Harmonized Air Missile Space Training Environment

Ariel Aybar
SimIS, Inc.
Orlando, FL
ariel.aybar@simisinc.com

Michael Neeley
SimIS, Inc.
Orlando, FL
michael.neeley@simisinc.com

Warren Bizub
SimIS, Inc.
Orlando, FL
warren.bizub@simisinc.com

ABSTRACT

Various United States Air Force (USAF) service lines and program offices, from Air C2, Space C2 and Theater/Ballistic Missile Defense C2 offices, exist to provide end-to-end lifecycle services and capabilities. The involved training solutions are inherently stovepipe in nature as they are developed from domain specific requirements and focus on qualification training. Thus, training gaps exist to rehearse warfighting activities that integrate Air C2, Space C2 and Theater/Ballistic Missile Defense C2 Services, especially across small team core mission areas for warfighter proficiency. The Air Missile Space Training Environment (AMSTE) addresses these training gaps by integrating these service line training capabilities into a central enterprise training service line. The AMSTE initiative has four precepts: simplify Air, Missile, & Space (AMS) training, promote on-demand training, provide Training as a Service, and improve small team training. This paper addresses the current progress of AMSTE to accomplish these goals. AMSTE uses a collection of Government Off The Shelf (GOTS), Commercial Off The Shelf (COTS) and open source technologies to merge disparate legacy training solutions into a flexible, modular and scalable framework to facilitate cross-domain, on-demand training. The AMSTE is executed in a localized cloud architecture utilizing virtualization infrastructure running containerized training components. The orchestration of components is managed by the AMSTE framework abstraction layer. This unburdens the user from the complexities of the underlying legacy systems, while also providing an open framework for incorporating a variety of diverse legacy training systems. Training sessions can be rapidly provisioned, recycled and removed without the need to configure physical workstations, servers, and networks. The AMSTE ability to readily orchestrate and alter scenario content and event list in a system of systems architecture allows the training audience to tailor sessions at the point of need. Bringing this level of control closer to the target audience through a cloud and data center structure assures higher fidelity, improved responsiveness and shorter turnaround times.

ABOUT THE AUTHORS

Mr. Warren Bizub is the Vice President/Chief Technology Officer for SimIS, Inc. He served 35 years as a DoD civilian and held various positions to include Program Director, Program Manager, Advanced Training Technology Director, In-Service Engineer and Project Engineer. He received an MS in Engineering Management and a BS in Ocean Engineering, is a graduate of the Navy's Senior Executive Management Development Program, and is an MIT Fellow in Foreign Politics, International Relations, and The National Interest.

Mr. Michael Neeley is a Project Manager for SimIS, Inc. He has 8 years of experience working in modeling and simulation, including work as a Software Engineer, Systems Administrator, DODAF Architect and Project Manager. He has supported both Department of Defense and private sector development projects including Joint Forces Command / Joint Staff J7, NWDC, Eastern Virginia Medical School, the Air Force Agency for Modeling and Simulation, and the Program Executive Office for Simulation Training & Instrumentation. Mr. Neeley holds a Bachelor’s degree in Information Sciences with a concentration in Networking and Communications.

Mr. Ariel Aybar is a Software Engineer for SimIS, Inc. Mr. Aybar has two years of experience in the DOD modeling and simulation training and experimentation environment. He is a key developer in enabling the future Live Virtual Constructive (LVC) integrated environment through application of open source and MOSA principles. Mr. Aybar earned a Bachelor of Science Degree in Computer Science and he enjoys learning new subjects that involve innovative and contemporary technology and programming techniques.

Harmonized Air Missile Space Training Environment

Ariel Aybar	Michael Neeley	Warren Bizub
SimIS, Inc.	SimIS, Inc.	SimIS, Inc.
Orlando, FL	Orlando, FL	Orlando, FL
ariel.aybar@simisinc.com	michael.neeley@simisinc.com	warren.bizub@simisinc.com

INTRODUCTION

Background

There are various United States Air Force (USAF) service lines and Program Offices supporting Air Command & Control (C2), Space C2 and Theater/Ballistic Missile Defense (T/BMD) C2; these offices are accountable for supporting their respective customers (i.e., warfighters with their unique and specific mission requirements). Each of these service lines, are sub entities within the USAF and Department of Defense (DOD) consisting of a grouping of personnel, resources, specialized facilities and funding to support each of the respective communities. They exist to provision lifecycle support services required to procure, develop, maintain, support, train and dispose of operational Air, Missile and Space (AMS) capabilities across the full lifecycle. Unfortunately, because there are multiple service lines responsible to provision training, a training gap exists to rehearse warfighting activities that integrate Air C2, Space C2 and T/BMD C2 services, especially across small team core mission areas for warfighter proficiency. Historically the stovepipe approach that also relied on “white cards” was acceptable, but that changed when a senior Joint Training and Exercise (JTrEx) Specialist at Headquarters, United States Strategic Command (HQ USSTRATCOM), Exercises and Assessments Directorate, Joint Training and Exercise Division had to setup a complex event.

The USSTRATCOM senior JTrEx Specialist had to host a training exercise between several divergent warfighters that normally don’t rehearse together, such as the warfighting activities that integrate Air C2, Space C2 and T/BMD C2 services. Funding for this effort had a multiplier effect, since it funded the aggregation for support from each of the service lines and Program Offices from Air C2, Space C2 and T/BMD C2. The time it took to coordinate resources and negotiate between the service lines to ensure product release cycles would not vary prior to exercise execution were hurdles in their own right. The amount to fund the integration and configuration between each of the systems for a one-time exercise was expensive, but the requirement for subsequent exercises that required on-going coordination of product release cycles and evolving requirements suitable for each exercise became an enduring financial and time extensive effort for USSTRATCOM. USSTRATCOM began to ask, was there a way to take the real live systems (or their respective training systems) and merge or at least configure them to allow migration of a centralized enterprise simulation capability that could provide the appropriate and realistic stimulation to these live C2 systems and ensure accurate representation was delivered more affordably and quickly? USSTRATCOM’s question then drove a new program of work (e.g., Air Missile Space Training Environment (AMSTE)) for the Air Force Agency for Modeling & Simulation (AFAMS) within an incubator concept framework based on a published study describing the potential for transforming the architecture (culture, processes and the use of new and emerging technology) to enhance services for the Integrated Air and Missile Defense (IAMD) capability (Petty, M.D., Barbosa, S.E., Hutt, J.R., 2016). The architecture described in this study is focused on readiness and preparedness of the warfighter's C2 decision making, the product systems they emulate are those Live C2 systems that are currently fielded. In summary, the study presented the case that a change to the architecture (consolidation of products and their infrastructure) could provide efficiencies in the processes and the human involvement to support services for an IAMD C2 capability.

As a result of USSTRATCOM influence, Joint Requirements Oversight Council Memorandums were issued directing the USAF to link existing AMS trainers and Joint Modeling and Simulation (M&S) federation programs, and develop as necessary, an end-to-end IAMD continuation training capability in support of theater and cross-Area of Responsibility (AOR); this was later followed-up with a Memorandum of Understanding (MOU) between USSTRATCOM and AFAMS to define an architecture that would be suitable to begin demonstrating a capability to seamlessly migrate the service line training capabilities through changes in Doctrine, Organization, and non-material process solutions.

The AMSTE pilot effort explores a new modular open architecture that improves and integrates quality performance characteristics of existing capabilities. AMSTE is implemented and fielded as follows: (1) host service line systems on a virtualized infrastructure, (2) Cloud enabled service line systems in a containerized fashion (harness and encapsulate components), and (3) Cloud optimized by reconstructing service line systems. Implementation in this order demonstrates to the community that using a collection of GOTS, COTS and open source technologies to merge disparate legacy training solutions into a flexible, modular and scalable architecture is possible. AMSTE facilitates training sessions that can be provisioned, recycled and removed without the need to configure physical workstations, servers, and networks. Furthermore, AMSTE implements agile development operations as a major benefit that provides flexibility in change management and out-of-cycle releases. Finally, the AMSTE architecture allows senior leadership an opportunity and time required to migrate and merge multiple service lines into a data driven central AMS training enterprise.

Purpose

This paper addresses the current progress of the AMSTE project to accomplish the goals as stated above with the following four precepts in mind: simplify Air, Missile, & Space (AMS) training, promote on-demand training, provide Training as a Service, and improve small team training. Currently, AMSTE is executed in a virtual environment utilizing multiple hypervisors in a modular architecture in order to implement containerized training components. The orchestration of components is managed by the AMSTE framework abstraction layer to unburden the user from the complexities of attempting to accomplish the interoperability aspects of the underlying legacy systems. This data-centric approach of providing the components and their service line systems as needed under an open framework is possible via intelligent AMSTE middleware. According to Scott Harrison, an IBM Global Services senior consultant, "The path to achieving the vital goal of coalition interoperability may require abandoning longtime networking tenets in favor of a data-centric approach. Unlike current net-centric models, cloud technologies have the ability to make relevant and reliable information available, regardless of network or location." (Harrison, S. 2012). This novel approach provides a web-based, modular and open framework to facilitate on-demand training sessions. "Data-centric design is a powerful methodology for building interoperable, scalable, modular distributed systems and for integrating independently developed sub-systems. It decouples the application logic from the management of stateful data." (Joshi, R., 2011). The AMSTE system is implemented on a virtualized infrastructure, leveraging segregated components to lay the ground work for establishing a Modular Open System Architecture (MOSA) to gain more efficiency, and in doing so, AMSTE will enhance military system capabilities, accelerate military system development and integration, reduce costs and technical risks, and improve the timeliness of Test and Evaluation outcomes. By virtualizing and enabling a data-centric approach, existing service line systems that support Air C2, Space C2 and Theater/Ballistic Missile Defense C2 can be integrated into a seamless central enterprise service line.

THE OPERATIONAL PERSPECTIVE/RELEVANCE

There is a current need to begin migration of the existing service line systems that support Air C2, Space C2 and Theater/Ballistic Missile Defense C2 in a seamless manner as required as we continue to integrate our defense posture with our allies. It is unaffordable to have any disconnects with our layered defense capabilities simply because we have different product service lines maintaining our systems. This is vitally important as we support our allies in their effort to incorporate integrated Air and layered missile defense as a core element of alliance security; an example of this is operationally addressed in the European Phased Adaptive Approach (EPAA). This is articulated further in the AMSTE Framework Effectiveness section of this paper which describes the means to mitigate the growing Iranian missile threat along with a vulnerability for a region unable to prevent, detect or defend itself from Intermediate / Medium-Range Ballistic Missiles (IRBMs/MRBMs) (Arms Control Association, 2013) because the current architectures do not support on-demand missile warning/defense training resources for remote small team training drills or exercises for all the systems present in the Global Operations Center, Combatant Command Combat Operations Centers, Air Operation Centers and Maritime Operations Centers. Combatant Commanders and their component commands require a distributed, integrated, synthetic IAMD training and exercise modeling and simulation (M&S) capability as noted in numerous World-wide Joint Training Scheduling Conferences (WJTSC) from 2007 - 2010.

The Air, Missile, & Space Training Environment (AMSTE) is an architecture framework that leverages emerging technology to facilitate simulation systems and C2 interactions between the Air, Space and Missile C2 readiness. By integrating these C2 systems across each domain, AMSTE supports our layered defense capabilities – the technical capabilities will be described in the following sections of this paper.

TECHNICAL APPROACH

Objectives and Scope

As discussed above, an on-demand distributed, integrated, and scalable synthetic training environment that allows individuals and small teams to train ubiquitously is needed. Current training system architectures that support missile warning/defense training are not readily assimilated and consist of servers that execute scenarios and effects to a bank of clients over a local IT network. For clients to participate in training events, they presently must be physically co-located or require extensive/unique set up at distributed sites to support designated training locations where the training systems and audience are participating. These training systems are typically set in a client-server architecture that requires administrators to provision and prepare the systems for training execution.

The AMSTE proof of concept provides the nucleus for a solution that consists of standing up a scalable, distributed virtualized platform for training of missile warning/defense knowledge, skills, and competencies. Various training environments can be instantiated as needed, customized with modular scenarios and provide omnipresent services and tools to enable performance control and management. The solution consists of tools and services that can interact directly with the training and operational systems, provide tactics, techniques, and procedures (TTPs) for training, and adjust levels of difficulty and complexity. The nature of the synthetic environment can be integrated with existing training/operational systems, networks and new tools/services to create a more advanced training environment that can be centrally managed via web interfaces.

The core AMSTE cloud enabled systems service model is developed to enable the four precepts the AMSTE initiative is implementing to enhance DOD IAMD end-to-end training capability (see ***Figure 1***).

The Simulation Element Harness, which is in the M&S and other Modular Services Layer, simplifies integrated air, missile and space training by decoupling simulation and operational systems and providing a management and control interface to the resident system. This Harness allows for AMSTE specific protocols and messages to be sent between systems in the training environment. The Harness also provides an interface for a system specific plug-in which controls and implements all AMSTE specific controls for the resident system. Plug-ins are unique to each type of system that is incorporated into the AMSTE environment, so any changes to specific system plug-ins have no effect on other component plug-ins, reducing the overall cost of ownership.

AMSTE Cloud Enabled Systems Service Model

	Data Unit	Layer	Function
Hosted Layers	AMSTE Cloud Enabled Environment	**6. Web Frontend Applications**	Suites of applications that support user access, management and control of model services, operational services and data services for specific AMSTE training events.
		5. Virtual Application Services	Cesium, provisioning, virtualization and C2 capabilities that allow virtual application stimuli to be presented to trainers and trainees in appropriate modalities.
		4. M&S and other Modular Services	Simulation services and tools provide white box capabilities to represent the dynamic behavior of specific entities. Simulation Element Harness, AMSTE Protocol, Vagrant, Libvirt, etc.
		3. Database Repository	The AMSTE central database services that allow a user to discover, integrate, and deploy a training environment for a specific training objective. Data services provide invoked access to representations of the static characteristics of specific integrated AirC2, SpaceC2, Theater/Ballistic Missile Defense C2 and other battlespace entities.
Provider Layers	Storage/VM	**2. Data Center IaaS/PaaS Service Provider**	Single sign on security, server hardware, storage hardware, back up systems, cybersecurity, continuity of operations program, etc.
	Transport	**1. Network Services**	Data Transport- GIG, JIE, DISN Core, IP services, voice.

Figure 1. Cloud Enabled Systems Services Model

The Data Center Virtualization architecture parts are located in the Database Repository and Infrastructure as a Service (IaaS)/Platform as a Service (PaaS) Service Provider Layers, which facilitates on-demand training.

An innovative AMSTE protocol resident in the M&S and other Modular Services Layer provides a wrap around the Hosted Layers AMSTE Cloud Enabled Environment and links to the IaaS/PaaS Service Provider Layer to provide Training as a Service (TaaS) to the warfighter. Finally, small team training is available at home station or forward deployed by automated virtual machine provisioning and remote desktop virtualization based in the Virtual Application Services Layer.

Some key objectives the team focused on in executing the AMSTE proof of concept development activities include:

- Establish an enterprise architecture with virtualization for a web enabled collaborative delivery mechanism for legacy systems, related systems and services.
- Enact a web-enabled cloud enterprise approach that centralizes software & hardware for related systems into a consolidated datacenter, simplifying operation, maintenance and cyber security challenges.

- Develop an intuitive Graphical User Interface (GUI) so trainers can create and execute scenarios on client systems that are browser-based and web accessible.
- Authorize distributed training participants to remotely access training capabilities anywhere, any time.
- Ensure missile warning/defense training platforms and services can be virtualized to benefit from the ability to scale appropriately for the training environment on-demand.

Virtualization Overview

Virtualization of the hardware of a computer is the abstraction of the logical functions of the computer from its physical hardware. A key benefit of this abstraction is that it allows software application defined virtualized machines to simultaneously run on a single physical host. The hardware of the physical host effectively becomes a pool of resources that are shared between and/or allocable to the Virtual Machines (VMs) (see ***Figure 2***).

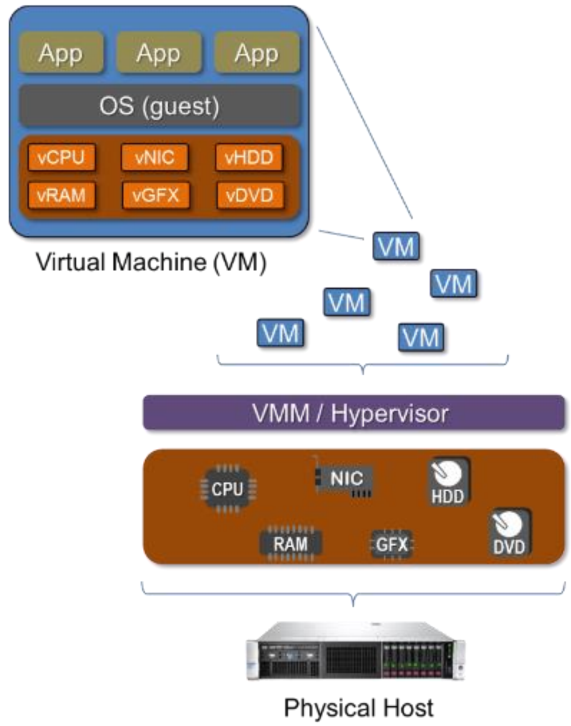

Figure 2. Virtual Machine (VM) Concept

The AMSTE framework leverages the use of virtualization in order to maximize efficiency of resources and create a compact, reconfigurable bank of systems. The software that creates and runs VMs is called a Virtual Machine Monitor (VMM) or hypervisor. (Popek, Gerald J. and Goldberg, Robert P., 1974). This hypervisor allows AMSTE control mechanisms to start, stop, and pause the virtual systems via the web based GUI accessible to administrators. Scenario information is stored on a persistent VM which allows users to select what training objectives they will train to before provisioning the training environment. These training objectives, in conjunction with the selected scenario(s), determine which virtual systems the AMSTE control mechanism provisions for run-time.

Virtual Desktop Infrastructure

In order for trainers and trainees to access the distributed simulation and C2 systems provisioned for their training session, virtual desktop infrastructure is leveraged to publish the virtual systems display in the users client software. There are multiple ways to accomplish this publishing of a remote desktop; the most economical being the use of thin clients as the end user interface. These clients are small, light-weight computers that are purpose-built for remote access to a server. Typically, these devices have no permanent resident storage and therefore rely on the publishing server.

AMSTE Architecture Overview

Architecture design for the AMSTE framework followed design principles for purpose driven subnets in the virtual infrastructure. Each data and simulation type is segmented away from disparate data generators and consumers. C2 systems used to display entity tracks for situational awareness are segregated from other systems, which are typically generating the tracks in another data format. The generated data is passed through a translator which allows the C2 systems to consume their native data types. The architecture framework can be seen in ***Figure 3***. This design principle also serves to segregate data leakage between non-like systems and provide buffers between systems which would not normally communicate during real world operations.

Portions of the AMSTE architecture are perpetually available in order to provide the system with required data and services. These systems include the web servers, databases, AMSTE controller system, and service registration system. These non-volatile systems give both administrators and users an entry point into the AMSTE structure to set-up, modify, and begin their training session.

The AMSTE Web Server provides the training support and administrative services through a web portal using the Node.js application, which is an open-source tool that creates flexible web servers using the Google V8 JavaScript engine. AMSTE also leverages the Nginx web server to create a reverse proxy for CAC authentication for users and administrators. Authentication using PKI certificates allows for strong encryption of user sessions and also non-repudiation of user and administrator actions by mapping all actions to user credentials during the sign in process.

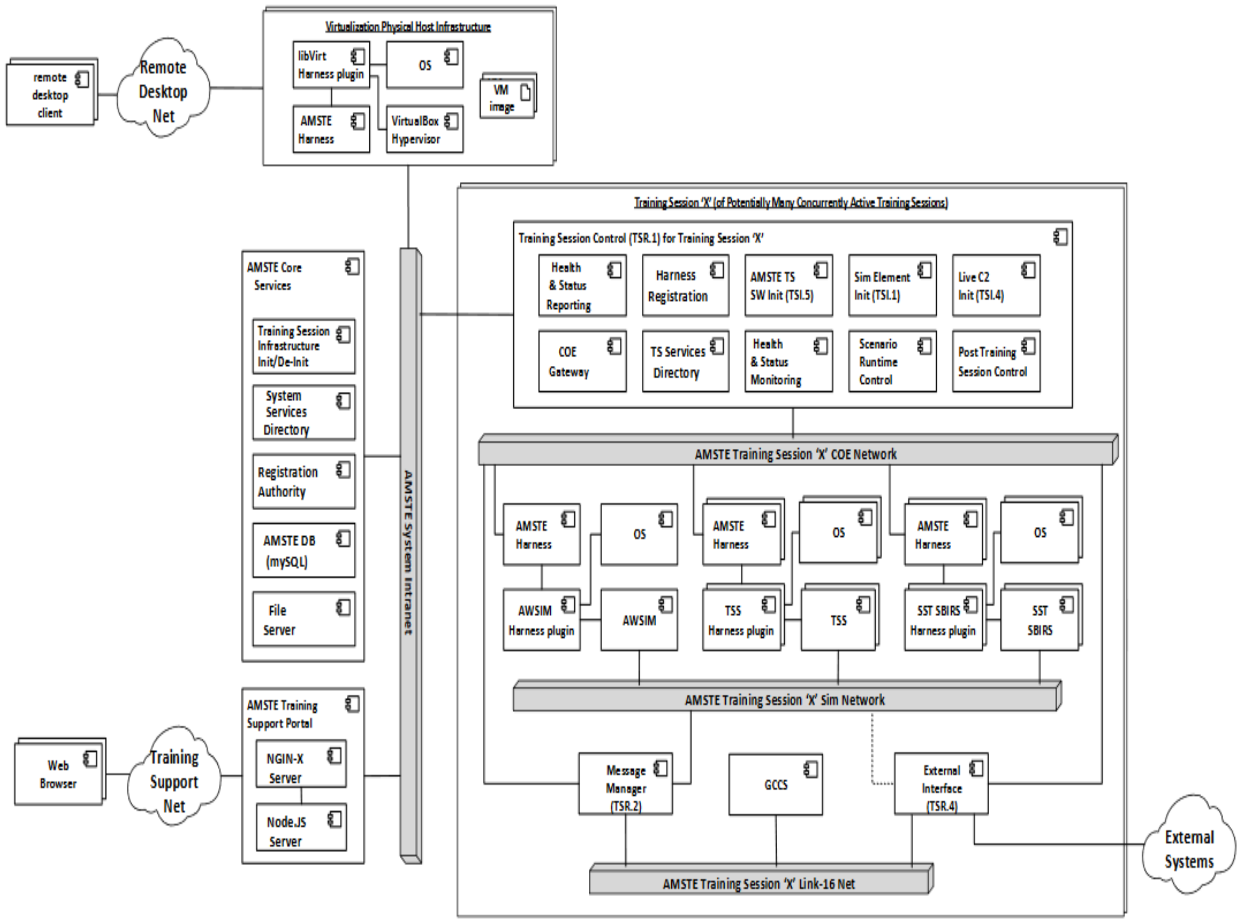

Figure 3. AMSTE Architecture Overview

The AMSTE web server provides an interface for users to create, modify, and execute training sessions, which are provisioned in the resilient 'AMSTE Training Session'. These VMs and networks are dynamically created and dismantled as needed by the user. Messages generated by the user's interaction with the web server are sent to the AMSTE Controller system, which interprets these messages and provides the appropriate response. The AMSTE controller keeps track of the provisioned training session, which is given a unique identifier, and provides the messaging interface between the back-end training session systems and the web server.

AMSTE Virtualization

Platform virtualization and cloud computing continues to revolutionize the IT industry, and a key aspect of the AMSTE technical approach is to properly design a training environment framework that leverages virtualization and cloud computing paradigms for flexibility, scalability and agility. At a foundational level, AMSTE incorporates data center virtualization and cloud computing through a vendor-agnostic virtualization management abstraction layer (see ***Figure 4***). This decouples AMSTE from proprietary virtualization solutions while retaining the necessary orchestration control of the virtual resources.

Current training system architectures are generally implemented on a set of servers executing scenarios and effects to a bank of client workstations over an IT network. For clients to participate in training events, they typically are physically co-located at designated training locations where the training systems and audiences are located. Substantial amounts of computational, network, and storage hardware resources are involved with the execution of a training event, as well as a significant personnel resource footprint to install, configure and administer the collection of servers and client workstations and required software. Collectively, these equipment, personnel and potential travel costs constrain training to either persistent, dedicated training centers or to non-persistent, larger-scale training exercises. This is prohibitive toward individuals and small teams, and their duty stations, to conduct proficiency or continuation training in support of theater and cross-AOR operations.

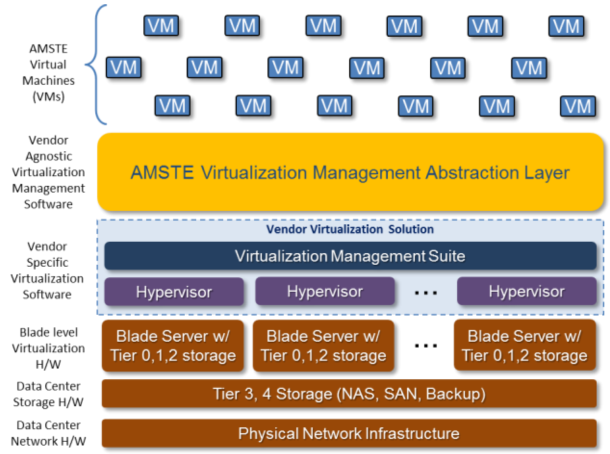

***Figure 4. AMSTE Virtualization Abstraction* Layer**

Once the VMs are established, complete with preinstalled and preconfigured constituent training system software modules, instances of these VMs can readily and rapidly be provisioned in data center virtualization or cloud computing hardware. Likewise, upon completion of a training event, these same VM instances can just as rapidly be de-provisioned or destroyed to free up data center virtualization or cloud computing hardware. VMs are also easily exported from their hypervisor, in a commonly supported format, for archiving and configuration management of exercise tasks. This allows for exercise controllers to capture their entire architecture or piece parts, especially databases, and their running configuration for After Action Review (AAR), preparation for future iterations of the exercise, or for data integrity regarding long term data storage.

AMSTE Integration Framework

There are two major aspects of the AMSTE integration framework: the AMSTE Simulation Element Harness and the AMSTE protocol.

The AMSTE Simulation Element Harness is interface software that allows any legacy simulation system (which AMSTE refers to as a Simulation Element) to interoperate at the AMSTE system of systems level with all other AMSTE services and Simulation Elements.

The AMSTE protocol is the internal "system of systems" communications protocol for all AMSTE software subsystems/components and elements. It facilitates:

- registration services for AMSTE software components and Simulation Element Harnesses
- data access services for AMSTE software components and Simulation Element Harnesses
- health/status monitoring
- event reporting
- initialization
- control

The simulation harness is what allows AMSTE to simplify the end-to-end training structure. One administrative user has access to starting multiple simulation systems and C2 devices intuitively with minimal training required. The simulation harness provides direct access to not only start, stop, and initialization states of a VM, but also the ability to instruct that VM to provision its resident simulation system or C2 device. Orchestration of these systems can be mapped to system dependencies, such as domain controllers or databases to ensure complete integration of the training environment.

In some cases, simulation servers require multiple networked components in order to fulfill their operational equivalent capability. During the startup phase, these components typically communicate via messaging protocols for heartbeat, state information, and provisioning configuration data and can require human in the loop interactions in order to proceed. The AMSTE simulation harness provides a means for automating these message interactions between components by emulating these packets and sending them from the AMSTE Controller in place of human interaction.

The system specific plug-ins that are resident in the simulation harness can also give administrators real time health and status reporting of the virtual environment, including both the VM and simulation or C2 system. System specific protocol messages can be designed for these plug-ins to provide enhanced tools for fixing runtime issues for administrators.

AMSTE FRAMEWORK EFFECTIVESS

In September 2009, it was announced that the U.S. would pursue a “Phased Adaptive Approach” to missile defense in Europe (Collina, T.Z., 2013). The new approach is centered on the Aegis missile defense system and is being deployed in three main phases from 2011 to 2018. The European Phased Adaptive Approach (EPAA) is designed to deal with the threat posed by Iranian short- and intermediate-range ballistic missiles to U.S. assets, personnel and allies in Europe. It is flexible and based on proven technology, initially using mobile radars and interceptors mounted on Aegis-equipped Ticonderoga class cruisers and Arleigh Burke class destroyers. This system is also based on land as “Aegis-Ashore”. The system has been increasingly integrated with an evolving network of land and space-based sensors, which adds to the complexity of ensuring coordinated C2 in the European Theater.

EPAA is strategically and operationally vital to NATO and the United States interest. Moreover, the IAMD training capability for the European Combatant Commander (EUCOM) and their component commands is critical. It is estimated that the United States military and their partners would only have a 100 second window to launch an EPAA intercept to successfully shoot down an Iranian Shahab-3/3A missile aimed at our closest neighboring partner, Turkey or 190 second window to launch an intercept to provide protection to our central European partners (Sankaran, J., 2015). This means our IAMD forces would have between 1.5 and 3 minutes to locate, identify, classify, acquire, track and attack potential targets, which makes this process short-fused and complicated. The IAMD process is even more complex at division and higher echelons with more decision makers, acquisitions, surveillance assets, and weapon systems in the mix. This challenge is particularly true when joint and combined assets are included. Detailed policy, procedures and guidance, thorough detailed planning and disciplined, engaging and repetitious training exercises is paramount for our IAMD personnel and partners not only in the EUCOM Theater, but throughout the world. AMSTE is the tool that will allow our global force to collectively plan, prepare and train for real-world situations allowing them to react spontaneously as a cohesive unit to successfully thwart potential missile attacks in a coordinated and timely manner.

Successful IAMD readiness requires integrated AMS training capabilities to include AMS warning/cueing information, combat identification procedures and engagement authority. IAMD is a distributed process occurring at all echelons and requires all personnel—from the Joint Force Commander (JFC), in coordination with other service component commands, and in some cases, multinational partners to conduct rigorous training regimens. Today, our military personnel and partner nations have gaps in their ability to receive end-to-end AMS training. The AMSTE tool will provide the on-demand training capability for the total force that operates globally and allows them to train as they operate. Furthermore, the AMSTE effectiveness by being operated, maintained and provisioned from a MilCloud Data Center(s), provides the global presence with a sustained and persistent capability for providing training and education anytime, anywhere.

The AMSTE ability is based on existing technology utilized by major IT companies like Google, Amazon, Ebay, Microsoft and others with a proven track record of showing benefits through increased information sharing, increased process efficiencies, increased personnel efficiencies, improved ease to scale, reduced licensing/software cost and a substantial reduction of total ownership costs. The military recruiting pipeline is populated by digital natives, with an expectation of a multi-media rich training environment with evolving learning and communication technologies. This environment must be technologically intuitive, agile, and globally accessible 24/7. The AMSTE long-term objective is to produce an immersive training environment that stimulates cognition, intuition, innovation and adaptive thinking, and hones complex decision making skills. This is a cognition-based immersive training environment that is fast paced, of sufficient duration to induce fatigue, and conducted in a controlled environment that allows for on-the-spot correction or a detailed debriefing of training audience performance (for both soft and hard skills). The AMSTE omnipresent immersive training environment is institutionalized in order to build collective small team self-awareness, resilience and confidence in decision making under stress.

The AMSTE underlying tenets can be applied to other integrated training domains (i.e., Urban and Irregular Warfare, Chemical, Biological, Radiological, Nuclear, and high yield Explosive (CBRNE) missions, security situations, nation building exercises, and relief and reconstruction activities) to put students in difficult, unexpected situations, and require them to decide and act under pressure, which systematically teaches them how to master complex decision making skills. The AMSTE architecture approach can be used for test and evaluation purposes or to accelerate the development and ability to deploy system of system capabilities through the open-architecture environment approach that provides plug-and-play interoperability for a full range of live, virtual, and constructive assets. The core AMSTE cloud enabled systems service model affords:

- Practice and rehearsal to ensure the best outcomes.
- Deploying individuals, units, staffs, and organizations to ensure they are rehearsed and ready to execute their missions through a habitual training template.
- Establishment and operation of an affordable, on-demand, global Web-based training capability that enables integration of combatant command, service, and defense agency knowledge assets and tools to "train and test as we operate."
- Full integration with real-time, globally distributed mission rehearsal assets using operational information networks.
- Synchronization of live and virtual operations in near-real time to enable realistic stimulation of sensors, replication of visual cues, and platform interactions between live, virtual and constructive participants.
- Focused training to improve the performance of small teams, allowing the exercise of distributed operations at increasingly lower echelons and developing their proficiency in the use of data-centric information.

Finally, as the US Government and our partners move towards a common global cloud based infrastructure (Fiorenza, P, David, K., 2013), the AMSTE cloud enabled systems service model will inform others on how to be sufficiently interoperable with interagency and multi-national partner capabilities to permit combined and whole-of-government/nations analysis, experimentation, test and training, conduct automated audit of the performance of users in key learning objectives, enable rapid development and display of reference points for instructor use in debriefings and after-action reviews and support operations in a degraded cyber/information technology environment.

SUMMARY

The AFAMS in partnership with USSTRATCOM initiated the AMSTE pilot effort to explore a new modular open system architecture that improves, integrates and deploys characteristics of existing AMS training capabilities. Development of AMSTE focuses on four tenants: simplify Air, Missile, & Space (AMS) training, promote on-demand training, provide Training as a Service (TaaS), and improve small team training. AMSTE is implemented in a virtual environment utilizing multiple hypervisors for host service line systems in a containerized construct through a modular architecture. The orchestration of components is managed by the AMSTE framework abstraction layer to unburden the administrators and users from the complexities of having to manage and control the underlying legacy systems. This data-centric approach of providing components and their service line systems as needed under an open framework is possible via intelligent AMSTE middleware and simulation harness(es). The AMSTE implementation concept presents to the community that using a collection of GOTS, COTS and open source technologies to merge disparate legacy training solutions into a flexible, modular and scalable architecture is possible, efficient and effective. AMSTE facilitates training sessions that can be provisioned, recycled and removed without the need to configure physical workstations, servers, and networks. Furthermore, AMSTE implements agile development as a benefit that provides flexibility in change management and out-of-cycle releases. Finally, the AMSTE architecture allows senior leadership an opportunity and time required to migrate and merge multiple service lines into a data driven central AMS training enterprise.

ADMONITION AND ACKNOWLEDGEMENTS

The authors have prepared and present this paper based on their thoughts and perceptions only. Nothing in this paper is endorsed, acquiesced or acknowledged by the US Government. The AMSTE project is implemented with a multidisciplinary Integrated Product Team (IPT) comprised of industry and academia members. In addition to the authors of this paper, the AMSTE team includes key contributions from Dr. Mikel Petty and Katie Preston at the

University of Alabama Huntsville (UAH); Huat Ng, Ben Shen, Marc Banghart, Scott Holben, Steven Mylett, and Camille Barie at Wyle; and Richard Johnson, Chris Blancett and Thomas Langhorne at SimIS.

REFERENCES

Collina, T.Z. (2013). Arms Control Association (2013). The European Phased Adaptive Approach at a Glance. *Arms Control Association, Fact Sheets & Briefs*. Retrieved June 16, 2016, from https://www.armscontrol.org/factsheets/Phasedadaptiveapproach

Fiorenza, P, David, K. (2013). The Govloop Guide – Agency of the Future – Cloud Computing. *GovLoop*. Retrieved June 16, 2016, from https://www.govloop.com/blogs/2001-3000/2450-GovLoop_Cloud_Agency_of_the_Future_December_2013.pdf

Harrison, S. (2012). It's Time to Move From Net-Centric to Data-Centric. *SIGNAL Magazine, Feb 2012*

Jarvis, E (2013). The Govloop Guide – Agency of the Future – Telework. *GovLoop*. Retrieved June 16, 2016, from http://govloop.com/blogs/3001-4000/3366-AoF_Telework2.pdf

Joshi, R. (2011). Data-centric architecture: A Model for the Era of Big data. *Dr. Dobb's Journal*. Retrieved June 16, 2016, from http://www.drdobbs.com/architecture-and-design/data-centric-architecture-a-model-for-th/229301018

Petty, M.D., Barbosa, S.E., Hutt, J.R. (2016). Using a mock simulation event and Monte Carlo simulation to compare alternative network architectures for distributed training simulation. *The Journal of Defense Modeling and Simulation: Applications, Methodology, Technology, April 19, 2016*, 1-14.

Popek, Gerald J.; Goldberg, Robert P. (1974). "Formal Requirements for Virtualizable Third Generation Architectures". Communications of the ACM 17 (7), 412–421.

Sankaran, J. (2015). The United States' European Phased Adaptive Approach Missile Defense System – Defending Against Iranian Threats Without Diluting the Russian Deterrent. *RAND Corporation, RR957*, Retrieved June 16, 2016, from http://www.rand.org/content/dam/rand/pubs/research_reports/RR900/RR957/RAND_RR957.pdf