Integrate vs. Interoperate; an Army Training Use Case

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

ABSTRACT

The Joint Vision 2020, which guides the continuing transformation of America's armed forces, states "Interoperability is the foundation of effective joint, multinational, and interagency operations." Most of us have our own ideas on the difference between the terms interoperability and integration when it comes to systems, and probably tend to use them interchangeably and incorrectly. This paper explores the difference between the two terms within the context of an Army System of Systems (SoS) training product called the Live, Virtual, Constructive Integrated Training Environment (LVC ITE), and its integrating architecture and infrastructure. The Live, Virtual, Constructive – Integrating Architecture (LVC-IA) is a U.S. Army Program Of Record (POR) intended to provide a two-way network-centric linkage between models, simulations, instrumentation, and Mission Command (MC) systems supporting collective and battle staff training and mission rehearsals for a Brigade Combat Team (BCT). This paper examines how the systems, or components, within the LVC ITE SoS domain exchange information and how that information is used. The paper also describes how the LVC-IA POR performs the act of integration by coordinating and blending disparate pieces into a functioning and unified system. Key pieces of this integration and interoperability use case include simulations such as the Joint Land Component Constructive Training Capability (JLCCTC) Entity Resolution Federation (ERF), the Homestation Instrumentation Training System (HITS), the Close Combat Tactical Trainer (CCTT), and the Aviation Combined Arms Tactical Trainer (AVCATT). The paper will also examine how pieces of the LVC-IA POR, such as Cross Domain Solution (CDS), Gateways, Agile Development Methodology (ADM), and product-line engineering approach, are integrated to meet an architectural objective. Lastly, lessons learned from a SoS Engineering perspective are presented in addition to a way ahead on LVC-IA compliance with the Army Common Operating Environment (COE).

ABOUT THE AUTHOR

Paul Dumanoir is the chief engineer for the U.S. Army Product Manager Warrior Training Integration (PdM WTI) at U.S. Army Program Executive Office (PEO) Simulation Training and Instrumentation (STRI). He has 25 years experience working in DOD simulation and training programs as product manager, project director and systems / software engineer. His current interests include component-based product-line engineering, and System of System (SoS) integration and interoperability. 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.

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INTRODUCTION

As technology becomes more far-reaching and interconnected, interoperability has become ever more critical. The Joint Vision 2020, which guides the continuing transformation of America's armed forces, states "Interoperability is the foundation of effective joint, multinational, and interagency operations" (DoD 2000). This paper explores interoperability and integration from a single system and a System of Systems (SoS) perspective by using an Army training environment as a use case, and investigates different elements of integration and levels of interoperability (DoD 1998). Several system component and development processes are examined to illustrate how they are integrated to produce a high level of interoperability (DoD 2000). In addition, lessons learned from a SoS engineering perspective and a way ahead on LVC-IA compliance with the Army Common Operating Environment (COE) are presented.

Integration vs. Interoperability

All forms of integration exhibit some quality of interoperability. The type of integration method or approach dictates the level of interoperability that is achieved. The following definitions are provided as a simple reference that describes the differences between the two terms.

- Integration is the process of linking together diverse systems of organizations.
- Interoperability is a property of integration that ensures a level of independence between existing and future systems or organizations.

AN ARMY TRAINING USE CASE

Currently the Army's "Blended Training" approach uses Live, Virtual, Constructive and Gaming (LVC-G) capabilities simultaneously in a non-persistent or non-consistent manner to create a more realistic collective training experience that meets the commander's training objectives. Looking into the future, the Army is also executing an Integrated Training Environment (ITE) strategy that by design combines, or technically connects, support tools and selected Training Aids, Devices, Simulations, and Simulators (TADSS) in a persistent and consistent manner; while leveraging the tactical unit's Mission Command (MC) systems. The ITE is structured to meet the commander's training objectives within the appropriate Operation Environment (OE) and is capable of supporting individual and multi-echelon collective training within all of the Army's training domains and training environments. The Live, Virtual, and Constructive Integrating Architecture (LVC-IA) is the Army's Program of Record (POR), which provides common protocols, standards and interfaces, in a persistent and consistent manner, allowing the interoperability of dissimilar TADSS in a LVC-G training environment while simultaneously stimulating the unit's MC systems.

Figure 1 shows how the LVC-IA system, along with an associated installation's supporting training infrastructure, are mutually dependent on each other to create an ITE SoS.

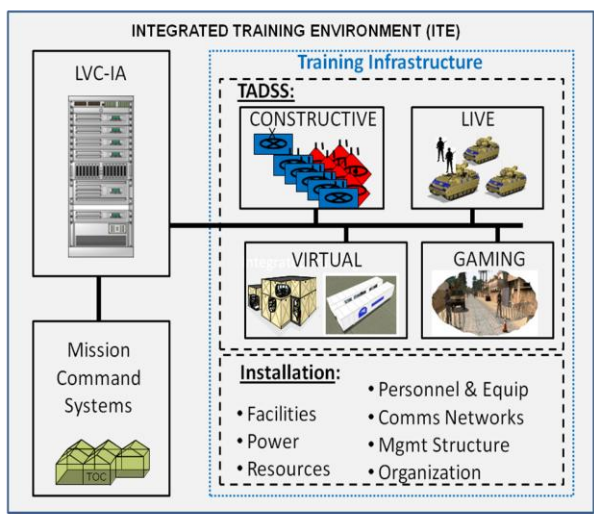

Figure 1. ITE SoS Constituent Systems.

The LVC-IA is a network-centric linkage that collects, retrieves and exchanges data among live instrumentation, virtual simulators, and constructive simulations as well as Joint and Army MC systems (i.e., the constituent systems).

This integrating architecture defines "how" information is exchanged among the LVC-G domains and MC systems. In addition to common protocols, standards and interfaces, this architecture provides common software components and tools required for interoperability of the LVC-G systems and for simulation / stimulation (SIM / STIM) of the unit's MC systems.

On the other hand, the ITE training infrastructure provides the "means" for communicating, exchanging data and networking for all of the LVC-G domains. This infrastructure includes the installation's foundational elements and components needed to perform net-centric mission command training and includes: facilities, power, communications (Radio Frequency / Fiber) networks, training support systems (i.e., TADSS), personnel and equipment, resources, management structure and organization. The end-state goal of the LVC-IA and the training infrastructure is to enable an ITE that approximates the conditions of the OE allowing the combat unit to train for Unified Land Operations (ULO) using a mix of training domains.

Version 1 of the LVC-IA is scheduled to begin fielding at FT Hood, TX, during 4QFY12. As expected, the LVC-IA POR is involved in various aspects of interoperability and integration during its Engineering, Manufacturing Development and Demonstration acquisition phase. This section discusses some of those aspects from the perspective of the ITE SoS and how the systems, or components within that SoS, exchange information and how that information is used. This section will also describe how the LVC-IA POR performs the act of integration by developing, coordinating, and blending disparate pieces into a functioning and unified system.

LVC-IA INTEGRATED PRODUCTS

The LVC-IA POR made a conscious decision to execute a product line engineering approach that provides an architecture based on commonality, as well as planned variability. The different product variants can be derived from a basic product family, which creates the opportunity to reuse and differentiate on products in the family. This approach integrates existing tool sets / software components, also known as reusable components, to reduce development level of effort, thus decreasing overall program cost. Using these common components and tools wherever possible provide commonality in user interfaces, source code and updates required from tool to tool as new functionality is built into the system. Integrating reusable components comes with its own set of challenges and these are described later. Figure 2 provides a top level overview of the LVC-IA and its key common components. These common components are described in more detail in the LVC-IA System / Subsystem Description Document (SSDD), (PEO STRI, 2012)

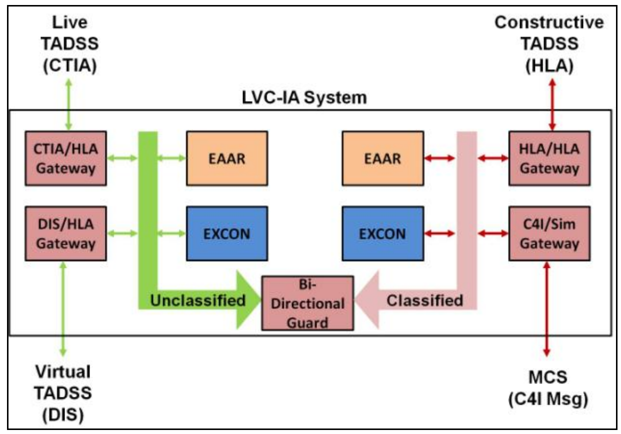

Figure 2. LVC-IA Overview.

Gateways

The Joint BUS (JBUS) is one of the main common components, selected as the common 'Base' tool for all gateway implementations (except Command, Control, Communications, Computers and Intelligence (C4I)) and for Enterprise After Action Review (EAAR) data collectors. JBUS is a Government Off-The-Shelf (GOTS) open source, plug-in based, architecture used primarily for message translation. The four plug-ins used by the LVC-IA's JBUS implementation are:

- A High Level Architecture (HLA) plug-in, common to all JBUS gateways, ensures consistent handling of the LVC-IA HLA Federation Object Model (FOM) throughout the LVC-IA system. The LVC-IA backbone operates using HLA with the LVC-IA FOM v1.0 using NG-Pro Run Time Infrastructure (RTI) v6.0. This LVC-IA FOM v1.0 is based on the Entity Resolution Federation (ERF) FOM v6.0.

- The CTIA plug-in allows for communication with CTIA based architectures such as the Homestation Instrumentation Training System (HITS).

- A Distributed Interactive Simulation (DIS) plug-in ensures that the DIS PDUs across DIS versions are translated correctly to and from HLA. The main users of the DIS are the virtual TADSS, such as the Close Combat Tactical Trainer (CCTT) and the Aviation Combined Arms Tactical Trainer (AVCATT).

- The XML plug-in is used to ensure data validity and conversion to and from HLA for the Cross Domain Solution (CDS).

Another key LVC-IA component, which reuses existing software components, is the C4I / Simulation (SIM) gateway. The purpose of the LVC-IA C4I / SIM gateway is to stimulate the Command and Control (C2) Tactical Local Area Network (TACLAN), with simulation data and also provide HLA interactions from the C2 data such as fire support messages. This is accomplished by translating simulation based DIS / HLA data into C2 messages where and when appropriate. The C4I / SIM gateway is based on reuse of the following four components:

(1) Simulation to C4I Interchange Module for Plans, Logistics and Exercises (SIMPLE) / Joint Master Scenario Event List (MSEL) and Exercise Control Station (JMECS).

(2) Joint Deployment logistics Model (JDLM).

(3) Digital Army United States Message Text Format (USMTF) / Variable Message Format (VMF) Stimulator (DAUVS).

(4) Simple Artillery (SARTY) / Extensible C4I Instrumentation Suite (EXCIS).

JDLM and DAUVS are run in the Constructive simulation and are not part of the LVC-IA architecture and suite of tools. Figure 3 shows how the C4I / SIM gateway has a link to the C2 architecture and is the mechanism for translations of DIS PDU's or HLA interactions into C2 messaging.

Using these gateways, as a key component of the LVC-IA, addresses the requirement of interoperating dissimilar TADSS without changing their internal core protocols and communication standards. This issue of interoperating with legacy systems is explored further in subsequent sections.

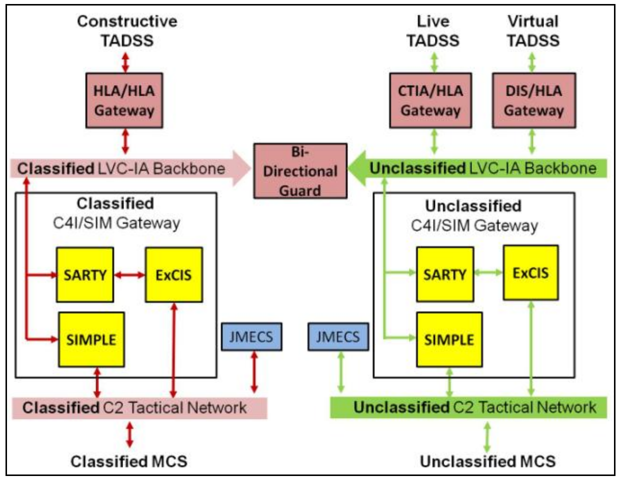

Figure 3. LVC-IA C4I / SIM Gateway Overview.

EAAR and Exercise Control (EXCON)

The LVC-IA EAAR and EXCON components are also based on reuse of existing software components. The EAAR provides AAR capabilities for the brigade and battalion commander and their staff for the LVC-ITE training exercise. The EAAR records simulation, voice, and control data during the exercise. EAAR also collects the screen captures, video data, and other relevant materials via intranet portal file share and other portable media such as CD and DVD provided by the core systems. The collected data and information are used to playback ground truth and perceived truth to paint the common operating picture for the training audience. The data and information are also used to build EAAR reports and presentations for the training audience. While the LVC-IA EAAR focuses on the higher echelon, some lower level detailed information can be made available if the need for the information is predefined and means to collect and display the information exists. The JBUS and the After Action Review System (AARS) were selected for reuse to support different subcomponents of the EAAR. The AARS is also used to meet the AAR requirements for the Joint Land Component Constructive Training Capability (JLCCTC) Entity Resolution Federation (ERF).

The main purpose of exercise control, within the LVC-IA, is to coordinate all data elements involved in the execution of a live, virtual and constructive exercise in order to provide a realistic ITE. The EXCON components provide the capability to create a simulation order of battle, perform simulation control, exercise monitoring, collect and record exercise data for AARs, display perceived (C2) truth, display ground (simulation / simulator / live) truth, and provide C2 injects. The Joint Remote Client (JRC) / EDIT tool was selected for reuse to support the scenario development subcomponent of the EXCON. The scenario development tool provides users, models and live players the capability to share and integrate scenario data. JRC / EDIT allows users to create new scenarios (i.e., unit, systems within the unit, etc.), edit existing scenarios and place units on a standard 2D map common with ABCS. In addition, the JLVC Analysis Workstation (JAWS) and the Virtual Battle Space 2 (VBS2) applications were selected for reuse in support of other EXCON subcomponents. The JAWS is used for situational awareness and event analysis. VBS2 is used for 3D display.

Bi-directional Guard

The bi-directional guard is another key LVC-IA component that reuses existing software components. It provides protection and sanitization of data flowing from the low to high and high to low security enclaves. As shown in Figure 4, this simulation guard sits between the classified and unclassified simulation backbones. It provides connectivity from one to the other but only allows defined message traffic and data to pass.

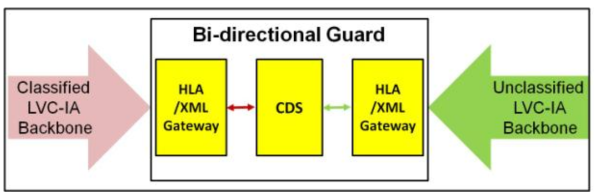

Figure 4. Bi-directional Guard.

This bi-directional guard is composed of a CDS and bi-directional data translation gateways. Radiant Mercury with Rialto was selected as the CDS solution set. Although the Unified Cross Domain Management Office (UCDMO) offers other validated cross domain solutions, this solution set was chosen because the JLCTCC TADSS is also using this solution set and it satisfies a large set of common requirements. This CDS software application operates according to user defined rules and automatically sanitizes and downgrades formatted classified documents. The automation of the sanitization and downgrade process decreases the time needed to perform these functions, and eliminates human error. Rialto provides translation of simulation data to and from XML. The JBUS is the other reusable component used in this bi-directional guard to conduct the data translation from XML to HLA. This combined bi-directional guard system provides an end-to-end sequential process which includes HLA-XML data translation, data sanitization, and XML-HLA data translation.

The LVC-IA Bi-directional Guard has its own accreditation boundary. In addition, the LVC-IA has a DoD Information Assurance Certification and Accreditation Process (DIACAP) Type Authorization To Operate (Type ATO) at the MAC III Classified (Secret) level. Figure 5 provides a distinction between the DIACAP and the CDS accreditation boundaries.

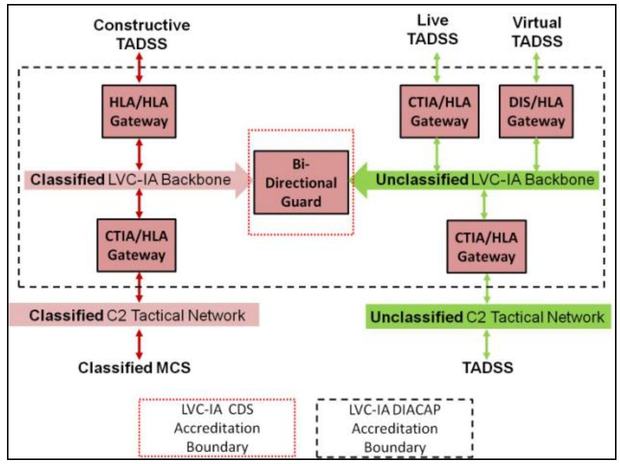

Figure 5. LVC-IA Accreditation Boundaries.

Virtual Machines

Another common tool set integrated into the LVC-IA design is the VMWare's ESXi and VCenter. LVC-IA has implemented this virtualization solution because it offers effective redundancy and load balancing options. This solution allows for ghost images, quick migration upon failure and it manages the Virtual Machines (VM) images across the VMServers allocating resources as needed. This tool set also reduces the hardware footprint from 34 workstations to 34 VMs, which run on 6 servers, expediting the process of patches and updates since the entire VM image can be easily replaced. In addition, it provides significant cost reductions since the cost of VM licensing and high end servers are less than the number of desktop running each component.

Agile Development Methodology (ADM)

The careful execution of software development and integration processes, which enable the linkage of all these common components and tool sets, have yielded this robust and cost efficient integrating architecture for the Army's ITE. One of the processes implemented during the development, integration and test of the LVC-IA was the Scrum process. Scrum is an iterative and incremental agile software development method where small teams, led by a Scrum master, develop software in Sprints. The main tenets behind this agile software development methodology are:

- Individuals and interactions preferred over processes and tools
- Focus is on working software vs. comprehensive documentation
- Customer collaboration emphasized over contract negotiation
- Attention on responding to change over following a plan

In addition, the ADM is intended to facilitate a "build and release" type approach whereby incremental capability is developed and provided to users regularly. This feature is in stark contrast to the traditional Government contracting approach which builds a "final capability" and delivers it to end users when complete.

LVC-IA SYSTEM INTEGRATION LESSON LEARNED

1. CDS. Since the Army is planning to field LVC-IA at various sites and each site would require a separate accreditation for the CDS, the LVC-IA POR obtained approval from the Defense Information Assurance Security Accreditation Working Group (DSAWG) for a repeatable accreditation of the CDS. This approval was contingent on the utilization of defined technical and non-technical processes which addresses items such as asset tracking, configuration management, and CDS replication. This repeatable accreditation process enables the Army to field additional instances of one CDS ticket at various LVC-IA sites, based on CDS Accreditation (CDSA) of one master CDS ticket. This optimized repeatable accreditation process requires significantly less schedule time for accreditation and at significant reduced cost.

For subsequent versions of LVC-IA, the defined message and data traffic will most likely need to be expanded. For example, in order to meet new interoperability requirements, a future version of LVC-IA may need to expand the CDS rule set allowing MC message and data traffic flow This will enable Intel and C2 data exchange amongst the TADSS between the low and high side and provide the Soldier with a more realistic “go-to war” experience. This will most likely require a new CDS ticket and re- accreditation.

2. Reusable software components. Although the LVC-IA POR conducted an extensive reuse evaluation for all LVC-IA software components, and the reusable components have been a key factor in the efficiencies achieved by the POR, these reusable components require a centralized management infrastructure with the responsibility of updating, maintaining and managing the software configuration. Because these reusable components were not originally designed for reuse, a centralized management structure, responsible for adopting software changes and new capabilities, would add value for all the potential users. This would allow the different users of these reusable components to focus on using the software to meet their specific needs without having to worry about other program needs.

3. ADM. Although the LVC-IA implementation of Scrum was successful, by accomplishing its software project management objectives, there were some challenges in getting use to the aforementioned ADM tenets and executing them within a traditional DoD contract. For example, LVC-IA contract requires extensive documentation (i.e., CDRL’s) which somewhat contradicts the ADM tenet of “focus on working software vs. comprehensive documentation.” The fact is although Agile methods do downplay documentation, they don’t exclude it as a management principle. Another example is related to a planning paradigm of this Agile methodology, where a situation arises that was not planned, it is treated as new information, and the plan is readily changed to reflect the new reality. Traditional software development methods see this as risk and managers attempt to get back on the original plan. In fact, traditional methods tend to treat any change as additional program risk and often evaluate it in the court of the Change Control Board (CCB). Another challenge was related to the communication paradigm of this Agile methodology, where face-to-face communication is valued over program documentation as the main form of communication. For example, most Government organizations will not accept a verbal change over a written contractual obligation. The fact is, although verbal communication is favored in Agile methods, written communication is not ignored.

Although Agile methods are not a magic bullet to solve all software problems, they have been proven beneficial on small and medium sized projects. Each organization and project needs to assess their requirements and choose the best method for them. Scrum could be right for some projects, while other processes are right for other projects. Flexibility and knowledge are keys to choosing correct development methods.

ITE SOS LESSONS LEARNED

Besides the integration of reusable components and tools sets within the LVC-IA system, the LVC-IA system interoperates with other external systems and organizations (i.e., constituent systems) within the ITE SoS. As previously discussed and depicted in Figure 1, the LVC-IA is one of three system groups within the ITE SoS. The other system groups are the training infrastructure and the MC systems. Within the training infrastructure there are two main subsystems that the LVC-IA needs to interoperate with: (1) the TADSS (also known as core simulation systems) and (2) the Installation. The LVC-IA Version 1 baseline only interoperates with specific versions of following core simulation systems: CCTT, AVCATT, HITS and JLCTCC ERF. Future versions of LVC-IA will be able to interoperate with additional versions of these and new TADSS to include Army Gaming (G) systems. The other subsystem within the training infrastructure, the installation, is where these TADSS reside. The third system group with which LVC-IA interoperates is the MC systems, which allows the Soldiers to train with their actual "go-to-war" operational equipment, providing a seamless training experience.

SoS Interoperability

Achieving large-scale and dependable interoperation among systems requires a consistently applied set of Program Management, System Construction, and System Operation practices that support the addition of new and upgraded systems to the growing interoperability web (CMU / SEI 2004). Figure 6 depicts these practices as parallel efforts where program management defines the activities that manage the acquisition of a system; system construction defines the activities that develop or evolve a system (e.g., use of standards and COTS products, architecture for each TADSS); and, operational system defines the activities within the executing system and between the executing system and its environment, including the interoperation with other systems. The end user is considered part of the operational system.

Within the ITE SoS, each of the constituent systems has their own unique technical interoperability challenges. In order to increase the level of interoperability, the SoS also requires appropriate processes for identifying and communicating requirements, working in concert on enabling technologies, strategy and schedule; and managing joint risks. Communication barriers between the management, technical, and operational communities have to be overcome. Program agreements have to be reached, which means compromises have to be realized, and some systems might have to be reworked or completely rebuilt to achieve and implement consensus. There are reasons program managers resist making these compromises that relate to matters of funding, risk management, and incentives. Some of these are explored below.

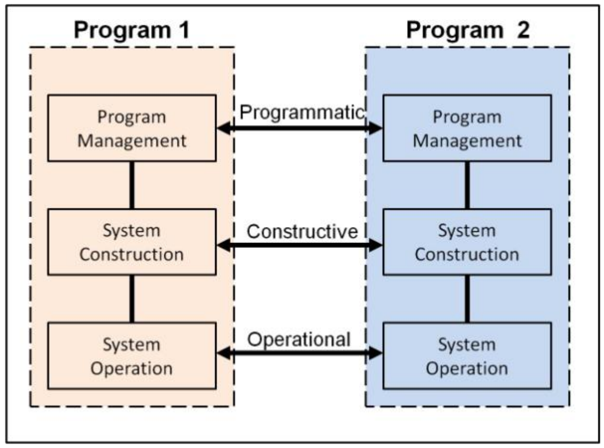

Figure 6. Types of Interoperability Practices.

<u>Funding and Control: Not Aligned</u>. Contradictions exist between the objectives for interoperability and current funding models and incentives, which emphasize individual program success for a specific system. In addition, reaching agreements between programs is dependent on money. At the end of the day, it comes down to a big stick and money. In the case of LVC-IA, and interoperability with the different TADSS, it helped that the PEO ensured each of the Project Managers (PMs) and systems under his purview avoided the stove-pipe mentality, and focused specific dollars to achieve interoperability. In addition, the Army decided that the LVC-IA Version 1 TADSS baseline would be based on existing solution sets that met the individual system requirements in order to avoid negative impact to TADSS POR budget and requirements.

Contractors also need to receive incentives to tie a program's success or profit to another program's success. For LVC-IA, this was accomplished through the use of various acquisition contract types with incentive clauses. In addition, flexible processes were executed which allowed contractors to work as peers to achieve interoperability.

Leadership Direction and Policy. Another barrier to interoperability is a lack of centralized or coordinated ownership of the problem. Shortsighted decisions promote a single system's view at the expense of other systems. Also policy making, with respect to interoperability, needs to be sensitive to the implementer's controls and constraints and needs some flexibility. As mentioned before, this was not as much of a problem for interoperability between the LVC-IA and the TADSS because the LVC-IA and TADSS were all under the purview of the same PEO. This lack of centralized or coordinated ownership became more apparent with interoperation between the LVC-IA / TADSS and the Army installations where LVC-IA was being fielded, since there are different organizations, with different funding streams, responsible for different assets at each installation.

Another example of lack of centralized or coordinated ownership is related to the "overhead" associated with management of reusable products. Although the LVC-IA POR consistently strives to achieve efficiencies through initiatives such as using common components, the infrastructure and product management framework necessary to maintain a family of common products is ad hoc at best. An example is when a software component is chosen because it's being used by several other programs and satisfies a majority of common requirements, there is no centralized or coordinated ownership of that software component to manage the potential divergent baselines that will evolve since that component will have to meet not only common requirements but unique program requirements as well.

Legacy: a Persistent Problem. Can existing systems be altered to achieve sufficient interoperability, or must legacy systems be abandoned to ensure new capabilities? That is one of the dilemmas faced when satisfying interoperability expectations. In order to meet their ITE capability gaps, the Army decided that it was not cost effective to abandon years of TADSS investments therefore the first version of LVC-IA would be based on existing TADSS baselines or "come as you are". The LVC-IA also had to interoperate with current MC system baselines that are being used in the field in order to provide a realistic training experience. This was accomplished by ensuring integration with specific C2 system versions and Software Block 2 capability set.

ITE SoS Design

Besides the aforementioned programmatic interoperability challenges, the ITE SoS faced several operational and construction challenges that required design decisions affecting the evolution of the SoS and its level of interoperability. One of those design decisions focused on data models establishing an underlying common data model that all systems within the ITE SoS used or letting each program choose its own approach and use technologies like XML to bridge the gap. As it turns out, choosing a common data model that was enforced across all programs was not practical, since it would mean that all constituent systems would have to be reworked or completely rebuilt. Instead each system kept its existing data model scheme and the JBUS-based gateways were used to bridge the gap between the constituent system data models and the LVC-IA data model.

In general, the lack of a SoS architecture makes it nearly impossible to understand how systems will interoperate. Early on, the LVC-IA established a SoS architecture that made it possible to isolate components and services and promote interoperability and reuse. This architecture required planning and flexibility in the definition and use of services and agreements on common semantics for messages and data. The basic architecture premise for LVC-IA is to enable various constituent systems to interoperate with each other by sending and receiving data in their own format. While each constituent system has its own hardware and methods to satisfy various requirements, LVC-IA expects that the interfaces that define the touch points with those constituent systems adhere to the standards specified in the LVC-IA interface specifications. For LVC-IA Version 1, the simulation protocol used to interface with the Constructive TADSS is HLA JLVC-ERF (v.5.3 and v.6.0); to interface with the Virtual TADSS is SE Core VDIS 1.5.3 and 1.5.6; and to with the Live TADSS is CTIA 2.0.5.1. In addition, a simulated radio data (DIS - IEEE 1278.1a-1998) protocol is used to interface with the ITE radios, and various C2 messages and formats are used to interface with the MC systems.

Another ITE SoS design element that influences the level of interoperability is the use the use of a common Semi-Automated Forces (SAF) application across the different TADSS. For LVC-IA Version 1, AVCATT and CCTT are using the OneSAF application, and although JLCCTC ERF 5.3 is currently not using the OneSAF application, LVC-IA has made integration decisions that do not preclude it from being able to interoperate with a constructive federation that uses OneSAF in the future. One of the main goals of using a common SAF among the different TADSS is to begin addressing the various complex fair fight issues, such as common terrain and models, encountered when interconnecting heterogeneous simulations. For example, Synthetic Environment Core (SE CORE) terrain data bases were produced and used for all the different TADSS. In addition, artifacts like the SE CORE Master Entity List (MEL) are used to aid development teams to more easily complete the full thread between OneSAF and host visuals. The MEL provides a listing of all entities and units that are available for each simulation along with pertinent information regarding each.

ARMY COMMON OPERATING ENVIRONMENT (COE)

The COE was initiated based on direction from the Vice Chief of Staff of the Army (VCSA) to the Chief Information Office (CIO) / G-6 on December 2009 to develop "as is" and "end state" network architectures to set the vision for the evolution of network procurements and enhancements. As a result the office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology) (ASA(ALT)) issued a COE directive (ASA(ALT)) 2011) for PEOs which provided guidance on COE execution and Program Objective Memorandum (POM) 2014-2018 investment decisions and directed all PEOs / PMs to implement capabilities in accordance with the COE Computing Environment (CE) Execution Plans under the Governance process described in the COE Implementation Plan (ASA(ALT)) 2011).

The COE creates an environment where new and existing hardware and software systems can readily integrate and interoperate because of the existence standardized environments. Standardization may include services (data, geospatial, and data distribution), hardware, and interfaces, to name a few examples. The COE dictates that new programs leverage the standardized COE to meet their program needs. The COE reusable components are managed by an ASA(ALT) governance structure created by the System of Systems Engineering (SOSE) Office and executed by various ASA(ALT) team leads. Actual development and management of components is accomplished by a distributed set of PMs or agencies designated by ASA(ALT). Some of the key tenets and enablers of COE are:

- Open architectures and technical standards
- Services-based architectures
- Ensure SoS interoperability and application agility
- Commonality and reuse
- Alignment with industry trends, best practices and products
- Improved collaboration among the PMs

SOSE realized early on that one monolithic COE is not practical so the COE is divided into sub-environments designated as CEs.

- Data Center / Cloud CE
- Command Post CE
- Mounted CE
- Mobile / Handheld CE
- Sensor CE
- Real-Time / Safety Critical / Embedded CE

CEs provide the standardized environment for similar type systems and have overarching requirements levied by the COE.

PEO STRI is closely engaged with COE architecture and standards developers on operational systems as these are defined and developed. This allows PEO STRI to influence the development of operational architectures so that training system architecture components, data, services and applications may be more easily integrated into operational systems. Although some thought has been given to standing up a Training CE, it is too early to decide if that would be the best approach to address training within the COE. Currently, PEO STRI is actively engaged in each COE CE IPT making sure training capability impacts associated with COE changes are addressed.

As the ITE SoS evolves it will have a requirement to be compliant with COE standards and any “touch points” it has with the CEs. For example, just as LVC-IA Version 1 had a requirement to be compliant with Software Block 2 Capability Set 11/12, future versions of LVC-IA will have to be COE V1 complaint. As the LVC-IA and the ITE move toward the future, the complexities associated with satisfying COE interoperability requirements will be driven by the level of interoperability that has been designed into the LVC-IA. As the COE evolves and new COE baselines are established the ITE will have a clearer idea of COE compliance requirements and adjust the LVC-IA baselines to meet those requirement.

CONCLUSION

While Integration is the process of linking together diverse systems or organizations, Interoperability is a property (or quality) of integration that ensures a level of independence between existing and future systems or organizations. Increasing the quality of the interoperability, when integrating systems, allows one to deal with future integration requirements as yet unseen during design time.

The Army training use case described in this paper is one of many examples of how DoD organizations are maturing their development processes to meet interoperability requirements. PEO STRI and the ITE SoS are striving to work with other organizations in a unified or enterprise way to maximize the benefits of collaboration across organizations and across multiple government investments or projects. As DoD continues to develop SoSs it will have to focus on the different types of interoperability practices (i.e., program management, construction, and operational) to ensure success when adding new and upgraded systems and interoperability requirements to the growing SoS interoperability web.

The Army's ITE SoS and the LVC-IA Version 1 is the beginning of an ambitious endeavour and although a solid and robust foundation has been established, it will require continuous updates to meet new and emerging interoperability requirements. Soldier feedback will be essential to understanding how to improve on the current LVCG "blended training" capabilities and subsequent future capabilities of the ITE SoS. Improvements related to reusable components, CDS, and "fair fight" will most likely be needed to continue to evolve a persistent LVCG training capability that is useful for our Commanders. In addition, compliance and interoperability with the Army's COE will help the Army training systems keep pace with operational equipment baselines and provide our Soldiers improved seamless training experiences.

ACKNOWLEDGEMENTS

The author would like to thank Mr. Rich Link, LVC-IA Chief Engineer, for his contributions to this paper and the LVC-IA program. In addition, thanks to all of the individuals who have contributed tirelessly to the successful development of the LVC-IA and helped make the ITE SoS a reality. Finally, thanks to our Soldiers who put their lives on the line for our country and are the main focus of the Army's ITE SoS.

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