Bold Quest 15.2: A Case Study in Establishing Multinational Simulator Interoperability

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ABSTRACT

As part of the U.S. Joint Staff's Bold Quest coalition capability demonstration and assessment event, Nations, Services and Programs (N/S/P) pool resources in a recurring cycle of capability development, demonstration and analysis. Bold Quest provides a venue where N/S/P can demonstrate integrated Live, Virtual and Constructive (LVC) environments, improve interoperability, and build and maintain joint fires proficiency. Unfortunately, LVC environments are, in practice, almost never "plug and play." Due to the number of simulation standards, and the various ways that systems are allowed to "comply" with these standards, simply adhering to a standard is no guarantee of interoperability.

Bold Quest 15.2 provided the first opportunity to extend this LVC environment to partner nation simulator sites in France and Canada. French Air Force Joint Terminal Attack Controllers at the Air-Ground Operations School in Nancy-Ochey Airbase in France conducted virtual close air support missions with a U.S. Special Operations Command (USSOCOM) virtual AC-130 trainer at Hurlburt Field, Florida. A Canadian infantry section at the Canadian Army Simulation Centre in Kingston, Ontario conducted virtual missions with U.S., Canadian and Danish units at Fort Bliss, Texas and U.S. squads at Camp Atterbury, Indiana. Despite a number of simulator interoperability issues, these events were generally a success. However, these fundamental interoperability issues are widely recognized, ongoing problems that stand as a significant barrier to improving multi-Service and multinational simulator interoperability.

This paper discusses the interoperability challenges faced during Bold Quest 15.2, outlines some of the solutions developed, and offers recommendations for improving joint and coalition simulator interoperability.

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INTRODUCTION

The U.S. Joint Staff-sponsored coalition capability demonstration and assessment series, more commonly known as "Bold Quest," is a collaborative joint and multinational enterprise in which Nations, Services and Programs (N/S/P) pool their resources in a recurring cycle of capability development, demonstration and analysis. The overarching aim is to improve interoperability and information sharing across a range of coalition warfighting capabilities. Since its inception in 2001, Bold Quest has highlighted numerous interoperability issues between joint and coalition systems that effect warfighting performance in joint fires, combat identification and digitally aided close air support.

Bold Quest 15.2 was conducted in September-October 2015 at Fort Bliss, Texas and Holloman Air Force Base, New Mexico in conjunction with the Army's Network Integration Evaluation (NIE) 16-1 and 1st Armored Division's Multinational Division Exercise at Fort Bliss and White Sands Missile Range, New Mexico. As the largest and most complex Bold Quest event to date, Bold Quest 15.2 represented an especially ripe venue for experimentation and assessment of Live, Virtual and Constructive (LVC) capabilities. Building on four years of LVC environment work during Bold Quest (Reitz & Richards, 2013 and Reitz & Seavey, 2014), Bold Quest 15.2 highlighted fundamental LVC interoperability issues that are widely recognized, persistent problems that stand as significant barriers to improving multi-Service and multinational simulator interoperability.

Bold Quest 15.2 LVC Overview

Bold Quest LVC operations began as a relatively simple, squad-based stand-alone event at Camp Atterbury, Indiana in 2011, using one virtual system. Since then it has grown into a complex and distributed air, ground and fires-focused event in 2015 that included partner nation simulator sites in Canada and France linked via a wide area network. During Bold Quest 15.2 French Air Force Joint Terminal Attack Controllers (JTACs) at the Franco-German Air Ground Operations School at Nancy-Ochey Airbase, France conducted virtual close air support missions with an AC-130 call for fire trainer at U.S. Special Operations Command's Joint Training Support Center (JTSC) at Hurlburt Field, Florida. Additionally, a Canadian infantry section at the Canadian Army Simulation Centre in Kingston, Ontario, Canada conducted distributed virtual missions with U.S., Canadian and Danish squads at Fort Bliss, Texas; virtual UH-60 Blackhawk helicopters and a U.S. infantry squad located at Camp Atterbury, Indiana; and the JTSC AC-130 simulator at Hurlburt. Figure 1 below depicts two vignettes that illustrate the complex multinational environment established.

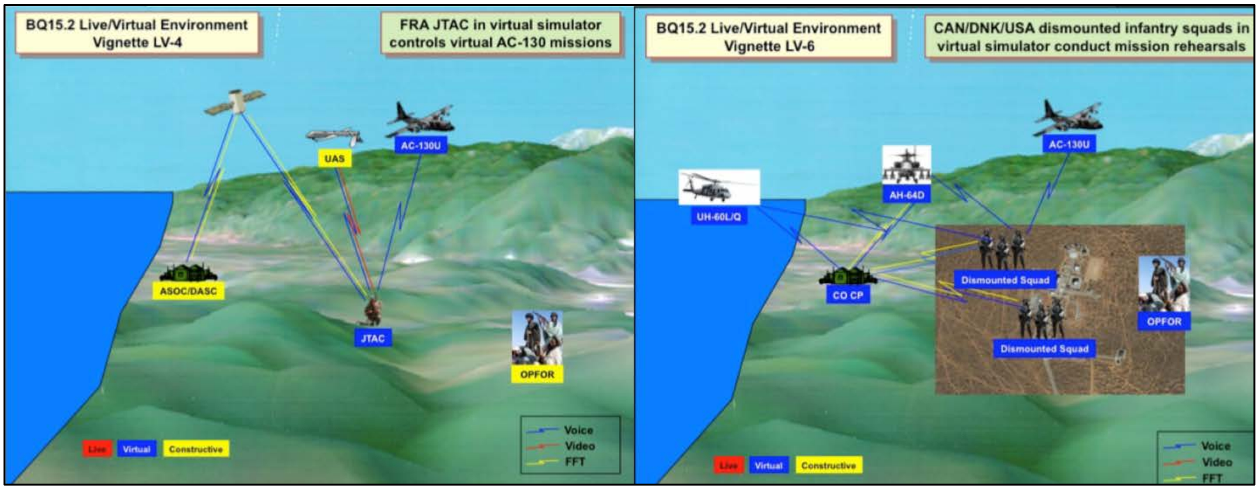

Figure 1 Bold Quest 15.2 Vignettes - Operational View

These events broke new ground in multinational simulator integration and provided realistic training for all participants. They also signal a trend toward increased distributed LVC operations in Bold Quest, as new partner nations – Denmark, Great Britain and the Netherlands – have stated an interest in participating as distributed simulation sites in 2016. However, this increasing interest in multinational, multi-system distributed events has also highlighted fundamental, long-standing simulator interoperability issues that demand resolution.

Interoperability in the LVC Domain

Interoperability in all areas is a primary requirement for building the future joint force. As the "Capstone Concept for Joint Operations: Joint Force 2020" states, the United States must:

"Become pervasively interoperable both internally and externally. Interoperability is the critical attribute that will allow commanders to achieve the synergy from integrated operations this concept imagines. Interoperability refers not only to materiel but also to doctrine, organization, training, and leader development. Within Joint Forces, interoperability should be widespread and should exist at all echelons. *It should exist among Services and extend across domains and to partners*." (Dempsey, 2012 [italics added])

While there are many definitions of interoperability, even within the U.S. Department of Defense (DOD), we are generally using the term as it is defined in Joint Pub 1-02, meaning "the condition achieved among communications-electronics systems or of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users." (DOD, 2015)

Within the LVC domain, there is a rich body of literature on types of interoperability, with the Levels of Conceptual Interoperability Model (LCIM) being perhaps the authoritative source (Tolk 2003). The LCIM model describes seven layers of interoperability between systems, ranging from no interoperability to interoperability at an advanced conceptual level, where "[i]nteroperating systems are completely aware of each other's information, processes, contexts, and modeling assumptions" (Wang, Tolk & Wang, 2009).The LCIM layers are useful in determining the degree of interoperability between LVC systems. In Bold Quest we are operating at a basic LCIM Layer 1 (Documented Data) level of interoperability, in which data is exchanged between distributed, heterogeneous systems using a common protocol. In our case, this protocol is the Distributed Interactive Simulation (DIS) (IEEE, 1998). DIS is the means though which Bold Quest LVC systems achieve interoperability.

However, for purposes of this discussion on Bold Quest, our concerns with interoperability between joint and coalition LVC systems go well beyond the technical interoperability addressed in LCIM, and include policy and programmatic issues, which have proven to complicate technical interoperability.

LVC Interoperability Challenges

The promise of LVC is the ability to rapidly compose integrated and demanding environments where warfighters can come together from distributed locations to train and rehearse in realistic joint and coalition operations. This vision was perhaps best captured 12 years ago in the Department of Defense's Training Transformation Implementation Plan that described an LVC environment whose purpose is to "prepare forces by providing units and command staffs with an integrated live, virtual, and constructive training environment that includes appropriate joint context, and allows global training and mission rehearsal in support of specific operational needs." (Department of Defense, 2004). To fulfill this vision, LVC interoperability is a critical requirement.

As most practitioners of LVC well understand, LVC environments are almost never "plug and play." After many years of LVC development and effort, significant challenges still exist to rapidly compose LVC systems into a coherent and integrated whole. This section will describe some of those challenges, especially within the context of the lessons learned during the Bold Quest 15.2 event. We assert that these challenges apply to the broader LVC community and fall into three broad categories:

1. Limitations in governing policies and guidance that promote interoperability (Policy)
2. Limitations in resources required to implement interoperability (Programmatic)
3. Limitations in technical standards or supporting technologies that enable interoperability (Technical)

As we have found in Bold Quest, policy and programmatic issues are often the larger and more intractable barriers to interoperability, and are generally harder to solve than technical problems.

Policy Issues. Current policies for information sharing and release represent the largest barrier to joint and multinational LVC interoperability. These issues generally involve guidance and directives that limit the ability to interconnect LVC sites, systems and networks for the purpose of sharing information with U.S. and international partners. During recent Bold Quest events, we have encountered numerous examples of current policies that impose barriers to interoperability.

To illustrate this point, there are many wide area networks established within the U.S. for enabling distributed simulators to interconnect in support of training or testing. Some of the primary networks include the Joint Training Enterprise Network (JTEN), the Joint Mission Environment Training Capability (JMETC) Secret Network (JSN), the U.S. Air Force's Distributed Mission Operations Network (DMON), the Navy Continuous Training Environment (NCTE) network and the Air Reserve Component Network (ARCNet). Each of these networks is designed to enable distributed operations by connecting distributed simulators around the country and, in some cases, outside the U.S. Even though all of these networks are U.S. networks and operate at the same classification level, with connections to outside networks tightly controlled, interconnecting them to support cross-Service training or testing requires users to carefully navigate barriers imposed by policy. As but one example, connecting a U.S. Air Force simulator site on the DMON to a U.S. Army site on JTEN to support joint training is generally prohibited without specific accreditation for a particular training event. Similarly, sites on certain segments of the Air National Guard's ARCNet (e.g., ARCNet-1) are prohibited from connecting to JTEN, while others (e.g., ARCNet-J) are permitted. Often, potential users discover these subtle differences in which networks can connect to other networks in a joint or multinational event in the middle of the planning process. Policies such as these on how LVC sites can interconnect also hinder warfighter training by making routine training extremely difficult. Not surprisingly, the barriers imposed for connecting these national networks to those of our partner nations are much higher; in fact, in most cases, they are currently insurmountable.

Another area of policy that can hinder interoperability is foreign disclosure and foreign release. As an example, one issue we experienced during Bold Quest 15.2 involved a fundamental requirement for developing coherent, shared LVC environments - providing consistent digital terrain for all systems. In many cases, digital terrain for a system is created from open-source maps and publicly available information sources. However, the digital terrain products created from these unclassified, publicly available, non-proprietary data may generally not be shared with users from other countries without special approvals. There is a process for releasing products, such as digital terrain, to our international partners, and these processes worked well for us during Bold Quest 15.2 in releasing digital terrain to the Canadian Army. In return, Canada provided the U.S. with 3D models of Canadian soldiers for use in the simulation. Nevertheless, foreign release is generally a lengthy, cumbersome process. These processes do not support rapid composition of LVC environments to meet time sensitive training or mission rehearsal requirements.

We also experienced significant delays due to policies involved in making standard coalition encryption keys available to both U.S. and Canadian participants. In fact, this action was completed in time only through close engagement between senior U.S. and Canadian security officials.

It should be noted here that we are not arguing against maintaining security of information at different levels of classification or releasability, or the need to maintain the separation of systems and networks that carry sensitive information. Today's cyber threats demand careful consideration of any changes to information security policies. However, we are proposing that emerging DOD and NATO policies on information sharing, through constructs such as the Mission Partner Environment (MPE) or Federated Mission Network (FMN) concepts, should be applied to the LVC domain as well (DOD, 2014b and NATO, 2015). This would greatly increase transparency of policies to the user community involved in any event.

Programmatic Issues**.** The way that N/S/P procure, field and maintain LVC systems represents another barrier to joint and multinational LVC interoperability.

First, the acquisition of LVC systems is generally managed in accordance with a nation's defense guidance**.** However, with rare exceptions, acquisition programs are initiated, funded and managed by the Services**.** Not surprisingly, primary interoperability requirements for each program tend to be Service-specific, focused on Service architectures and standards, with requirements for joint and coalition interoperability falling lower on the priority list.

Second, and closely related to the issue above, Services and nations sometimes use the same LVC systems and vendors, yet fund development and fielding in separate lanes. For example, many nations in Western Europe and North America fund development of the Virtual Battlespace (VBS) system. VBS is a highly capable LVC system, in use by several U.S. Services and many partner nations, with a growing presence in the LVC domain. However, because it is funded and fielded separately by most user communities, VBS has multiple customer-specific release baselines that contain different models and behaviors. Additionally, there is typically no synchronized schedule between N/S/P for deploying software versions or updates, leading to further interoperability issues.

We experienced an issue during Bold Quest 15.2 caused by a mismatch between Virtual Battlespace versions in use by the U.S. and France. As mentioned above, one fundamental requirement for LVC environments is that all systems must use consistent, correlated digital terrain. In Bold Quest 15.2, most LVC systems used digital terrain of Fort Bliss built in early 2015 by the Army's Synthetic Environment Core office. However, because the Virtual Battlespace database was built for VBS 3 (used by a number of U.S. and Canadian systems), it was not backward compatible with VBS 2, the simulation system used in the French Air Force's Simulator for Forward Air Controllers (SIMFAC). Accordingly, the French Air Force SIMFAC and the AC-130 virtual Call for Fire (vCFF) trainer had no common digital terrain for Fort Bliss and had to use a common default terrain database provided by the vendor that was located on a fictitious island in the middle of the Atlantic Ocean.

As another example, we will refer back to the issue of multiple, non-interoperable networks in use by joint and coalition LVC sites and systems. In the absence of a fielded wide area network to support the required joint and coalition interoperability, the Joint Staff J6 has historically created network connectivity itself to support Bold Quest events. This network has habitually been episodic and developed to meet the specific requirements of each event. During Bold Quest 15.2 the network needed to connect the SIMFAC system at Nancy-Ochey Airbase in France with the AC-130 vCFF at Hurlburt Field, Florida. Several options were investigated to provide this connectivity, including a French Air Force offer to install a French national network that would connect SIMFAC to the Combined Federated Battle Lab Network (CFBLNet), but time did not allow this. In the end the Joint Staff coordinated with the Joint Communications Support Element to provide a satellite terminal at Nancy-Ochey to support the necessary transport back to Hurlburt. The satellite link met all requirements for the event, but was certainly a non-standard solution. Without persistent alternative network connectivity, the satellite link is unfortunately representative of the type of interoperability solutions required today. Programmatically, few groups plan for consistent capabilities to connect to outside sources.

The episodic nature of the Bold Quest 15.2 network also meant that there were few opportunities to conduct systems integration and testing. In the early days of Bold Quest LVC operations, the number of simulation systems was small and the distributed sites were limited, which made it possible to bring systems together just prior to execution to do rapid interoperability testing. As the scope of the Bold Quest LVC environment has expanded to include systems distributed across the country, across Service programs of record, and around the world, “just in time” testing is no longer feasible. During Bold Quest 15.2, LVC systems experienced a number of technical problems that could have probably been resolved with additional testing time that a persistent, distributed testing environment would provide.

***Technical Issues*.** Especially for episodic LVC environments like Bold Quest, interoperability demands the use of international technical standards for data, architecture and messaging. Unfortunately, in the simulation domain, a number of competing technical standards exist. The two most common ones are the Distributed Interactive Simulation (DIS), which is defined in the IEEE 1278 series of standards, and the High Level Architecture (HLA), defined in the IEEE 1516 series. As a simpler and more widely implemented standard, DIS is the baseline standard used in Bold Quest to interconnect simulators. HLA is a more flexible standard that can meet a broader set of requirements than DIS; however, the HLA spec was broadly written, is more complex and requires no “on the wire” compatibility for systems, and therefore has led to multiple, disparate implementations that do not support interoperability despite remaining within spec. The result of all this is that international standards for simulation promote interoperability, but do not guarantee it.

In response to this situation, many program offices, driven primarily by Service requirements, have developed particular interpretations of standards for providing interoperability among their own systems. These Service-centric guidelines generally work well for a particular simulation environment, but usually do not provide interoperability between LVC systems of other Nations or Services. As a result, program offices generally field non-interoperable, Service- or program-specific LVC solutions. Therefore, whenever disparate simulators are integrated in an LVC environment, consensus must be reached on what standards – *and what specific interpretation of standards guidance* – will apply. Afterwards, lengthy cycles of development, integration testing, problem resolution and retesting are typically required to make it all work.

During Bold Quest 15.2, the French technical team solved this problem by providing a complete interoperability solution for SIMFAC and the AC-130 vCFF, including a standard configuration for the DIS exercise data and simulated voice radios. Additionally, because we were operating over a relatively low bandwidth satellite link, they developed an innovative method to send the orientation of the AC-130’s aim point via DIS Protocol Data Units, which then generated a streaming video display locally at Nancy-Ochey. Fortunately, these two systems had strong technical teams involved in supporting the event and were flexible enough to change configurations up to and during the pre-event final testing.

Despite wide acceptance and use of international standards for simulation, making LVC systems interoperable is typically a protracted process involving reaching agreements on technical standards to be used, making changes to system baseline configurations (often requiring modifying simulator or interface application source code), and conducting testing and integration. There should be an easier way.

LVC Interoperability Recommendations and Way Ahead

As we have experienced during Bold Quest events, joint and coalition interoperability is almost never easy. However, there are promising opportunities to improve joint and coalition interoperability in the simulation domain.

Seek Cross Domain Solutions to bridge N/S/P interoperability gaps. Resolving the policy, programmatic and technical issues outlined above will take significant time, investment and commitment on the part of the major players. In the meantime, the use of Cross Domain Solutions (CDS)[1] offers tremendous potential to bridge networks and systems of different classifications. While CDS present their own challenges in terms of policy and timely fielding, they may be a crucial part of improving joint and coalition simulator interoperability. Joint Staff is pursuing CDS capabilities that will help resolve several of the issues outlined above.

[1] A cross domain solution is a form of controlled interface that provides the ability to manually and/or automatically access and/or transfer information between different security domains. (CNSS, 2010)

Create a distributed simulator testing environment. As we routinely experience during Bold Quest events, making simulators work together requires test and integration. Since Bold Quest has traditionally been an episodic event, in which the Joint Staff and participants stand up networks and systems just prior to execution only to stand them down again at the end of execution, there is usually little time for extended periods of test and integration. Therefore, "out of cycle" testing which leverages existing network connectivity (e.g., CFBLNet) would be an effective strategy to verify systems interoperability. With additional test opportunities, many simulator interoperability issues, like those experienced during Bold Quest15.2, could be identified and resolved during test periods between Bold Quest events.

Use Mission Partner Environment (MPE) as a model for simulator interoperability at the network layer. As a step toward the future, Joint Staff led the implementation of an MPE during Bold Quest 15.2 that provided connectivity between the aligned events Bold Quest (with 14 participating nations), the Army's Network Integration Evaluation 16.1, and 1st Armored Division's Multinational Division Exercise. The MPE model has proven effective in the operational world and may be applicable to the LVC domain as well. This is a topic that will be the subject of future research.

Expand participation in the Joint Fire Support Executive Steering Committee (JFS ESC) Simulation Sub-Working Group. To improve LVC interoperability, the JFS ESC has chartered a sub-working group to address issues that stand as a barrier to effective multi-Service and multinational simulator operations. The simulation sub-working group will leverage the Bold Quest LVC environment to demonstrate and assess methods to improve LVC interoperability. Other N/S/P interested in improving LVC interoperability should join us in this effort.

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