order to improve their capabilities to interoperate. The I2MM considers five increasing levels of sophistication regarding system interaction and the ability of the system to exchange and share information and services. Each higher level represents a demonstrable increase in capabilities over the previous level of system-to-system interaction. Although this I2MM is still evolving to provide a more efficient benchmark for PEO STRI LVC I2, it provides a starting point for measuring LVC I2. Part of this I2MM evolution includes refining the levels of interoperability to align with net-centric warfare concepts related to training systems and Global Information Grid (GIG) interoperability.

Data Models. One of the key challenges associated with LVC interoperability is the use of consistent data models. An effort is underway to address the differences between the PEO STRI product lines data models, in particular as it pertains to supporting interoperability between heterogeneous systems and data models. The objective is to consider solutions that provide the best performance while still using the native data models for those simulations which are being integrated to provide a LVC-TE. Although a common data model has been given consideration, it might not be the most effective solution due to existing differences between the current product line data schemas and the impact changing that baseline would cause. So other solutions sets that include translators and/or data alignment schemes are being considered. Part of this effort includes addressing Command and Control Information Exchange Data Model (C2IEDM)/Joint Consultation Command and Control Information Exchange Data Model (JC3IEDM) compliance solutions. The FCS TCC effort is leading a similar initiative by defining a logical data model for the LVC TCC applications, as well as analyzing how to best align with Battle Command Systems (BCS) data models as defined by the C2IEDM/JC3IEDM. This TCC logical data model will be used in subsequent PEO STRI efforts to define a common logical data model for our product line simulations to follow.

Another initiative within the data model area explored interoperation between OneSAF and CTIA through solutions other than HLA and/or DIS (Dumanoir, Pemberton and Samper, 2004). This initiative explored a direct data model translation approach which offered improvements in interface performance and scalability, as well as for data model fidelity and the ability to automatically coordinate critical responsibilities across the interface. This solution has been implemented by the FCS TCCs to interoperate CTIA based components with OneSAF based components on top of the FCS SOSCOE.

Object Models. Another challenge within the Live domain, is aligning to the right object model for a given training exercise. Within the Live domain, two main object models are being used to support interoperation between service/component simulations in a JNTC environment. The JNTC Logical Range Object Model (LROM) is the object model of choice to support interoperability between all test and training ranges. These Joint test and training ranges are required to use the Test/Training Enabling Architecture (TENA) as the main communications architecture to move data from one service/component simulation to another. The Army, as well as other service/ components, have developed their own simulation architectures with their own object models. Since the Army's LT2-FTS has to interoperate with the JNTC to support Joint exercises it has addressed this difference in object models within its architecture services. This approach allows the LT2-FTS PL to use their internal OM and services for intra Army range communications, and also use the Joint LROM to support Joint inter service/component range communication.

Another initiative within the Live domain is looking at a couple of object model options to interoperate Live simulations with the constructive "wrap around" simulation required to augment the live entities in support of a large training exercise. The two object model options being considered are (1) using a common Joint LVC Federation Object Model (FOM), and (2) exploring an approach based on the aforementioned OneSAF–CTIA native adaptor solution.

<u>BCS System Interoperability</u>. Effectively simulating and stimulating BCS has always been both an operational and technical challenge. A common Command, Control, Communications, Computers, and Intelligence (C4I) adapter, which enables constructive simulation interoperability with C4I systems, is currently being used by OneSAF and WARSIM. The C4I adapter was originally a WARSIM software component that provides bi-directional stimulation for the Army Battle Command System (ABCS). OneSAF then adopted this software component and evolved it to fit within the OneSAF architecture, to satisfy additional OneSAF requirements, and to become a more efficient message translation mechanism. The Virtual domain SE Core product line is currently using this same common C4I adapter to support some of their C4I interoperability requirements. Although the Live domain has identified some Live C4I interoperability requirements that could be satisfied by the existing common C4I adapter, it is also investigating reuse of test community's Common Command and Control Driver (C3 Driver) functions as another capability that could be leveraged to support the Live needs for "injecting", "querying" and "listening" to C4I data. PEO STRI's final objective is to try to achieve a common C4I interoperability solution set that can satisfy all the L, V, and C needs for C4I data interchange and ultimately provide a LVC-TE solution as well.

<u>Common CGF for Virtual domain</u>. Another area that has impeded efficient and seamless interoperability among LVC simulations is trying to interoperate different CGF applications. Within the PEO, the virtual domain products, such as the Common Gunnery Trainer (CGT), the CCTT and AVCATT systems, are either integrating a OneSAF-based CGF from the beginning or planning to phase in the transition to a OneSAF-based CGF. This will allow a common entity based CGF to be used throughout not only the virtual domain products but throughout the other L and C domains since the OneSAF is the preferred entity based CGF across the PEO and the Army.

<u>Dual Use Tactical Equipment</u>. Within the Army there is a push to leverage as much tactical capabilities for training and test purposes as possible. One of those capabilities being targeted for dual use is tactical radios and communications networks. In particular, with the evolution of FCS, the Army would like to use capabilities such as the Joint Tactical Radio System (JTRS) and integrate it with communications network infrastructure to support training and testing. The objective is for this same radio and data communications infrastructure to be one of the key subsystems that also support a LVC–TE. This initiative is also allowing the Army and the training/test communities to address frequency spectrum and data encryption challenges. Other dual use opportunities being pursued are focusing on embedding Tactical Engagement Simulation System (TESS) capabilities and different hardware and software tactical equipment solutions that can enable this goal. These areas are being pursued by PEO STRI Live and FCS PLs and play an important role in the future of LVC-TE.

CONCLUSION

The Modeling, Simulation and Training (MS&T) communities have made significant progress in enabling users to link critical resources through distributed heterogeneous architectures. Today, the DOD is in the middle of a Live-Virtual-Constructive Architecture Roadmap (LVCAR) study which will provide a blueprint for LVC architecture issues for the next 5 - 7 years. The study is exploring and assessing a number of alternatives supporting simulation interoperability, business models, and the evolution process of standards management across the Department. The LT2-FTS common architecture framework – CTIA - is one of several architectures being studied as part of this LVCAR effort. The main goal of this initiative is to define an efficient and effective path to maximize technical interoperability of MS&T systems across the DOD. PEO STRI is a participant in this LVCAR initiative because it believes this effort is an important pillar in the future of LVC environments.

Another key dependency in the successful implementation of future LVC environments is the alignment of our individual PL integrated architectures with the new DOD Federated Enterprise Architecture (FEA) paradigm to provide our Warfighters and decision makers useful tools within a net centric warfare environment. This federated enterprise architecture paradigm is DOD's new approach for representing the "next generation" GIG Architecture, in which separate integrated architecture artifacts throughout the DOD are federated and employ a set of Enterprise Architecture Services for registering, discovering, and utilizing architecture data to support key DOD decision processes (DOD CIO, 2006). PEO STRI is ready to take on the next challenge of federating its PL integrated architectures to produce LVC-TEs that meet different user needs.

As PEO STRI continues to be engaged in these new initiatives, it also is developing a net-centric training strategy which addresses issues such as using actual C4ISR mission data while having to meet GIG Information Assurance requirements for integrity and non-repudiation of data and systems. In addition, this training approach will address not only "pulling" the information from the GIG, but also provide a means for the trainers to assess whether the right information is being "pulled" from the GIG.

This paper addresses just some of the areas that PEO STRI is working on to help enable LVC I2. Initiatives centered on open architectures, technical frameworks, common standards /interfaces /protocols, common components and common data/object models, to name a few, are the main technical pillars of our LVC I2. These initiatives and the continued advancements is the execution of PL engineering concepts, within our acquisition processes, which focus on component based architectures, standards, and processes, allow PEO STRI to continue making significant advances in MS&T and LVC I2 with the sole objective of benefiting our Soldiers, Sailors, Airmen, and Marines in their increasingly Joint training environment.

.

REFERENCES

ATIA web site, retrieved 2007 from http://www.train.army.mil/tddt/atia.htm

Department of the Army, FM 7.0, Training the Force, 21 October 2002, *p.* 4-15.

DOD CIO, *(2006). DOD Enterprise Architecture Federation Strategy*, Draft Version 1.01, 04 December 2006

DOD, JFCOM (2005), Draft (V0.1.9) Joint Capabilities Document (JCD) For Joint Live, Virtual, & Constructive- Training Environment (JLVC-TE), dated 3 Jun 05.

Dumanoir, P., Rivera, J. (2005). *LT2- A Strategy for Future Army and Joint Live Training*, 2005 Interservice/ Industry Training, Simulation, and Education Conference (I/ITSEC), Orlando Florida

Dumanoir, P., Pemberton, B, Samper, W (2004). *OneSAF Interoperability with CTIA – A LVC Connectivity Approach*. 2004 Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC), Orlando Florida.

Dumanoir, P., Pemberton, B, Walker, P (2006). *Embedded Training: A Future Combat System Live Training Use Case*. 2006 Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC), Orlando Florida.

FCS TCC web site. Retrieved 2007 from: http://www.peostri.army.mil/PRODUCTS/TCC/

JLCCTC web site. Retrieved 2007 from http://www.peostri.army.mil/PRODUCTS/JLCCTC/

LT2 web site. Retrieved 2007 from https://www.lt2portal.org/

OneSAF web site. Retrieved 2007 from: http://www.onesaf.net/community/

TRADOC, Initial Capabilities Document (ICD) for LT2-FTS, Aug 2005. Retrieved Jun 2007 from: https://www.lt2portal.org/

SE CORE web site. Retrieved 2007 from: http://www.peostri.army.mil/PM-CATT/APM_SECore.jsp