Operation Blended Warrior 2017 - Behind the Curtain!

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ABSTRACT

The *Wizard of Oz* quote, "Pay no attention to that man behind the curtain!" is applicable in many ways to the Modeling, Simulation and Training (MS&T) community. This paper takes you behind the Operation Blended Warrior (OBW) curtain. OBW, conducted as an I/ITSEC special event for three consecutive years, has allowed an opportunity like no other for industry, government and academia to collaborate and showcase their Live, Virtual, and Constructive (LVC) systems, tools, and capabilities. Integrating a disparate group of systems, requiring use of common data, defining a common infrastructure, and providing rules of operation are just a portion of the significant efforts undertaken by OBW and its participants. Yet, gaining real insights into what makes the event a success is difficult by merely watching the event from the conference floor. We, as an MS&T community, are far from turnkey integration of diverse LVC systems. The LVC community must do more than hope for a "plug and play" state where all systems magically connect, fully interact, and consistently represent the military mission environment. In fact, many do assume this is a relatively easy task, and for good reason; often the presentation of the final product is made to look easy. Flag level interest in LVC solutions for military applications continue, but the challenges in conducting successful LVC events are still not fully understood. Better understanding would allow leaders to better focus their resources. OBW 2017 was the most recent opportunity to bring all interested parties to such an open and varied networking event. This paper highlights specific topics to include technical challenges, innovative workarounds, and unintended benefits of bringing a slice of the MS&T community together for the common goal of OBW success. Valued insights gained from OBW are documented as a baseline for further growth.

ABOUT THE AUTHORS

Cathy Matthews has worked for government and industry in the modeling, simulation and training community. She retired from NAWCTSD after leading the Systems Engineering Division, which was responsible for the technical leadership of Navy training system acquisitions. She has also worked joint efforts for the DoD M&S office, and systems integration for distributed events. She has worked as a principal investigator advancing ASW systems and networking. She is now the director of two small companies working in the MS&T and Transportation sectors.

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Kent Gritton is the NAWCTSD LVC for Training (LVCt) Team Lead, and a member of the Acquisition Workforce supporting Navy training for 17 years. From 2015-2017, he led the Navy's efforts to bring Operation Blended Warrior (OBW) to I/ITSEC and remains involved in all aspects of future OBW events. Previously, he supported Team Orlando as the Director, Joint Training Integration and Evaluation Center (JTIEC) for 10 years.

Gary Fraas presently serves the M&S community as an independent consultant specializing in engineering, program planning & management, and business development. He represented the National Training and Simulation Association as the lead for Operation Blended Warrior during the years 2015-2017. Previously, Mr. Fraas was a career Navy civilian for 39 years and most recently served as the Advanced Simulation, Visual & Software Systems Division Head at NAWCTSD. Mr. Fraas has a M.S. in Computer Engineering from UCF, and a B.S. Electrical Engineering from Michigan State University.

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PURPOSE OF 3 YEARS OF OBW ("NOW WHICH WAY DO WE GO?")

How do we improve approaches to Live, Virtual and Constructive (LVC) interoperability? Operation Blended Warrior (OBW) provided a path to explore these issues. showing the way via the significant efforts of a significant volunteer-based Modeling, Simulation & Training (MS&T) technical event. Organized by National Training and Simulation Association (NTSA) during I/ITSECs 2015 through 2017, OBW can be considered an LVC prototype, providing a unique opportunity for interested participants to integrate their systems into a networked simulation environment. No environment of this kind existed for non-contract participation in an LVC event, and for some organizations OBW has provided the only opportunity to interoperate their products with other diverse systems. The OBW events have fostered unprecedented dialogue and teaming between government and industry organizations, and have allowed concepts and systems to be tested, requirements to be honed, processes to be established, and people to learn from hands-on experience. Although it is recognized that the volunteer aspect of OBW is different than a contractual agreement usually required to participate in a DoD (LVC) exercise, the many findings from the OBW events will directly benefit the LVC events of the future. In this context, OBW has elevated the understanding and the state of the art of LVC in the broader community. While this paper focuses on OBW 2017, highlights across all three OBW events are included.

WHAT OBW WAS ABLE TO DO ("WE WANT TO SEE THE WIZARD!")

There is not an Interoperability Wizard to solve all our problems, so there is a need to cultivate many. At its core, OBW has been a complex technical event, with the goal of providing insights into the LVC interoperability issues and challenges. However, OBW has also been uniquely successful in raising awareness, education, and exposure to MS&T and LVC topics.

OBW began with industry volunteers and government representatives. The question then was, "How effectively are a room full of competitors going to work together?" Interestingly, the industry partners readily formed a collaborative work environment. The harder problem turned out to be organizing the work effort and tackling the technical problems of interoperability. Developing interoperability solutions from design to reality often comes with a large learning curve. That is why the OBW environment is so important. OBW facilitated broadening the understanding and expertise within the MS&T community by providing first-hand experience solving the challenges of interoperability.

What all participants needed to define was their return on investment (ROI). What would constitute a viable ROI for an industry or government organization to participate in OBW? Obviously, exposure for their products and organization is a tangible benefit. From a technical perspective, the OBW experience also allowed participants to learn more about all the systems participating in OBW (including their own), use their product in an LVC networked environment for the first time, document ideas for system improvements, and to test, troubleshoot, modify and verify capability. What better evaluation environment than OBW? An additional, unexpected benefit is that some also found partners to team with and forge business alliances. These benefits are both subjective and objective, making it difficult to calculate the full ROI. For some, the benefit vs. effort would not tally as high as others. For many however, the ROI has been significant.

OBW leadership sought to foster inclusive participation. Once it was recognized that many small companies could not afford to participate, OBW leadership instituted a "First Timers" pavilion where booth space was provided on a sliding fee scale. This allowed, for example, UCF incubator companies to work alongside Fortune 500 companies. The comradery, expertise, and assistance shared among all participants created a great learning environment.

With a goal to capture the capabilities of these organizations, a data call was issued to the combined total of 66 organizations, which participated over the three years of OBW. Those who responded are included in the first edition of the Grey Book, a community resource for capturing the organizations' products, services, and strengths,

as related to LVC and M&S. The Grey Book is intended to be a living LVC reference document for the M&S community.

OBW also chose to capture participant and audience responses via surveys. In 2017, one of the small companies worked with the OBW team to provide a mobile phone-based SMS-text survey. It allowed OBW to collect data from participants immediately following each Block, which then populated a spreadsheet for further evaluation. It was a great test case for them, and an easy way for OBW to collect data. This was not the only incidence of OBW participants providing free use of their products. It was an unexpected outcome during the first OBW meetings where many companies provided free licenses for their products during OBW. Truly a win-win concept. Their products augment OBW capability and are showcased during an LVC environment at I/ITSEC.

To manage such a diverse workforce, a wide range of documentation was generated for OBW. A partial list of documents is provided in Table 1. It is very difficult to convey how much work goes into the planning and executing of an OBW event. Hopefully this list will provide a glimpse into that level of effort.

Table 1. OBW Documentation	
Note: This list does not include: all individual Block and Scenario documentation generated for the OBW event, the technical documents for the infrastructure components, or the coalition interoperability documentation.	
Documents	**Descriptions**
Participant Agreement	Agreement to participate and adherence; denotes cybersecurity risk management of OBW network
SharePoint access	Instructions for access to OBW files (excluding large environmental simulation files)
Participant Tracking	Tracking of participant information and status
General Planning & Pricing Briefing; All-Hands	Participant requirements, pricing, overview and schedule; updated briefing with additional details
Definitions	Particularly needed to define firewalls, connectivity, infrastructure
Roster & Capabilities	PoCs for all Participants and Team members with capabilities
Playbook	Describes booth layout, OBW events for each day, participants and team members
License Request / NDAs	Documentation for limited use and protection of proprietary information
OBW Event Schedule	Overview of all scheduled events prior-during-post on-site for I/ITSEC
OBW Room Assignments	I/ITSEC layout for showroom floor and additional meeting and presentation rooms
Goals and Objectives	Goals and objectives for OBW Program and Military Services
Switch / Booth location forms	Network tracking document for participant booth location: designing network and configuring switches
Capability Briefings	Opportunity to brief corporate capabilities. Twenty-eight briefings collected.
Playbook input forms	Participant information for Playbook generation
Coalition Briefings	Coalition (non-US) participant briefings to better understand integration opportunities.
Status Briefings	Leads briefings to capture and establish progress and way-ahead, numerous
Stage book	MC talking point material; LVC challenges and benefits
OBW Block Flow Spreadsheet	OBW Event was broken into 5 Blocks, this spreadsheet captures specific flow of each block (blocks had vignette subsections), document events, interactions, significant topics, control for display feeds, entity actions, tactical communication flow and narration points for MCs.
OBW Test Participation Form	Participant information and entry criteria for Test and Integration participation
OBW Munitions and Entity Enumerations List spreadsheet	All munitions and entities are identified and described based on capability and system users of requested enumerations. All entities used in the OBW event must be included in this list to be included in the scenarios.
OBW Off-Site Integration Test Plan	Test plan identifying OBW Navy infrastructure information with testing checklist.
Folder of Logos	Logos from participants for use in promoting their contribution to OBW in various OBW publications
Grey Book	An LVC corporate capability matrix of OBW 2015-2017 participants (who provided input), with accompanying individual corporate summary
ROI Journals	Frequent journals highlighting the progress for participants to share with their corporate leadership throughout the work effort

To begin the effort, OBW needed a network architecture and infrastructure. Creating a public simulation network was not a simple task. Specific rules had to be followed for the military services to receive approval to connect their certified systems to the network. These rules and restrictions were documented in a Participant Agreement that was signed by each participating company. The OBW network had to be implemented as a stand-alone, isolated network. As the Network Manager, NAWCTSD specially configured network switches loaned by Cisco, and subsequently installed these in the convention center's Main Distribution Frame, each of ten Intermediate Distribution Frames, each participant's booth, and in the OBW booth, also known as the Distributed Training Center

(DTC). The DTC served as the hub for network monitoring, technical oversight of the event, scenario management and execution, as well as the main audience viewing location of OBW.

The DTC provided a distributed training environment with a true test-bed for interoperability. When there were issues, troubleshooting and cross-participant coordination occurred. OBW became as much a "learning event" for the participants as it did for the audience. Systems were used to test prior to I/ITSEC on this DTC architecture. Throughout the three years of OBW, these testing approaches evolved. Based on lessons-learned from 2015, the Navy engineering team produced a test document and a set of testing checklists. Additional details on the 2015 and 2016 OBW events are provided in the referenced papers. (Gritton et al, 2016; Hoke et al, 2017)

A core component of any LVC event is the network connectivity and security. Planning and incorporation of multi-level mixed security networks is a challenge. In 2017, utilizing two separate but connected OBW networks, the I/ITSEC event was able to support the connection of assets associated with Coalition (International Partners) and US entities, including connection with remote locations and with live aircraft. In 2016, the OBW network also connected two types of live assets: dismounted soldiers on the I/ITSEC convention floor conducting medical and other simulated operations; and bi-directionally connected live aircraft interacting with simulated entities.

OBW allowed for expedient troubleshooting. An example of this is the passing of Coalition voice protocols and data protocols through two separate guards (firewalling the Coalition and the US OBW networks). Initially there was minimal data exchange planned, but the opportunity to expand the level of data exchange was recognized. Days before I/ITSEC, Coalition participants developed middleware for their HLA-based system to convert their data to DIS v6 data needed for the US OBW architecture. This development was expedited due to the OBW environment. The OBW environment allowed for testing with real-time feedback, thereby expediting troubleshooting efforts. Data was passed, and two-way conversations were held between the US and a Coalition site in Brazil over the OBW network. The power of a test suite with real-time test, feedback and modifications, was demonstrated by willing Coalition and US participants.

Common data is crucial for success in a networked environment. Prior to 2017, data management and distribution were based on a point-to-point basis. Terrain data for the same geographic area was generated from different sources and by different participating organizations. In 2017, a central repository was established providing direct access to data for all OBW participants. The repository contained terrain and 3D model data for both the 2016 data, and the newly generated 2017 data. Access controls were implemented in the repository to allow users with the proper credentials (including signed data release agreements) to access the appropriate data. Although the requirements for implementing these access controls delayed the ready state of the repository by a few weeks, a central repository proved very valuable as a single source for majority of OBW data. The repository was also hosted at I/ITSEC during the event for live access to data holdings. A 2018 I/ITSEC paper on OBW terrain and repository topics provides the details of this work (Woodman et al, 2018).

Technical innovations have been a key staple of OBW activities. OBW has included the incorporation of social media elements, cyber, and mixed networks to showcase many of these innovations. In addition, video streaming, tactical radios, integration with live assets, and measuring performance (Hoke et al, 2017) of both trainees and systems have been an integral part of OBW events.

Social media and cyber-centered environments are essential to conducting realistic exercises. Developing and incorporating a compelling and well-integrated social media narrative into the training events is significant work, and critical to today's training. Fortunately, tools and capabilities that make the integration of social media and LVC training significantly simpler are on the rise. Similarly, innovations in emulating and simulating cyber warfare have been highlighted during recent OBW events. The I/ITSEC 2018 paper on cyber and OBW (Moore, S., 2018) highlights many of the challenges and accomplishments of this evolving capability.

OBW accomplishments and lessons learned are directly applicable to the diverse uses of LVC in the community. The subsequent sections highlight insights into the workhours required, how some of the challenges were addressed, and what should be done as the community moves forward.

WHAT IT TOOK IN HOURS ("OH, YOU'RE WASTING MY TIME!")

It is difficult to capture the definitive number of hours expended throughout OBW. There is a significant level of effort involved, so it is important to provide some insight. The estimates provided here are the result of averaging 3 years of participant survey results. Noticeable hours are captured in the pre-event stage, highlighting that optimizing efforts and expediting the time-to-training could reduce significant time and resources.

The core government technical team, responsible for providing the OBW network, technical guidance, testing plans, integration requirements, and preparing both the testing and the I/ITSEC environments spent approximately 4500 hours. The estimated hours for the leadership team was 3200 hours, and for the scenario leads was 7700 hours. In addition to these estimates, there are approximately 20-30 participants whose hours are not accounted. The unaccounted hours are believed to vary from 300 – 500 hours for each participant integrating systems.

Also, it is important to remember OBW occurs over a compressed time frame with limited testing opportunity. For a military exercise, there should be additional time to test and integrate fully. Therefore, the level of effort needed would be larger than that used for OBW.


Figure 1. LVC Cost Curve
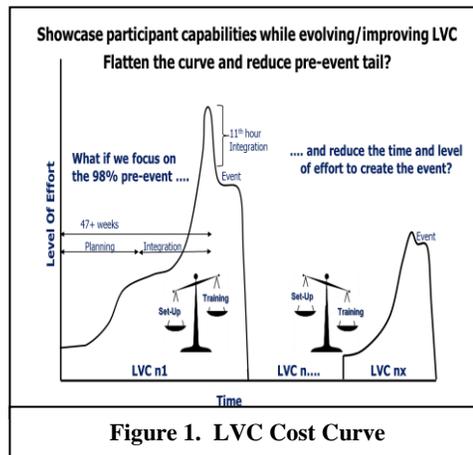
The level of effort required to organize and orchestrate an LVC event can be significant. As Figure 1 shows, any improvements and reduction in the preparation and test time can be a significant savings in effort. This is easier to achieve if there is: a persistent network, long distance (remote) testing capability, participating systems that are known/verified to be interoperable, defined processes, availability of and access to common data, experienced personnel, and a dedicated LVC network team. All supporting the goal of reaching the state of readily compatible (the "plug and play" goal).

FEEDBACK OF PARTICPANTS ("I THINK I'LL MISS YOU MOST OF ALL.")

Each year, the OBW planning team solicited feedback from all OBW participants, looking for areas that should be improved in subsequent events. Some of the data from OBW 2017 is included in Figure 2. Although the responses were focused primarily on future OBW iterations, the identified areas also apply for future LVC training initiatives. The most chosen future focus area was exercise generation and planning, followed closely by coordination and infrastructure.

One recommendation from the feedback regarding exercise planning was "connectivity solved, work on complex integration issues". Complex integration is an area that all DoD services are targeting for future improvement. Unfortunately, for some, plug-and-play connectivity issues remain a problem. A more complete solution to interoperability will be required to fully integrate future LVC capabilities into distributed mission training.

Figure 2. OBW Going Forward – 2017 Participant Feedback

Communications are always a challenge. This was no different for OBW. As the team worked through communication clients from various vendors, which is the exact same problem faced in a joint and coalition environment – as the services have
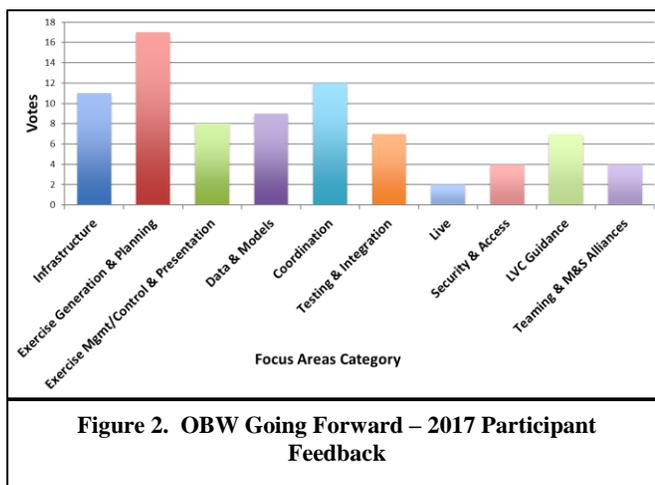
developed or purchased clients that meet their specific needs. Future developments will have to manage integration of diverse solution sets while simultaneously managing secure and non-secure modes of operation.

The focus area for coordination was centered on many of the duties required to plan and execute an OBW event, such as defining roles and responsibilities for participants, as well as better recognition of participant efforts. Other comments addressed those critical to future LVC events, such as the request for the government to better define LVC requirements in order to allow industry and academia to address the technical challenges, creating a forum for government-industry interactions, and providing LVC certification for acquisition.

CHALLENGES ("LIONS, AND TIGERS, AND BEARS! OH, MY!")

OBW provided a direct view into the tasks and effort required to participate in an LVC event, while trying to manage all the challenges "behind the curtain" for the audience. There are LVC artificialities for OBW, which in some ways made things more difficult. OBW was conducted once per year for three years, sometimes with return participants and leaders, sometimes not. OBW efforts for each year are completed within a one-year time frame, achieved with a volunteer workforce and conducted in an unclassified conference environment, with a need to showcase systems for marketing reasons. The similarities between OBW and LVC include the need for objectives and requirements, the integration of diverse systems, the scenario development, and all the administrative and technical artifacts for success. Because the goals and interests of the participants can be so diverse (for good reasons), the management and execution of OBW becomes a very complex endeavor. One of the surveys asked participants for their views on challenges.

The OBW 2017 survey results were analyzed and compiled into categories of challenges identified by the team and are tabulated in Figure 3. The companion Table 2 provides additional insights into each of the categories. It is worthy to note that many participants commented that what worked well despite the challenges was the "coordination among industry". That is a telling and welcome endorsement of the collaborative approach fostered by OBW.
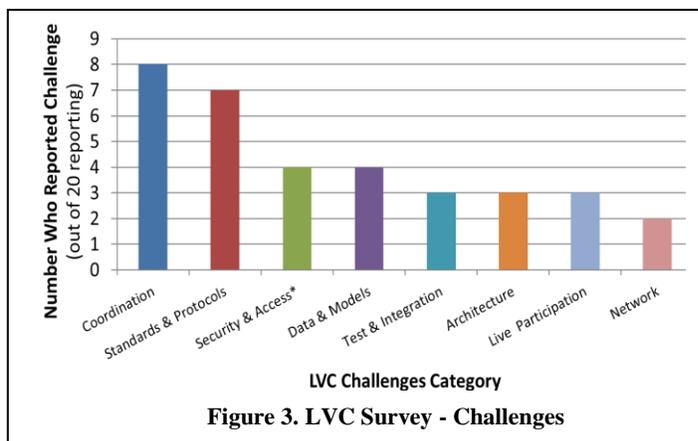

Figure 3. LVC Survey - Challenges

Table 2. LVC Survey - Challenges Detail

Topic	What was Difficult	Recommendation
Coordination	Complexity of LVC integration; Complexity of number participants; All participants at T&I; All participants at rehearsal; DTC to/from Booth communications	Tailor for Exercise objectives
Standards & Protocols	Enforcement; Support variety of Platforms; Enumerations	Detail for COTs
Security & Access	ITAR; Proprietary Systems; Coalition Access	Expedite Data and model availability; Less Network Restrictions
Data & Models	Correlation; Enumerations; Address existing known problems	Standardize use; Standardize implementation; Avail Test Datasets; Expedite availability
Test & Integration	Connectivity; Integration	Lesson Restrictions
Architecture	Integration of disparate systems	Support Innovation; Maintain Legacy baseline; Support COTs
Live Participation		Include more Live Participants
Network	New System Integration	Include all participants at T&I; Include all participants at rehearsal

Management and business aspects of OBW had the challenge of working with a team of volunteers, who in some cases, while being very dedicated, were assigned by their organizations the ancillary task of OBW, work to be done in addition to their normal "day job". Organizing and managing a complex technical event with variations in participants' availability, time and resources, all with a wide-range of interests and objectives, is a challenge.

The "Behind the Curtain" reference is in part related to the enthusiasm of industry, government, and academia to invest their time and resources to showcase their capabilities while meeting the OBW objectives. This is unique to demonstrations such as OBW and raises the challenge of how best to present discontinuities, problems, and

interoperability impediments to the audience, without implying some participant's system is the cause. In addition, in a networked environment, it is also not uncommon for a participant to assume the issue lies elsewhere; therefore, having good tools and using them early and often to troubleshoot can significantly minimize this challenge.

Guidance seems like such a well understood and manageable concept. However, diverse and geographically dispersed teams must plan to integrate with systems that have various levels of access, with various communication and storage mechanisms, and at different points during the event's timeline. This poses a management, communication, and logistic challenge, at both business and technical levels. An organizational structure was used to determine meetings and communication methods, and to attempt to provide "just the right" data at "just the right time" to minimize the efforts of many. Table 1, presented earlier, lists a sample of the management documents generated in support of the OBW events.

Over the past three years, OBW **processes** evolved, with each year reusing and adapting, as OBW itself evolved. IEEE Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP) Multi-Architecture Overlay (DMAO) (IEEE Std 1730.1-2013) was the basis for planning documentation. Tailoring of the standard was required to accommodate the compressed timeline, considering the entire participant process (from participant engagement to OBW event) was nominally 8 months.

In each of the three years, defining the OBW event used a different approach, each with its own unique challenges. The first year was a herculean effort at the grass roots, bringing together a large group of industry members (often competitors) to work collaboratively, some for the first time. The second year a strong stage production emphasis was put in place, resulting in a continuous four-day scenario, which posed its own coordination challenges. For the third year, specific objectives and challenges were used as the root requirements for defining the Block event scenarios and vignettes. All were an attempt to best showcase LVC benefits and challenges for the community, while balancing the marketing need for participants to showcase their product capabilities.

For 2017, several specific templates were generated to support the detailed interactions of the exercise flow, but the value of coordinating this level of detail in advance of the event was not fully recognized until the first dry-run on the I/ITSEC floor. Additional effort was required each day to prepare the templates for the events of the following day, adjudicating a variety of technical, scenario, presentation, and capability demands and limitations. Table 3 shows a sample of the information needed for each vignette. The details are necessary, so all participants have a common understanding of their roles and the vignette, and the stage displays are correctly fed with streaming video to match the narration message. A corollary challenge to a tactical exercise may not be obvious here, but while there may not be a need to sequence the interactions for presentation purposes, a tactical exercise spends a very similar effort in exercise planning to ensure all personnel are properly engaged to maximize training opportunities, training objectives are adequately addressed, and idle training time is minimized.

Table 3. OBW Block Flow Spreadsheet		
Column Headers		**Row Headers**
Time Start		Theme/Message:
Time Stop		Standalone block or multi-block scenario?
Time: Duration		Intro/Narration
Who		OBW Messages
What		OBW Challenges
Screen Preset		OBW Issues
Screen1		OBW Solutions
Screen2		Mission Narration
Screen3		Transition Discussion:
Screen4		
Message		
Notes/Comments		

There were challenges when systems were not able to perform their scheduled objective for their portion of the scenario. This could have been caused by their own system being offline, the systems they were interoperating with being offline, system crashes, incorrect protocols or enumerations, or lack of voice communications. In these cases, the presenters utilized this as an opportunity to explain the interoperability issue to the audience, or redirected the audience's attention to other LVC topics, while technical corrections were being made. This was successful, predominately because of the presenters' thorough knowledge of the participants' systems, of the OBW vignettes and events, and of the subject matter. It should be noted that in this regard, OBW was not unlike a real-world event, requiring some degree of unplanned work-around.

Sometimes, remote booth participants were unable to communicate with the OBW booth using the tactical communication or event coordination channels. An LVC environment expects to be in control of simulating these

failures to maximize the training opportunities; however, reality mandates remaining flexible throughout and having alternative actions, whether due to system failures or unanticipated mission decisions. Again, the cause, and recovery actions for OBW were no different than what are required in a real-world event.

One challenge is for all networked systems to self-protect. In other words, filter out data that is not needed or would cause their system harm (such as system overload). The opportunity to test systems during the OBW events allowed system weaknesses to be discovered. An example of this is when hundreds of entities unexpectedly published to the network, a system crashed due to the overload of entities. These entities were all legitimate, but the affected system had not planned for them. As a workaround to allow the scenario to proceed, the network guard was used to filter out the additional entities for the event to continue. Another example is a system was understood to be built for distributed simulation, but upon integration into the OBW exercise, it was found to work very well when integrated with its own type, but not so well when integrated with many disparate systems. These issues were undiscovered until the opportunity for final integration for the OBW event.

Common data is a challenge for networked events; OBW was no exception. A common terrain data product for the southern California area was generated in 2015 and again for 2016. In 2017, high-density northwest US terrain data products were generated, specifically for OBW. The technical details of these efforts are documented in two other I/ITSEC 2018 papers (Woodman et al, 2018; Moore, R. et al, 2018), however a few high-level process challenges and observations are noteworthy to mention here:

- The data was not available when desired by participants.
- Not everyone had access to the data when it was available.
- A method to share the data was not immediately available, and with some data products too large for usual data sharing methods, an unfunded solution was necessary.
- The data did not include all the oceanographic data needed for ASW (Anti-Submarine Warfare) operations, only the water surface and bathymetry representation was provided.
- Even using common environmental data, there were still issues with realistic interactions among entities and the environment.

On an assortment of technical and procedural topics, much effort went into crafting and distributing guidance, yet still the team ran into issues, all of which took a toll on team resources. A sample of these issues were:

- At Integration Testing, some systems could not load an OBW tool, because of operating system incompatibility.
- The submission deadline for enumerations had long passed, yet it was just realized a crucial threat contact was not included.
- On paper, there were several network compatible systems that seemed to fit well with the OBW architecture, but in practice it took more effort than expected to integrate them.

And then there were those obvious challenges that were not so obvious:

- System computer names were not intuitive. This made troubleshooting and communications difficult. For example, instead of Company A, Company B, Company B2, Company C, which could be more easily tracked down, there was, for example, HAL, My Precious, Bart and Kermit (not actual names).
- Representatives of some participating organizations had a difficult time during their "off-Block" periods narrating OBW events for the customers at their booths. (They did not have sufficient insight into the event in enough detail to present locally.)

Technology advancements have greatly assisted in advancing tactical and simulation system capability. However, two basic challenges remain for conducting training with an LVC environment: connectivity and interoperability. Sounds easy, but the community continues to struggle with problems identified decades ago. Future systems designed with requirements for standalone and networked operations – including flexibility of protocol usage, consistent representations, and common data usage – will enhance the ability to more effectively and efficiently conduct LVC exercises.

The responsibility of the OBW network was no small concern. The U.S. Navy and NTSA shared ownership. NTSA held ownership outside the Navy boundary. The Navy was responsible for 1) serving as the network manager, 2) providing configuration of the network resources/switches, 3) monitoring the network performance during

operation, 4) granting approval for connection to the network, and 5) overall technical operation of the network. There is an inherent challenge in this responsibility, which is somewhat subjective. How does delegation of ITAR and cybersecurity risk occur when additional networks are added behind the firewalls? Who is responsible if the (network) guard fails, and the firewall is breached. Who is responsible if a participant causes an ITAR or cybersecurity infraction outside of the network firewall or guard? The level of risk, the delegation of risk, the acceptance of risk is not a trivial matter, and can include or exclude significant training opportunities.

OBW adopted a philosophy of "test" during pre-I/ITSEC, and "validate" during onsite I/ITSEC integration. However, because of the distributed nature of OBW participants, and the fact that OBW did not have a persistent "site" throughout the year, it was impossible to fully integrate and test all systems prior to I/ITSEC. Some testing was performed, but full integration testing occurred on-site at I/ITSEC.

Testing and integration posed many challenges. Sample of these challenges are:
- Only one test and integration period of 4 weeks duration was available.
- Strict daily start and stop hours were imposed.
- Off-site (remote) testing was not available (no networked / long haul capability).
- Some systems were not easily portable, therefore not available during the testing period, the full system would only be available at I/ITSEC. In some cases, the best that was available was a "surrogate" (often a laptop) system.
- Not all systems' testing reached the point where they were ready to integrate, therefore not able to participate in a dry-run.
- Not all systems were able to be at the test-site at the same time as their scenario partners, therefore not able to participate in a dry-run.
- Not everyone had access to data when needed.
- Enumeration data was difficult to reach "data freeze" state.
- Systems were to be integrated which had never been integrated.
- Most test and integration happened just days before the event on the I/ITSEC floor.
- Not much opportunity for dry-runs, causing the learning curve to happen during the I/ITSEC OBW event.

When it comes to virtual training, cyber is a very interesting topic. While there is a need to train cyber operators, there is also a need for all warfighters to recognize a potential cyber-attack, while performing their normal mission, and subsequently be capable of basic troubleshooting and reporting. Integrating a network into a "cyber farm" raised concerns, needing to ensure the system injecting simulated cyber-attacks would also not cause damage to the "non" cyber part of the network. Cyber subject matter experts and network engineers did not agree on the level of risk, but having such debates are imperative if cyber events are to be integrated into traditional training exercises. Continued work for consensus on the right approach to train and protect is needed. The technical details of use of cyber in OBW are documented in an I/ITSEC paper (Moore, S. et al, 2018).

Simulated tactical communications and event coordination did not perform as "plug and play". Communications are very crucial, particularly in a distributed event. Continuing to ensure infrastructure tools are stable and interoperable is needed as the LVC and MS&T communities move forward.

In 2017, network data was captured, but it was not necessarily captured in context with the scenario data. Therefore, formulating system performance reports was not easy, although the network did not seem to have issues with the data loading for any of the OBW Block events.

While a new high-quality terrain database that included high-density urban content was generated for OBW 2017, there was some reluctance to use it because the OBW 2016 database was already "consumable" by many of the participants, and initially the new database was not marked as Distribution A (i.e. could only be used for OBW). Some did not see the ROI in the level of effort to integrate a new database, if they could not use it for other purposes. In response, the government updated the database (removing restricted source content), while retaining the high-density urban content, and released it as Distribution A. This provided a high quality, high-density, yet open data product to the broader community (not just OBW participants), which was so well-received that non-OBW users began using it during I/ITSEC. Going forward, generation, use, and reuse of data will be a continued challenge.

GOING FORWARD ("PROFESSOR MARVEL NEVER GUESSES, HE KNOWS!")

Many want to know if the government has a definitive, known plan going forward. It is recognized that LVC is the future of readiness. This core concept was utilized to focus the planning and execution of every OBW event. The next step is moving from an I/ITSEC Special Event to incorporation of LVC lessons-learned across the DoD training and readiness continuum. The FY18 National Defense Appropriations Act (NDAA) states: "the migration to more live, virtual, and constructive (LVC) training has the potential to fill training gaps and enhance the services' overall training program." (Senate Bill, FY18).

For the U.S. Army, the most recent posture statement defines the Army's major goals as: "improve readiness by fully manning in combat units, increase combat power, streamline headquarters, improve command and control, and conduct realistic combined arms training" (US Army, 2017). It is the last point that encapsulates the LVC focus, and the Army is addressing this goal through the establishment of the Synthetic Training Environment (STE), which is the evolution from Army's Integrated Training Environment (ITE). STE is being designed from the beginning to "incorporate the live, virtual, constructive, and gaming environments as one complete training capability" (US Army, 2017). The Army was the lead service for OBW 2017 and utilized OBW to describe and inform how the Army and Industry must pursue LVC-Gaming (LVC-G) interoperability into an augmented, live training environment. The key here is the close collaboration with industry and academia, and the ability to identify new technologies and processes for future implementation.

The U.S. Marine Corps (USMC) is working towards the refinement of its Live, Virtual, and Constructive-Training Environment (LVC-TE), "a transformational capability that will federate diverse training and exercise programs to meet individual, unit, and collective warfighting requirements to maintain relevancy, agility, and adaptability," as quoted in the USMC Training and Education Command (TECOM) Vision statement (USMC, 2018). The LVC-TE will link training from the individual level through the unit/collective, and culminate with battle staff training. The USMC Training M&S Master Plan identifies a broad road map to combine LVC objectives – such as improving augmented reality feeds, upgrading virtual simulation integration, and fusing virtual and constructive – all towards an end state with universal standards and overall LVC-TE integration. One area that OBW tackled over three years was data management, an objective requested by both the Marine Corps and the Army. The utilization of common data is seen as a critical requirement to increasing the interoperability between dissimilar platforms/devices.

U.S. Air Force (USAF) has requested funding in the FY18 budget for "additional virtual and constructive, or 'synthetic' Operational Training Infrastructure" realizing that "synthetic capability provides the opportunities to test and train against the world's most significant threats at a reduced cost" (USAF, 2018). This is in line with the USAF Modeling and Simulation Vision for the 21st Century, where the two key objectives are defined as: Making Better Decisions and Developing Better Skills. LVC is critical to the creation of realistic training environments to meet these objectives (USAF, 2010). The Air Force has utilized the LVC-Operational Training (LVC-OT) construct but is moving to the Operational Training Infrastructure (OTI), which will integrate training across the air, space and cyberspace domains. The Air Force has made numerous advancements with regard to LVC, and these efforts continue, especially as the Air Force integrates more live assets. Further developments of the range facilities are required to support the technical innovations being developed to augment live cockpit displays with simulated/ synthetic content.

For the U.S. Navy, the desire is to work towards a seamless training environment that enables robust, realistic, and cost-effective training by integrating LVC training systems to support the effective and efficient generation of maritime forces in support of Combatant Commander Requirements. Actions are underway to integrate LVC training capabilities into current training methods, such as the development and refinement of multi-level security solutions, institutionalizing link-based LVC training, and development of network architectures to support execution and testing. OBW played a key role in helping to identify the need for a test network outside of operational requirements; a network that replicates the operational construct but is also available for conducting testing on new technologies and processes. NAWCTSD is moving forward with an initiative to create a persistent LVC "sandbox", called LVC-NEXT, which will be used for testing with academia, industry and government entities. These are critical enablers as the Navy moves towards its Large Scale Exercises (LSE) in 2020 and 2025.

The services have been moving out on LVC initiatives within their purview, but the future will require all the services to not only work together in joint evolutions, but also with coalition partners. Innovations in LVC will have

to be developed with the imperative to include devices, networks, and forces from multi-national partners. Recent events have identified that the next fight will not just be in one realm, but require participation from forces across the spectrum – Air, Land, Sea, Space, and Cyber. The military must continue to train like we will fight, and that fight will be a joint-multinational effort.

CONCLUSION ("JUST TRY TO STAY OUT OF MY WAY. JUST TRY!")

OBW is an LVC endeavor with many layers and dimensions, providing insight regarding how systems are to be designed, integrated and used in a distributed fashion. Requirements for LVC capability will impact how the military acquires systems. A comprehensive description of all the issues, especially many of the secondary layer topics, is not feasible in a short paper. However, based on experiences gained over three years of OBW, this paper has attempted to highlight several important LVC-related topics and has offered suggestions for future direction.

- Requirements must be articulated and scoped for LVC participation.
- Individual systems should incorporate LVC requirements in addition to system-specific requirements.
- Continuation of OBW-like events is critical to advancing the state of LVC interoperability;
- Although each of the services in DoD has unique needs and challenges, the joint approach to LVC interoperability must take center stage.
- Testing, standards, standardized process and validated interoperable components are indispensable.
- Proper approach to management of LVC events is as important as addressing the technical challenges.
- The ability to test and integrate in a persistent LVC environment increases "LVC-ready" systems.

OBW has shown that, in some respects, the problem is larger than the sum of its parts. Addressing LVC challenges not only requires resolving the needs of the individual systems, but also directly addressing the problems at the systems of systems level. It is well understood that the interoperability of networked simulation systems is much more than just the exchange of data, packets, and protocols on the network. Similarly, LVC interoperability – any combination of live virtual constructive – requires attention to the entire system, both vertically and horizontally. This paper has identified a sample of these challenges. These include:

- Aligned understanding of rules, protocols, and objectives (both technical and administrative);
- Use, refine, and use (again) of critical processes;
- Establishment and use of common and central technical resources (e.g., data repositories);
- Active use of, and adherence to, standards;
- Systems engineering-based methodical integration of new capabilities and techniques (e.g. social media, cyber, augmented reality);
- Active evaluation and review of progress and performance (both technical and personnel).

Preserving the momentum of the OBW effort and the continuation of its work through coordinated activities across the services will ensure the state of the art in LVC interoperability will continue to develop.

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