# Operation Blended Warrior 2015 Cloud Computing: Capabilities, Lessons Learned, & Future Enhancements

**Dr. Michael D. Woodman, Lawrence A. Rieger**
**SAIC**
**McLean, Virginia**
**michael.d.woodman@saic.com, lawrence.a.rieger@saic.com**

## ABSTRACT

Cloud computing has been proposed by many as a means for Simulation as a Service (SIMaaS) to provide distributed stand-alone or integrated simulations. During Operation Blended Warrior (OBW) 2015 – "a Live, Virtual, and Constructive (LVC) event conducted between DoD and Industry to showcase new capabilities while documenting LVC integration and execution challenges" (NTSA, 2015) – SAIC contributed Simulation as a Service via cloud computing. SAIC and VT MÄK worked together prior to the OBW integration event in order to provide VR Forces and DI-Guy-based Enhanced Company Operations Simulation (ECOSim) to OBW participants via the cloud. In spite of this up front effort, there were still obstacles to overcome during the integration event. This paper will investigate the capabilities and pitfalls of cloud computing to support a large-scale LVC event, explore the lessons learned by our team during the integration event prior to OBW, and relate our experiences during execution of OBW at the 2015 Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC). Finally, we will take a look at future enhancements for SIMaaS to support OBW 2016.

## ABOUT THE AUTHORS

**Dr. Michael D. Woodman** is a Solutions Architect Senior Principal at SAIC, where he is responsible for the translation of requirements into an architecture and design that will become the blueprint for the solution being created. He is a retired Marine Corps Major with domain expertise in training, simulation, and human performance. Prior to his time as a Solutions Architect, Dr. Woodman worked in roles such as Program Manager and Principal Investigator in the Modeling and Simulation industry. He also has Government experience as the Modeling and Simulation officer in the USMC Training and Education Command, as a Project Officer at the Marine Corps Systems Command, and as a Program Manager at the Naval Air Warfare Center Training Systems Division.

**Lawrence A. Rieger** is a Solutions Architect specializing in cloud technologies and distributed simulation with SAIC. He received a BA from Belmont Abbey College an, an MS from Troy State University, and is also a graduate of the Army Command and General Staff College and the Army Management Staff College. Following active and reserve commissioned service with both light and mechanized forces, he spent 29 years in Army civilian service managing and developing simulations for training and combat developments, working in live, virtual, and constructive environments. His prior assignments include Deputy TRADOC Project Manager – OneSAF, Technical Configuration Manager for the Army Battle Lab Collaborative Simulation Environment (BLCSE), and served as the Futures Technology Simulations Analyst for TRADOC ARCIC. He received the CMSP in 2008.

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Cloud computing has been proposed by many as a means to provide distributed stand-alone or integrated simulations. During the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) special event Operation Blended Warrior (OBW) 2015 – "a Live, Virtual, and Constructive (LVC) event conducted between DoD and Industry to showcase new capabilities while documenting LVC integration and execution challenges" (NTSA, 2015) – SAIC contributed Simulation as a Service (SIMaaS) via cloud computing. SAIC and VT MÄK worked together prior to the OBW integration event in order to provide VT MÄK's simulation applications to OBW participants via the cloud. In spite of this up front effort, there were still obstacles to overcome during the integration event.

> OBW is an LVC event conducted between Department of Defense (DoD) and Industry to showcase new capabilities while documenting LVC integration and execution challenges….OBW was planned and its technologies integrated similar to the real world. The challenges uncovered will be addressed through LVC communities. The goal is to reduce the time and resources to employ this important capability. LVC is the future of readiness. The Warfighter and their platforms need LVC. The taxpayer deserves a fiscally prudent LVC. OBW is designed to improve LVC. (NTSA, 2015)

SAIC and its partner VMware provided a proprietary cloud solution called High Fidelity Network® (HiFiNet®) in which high fidelity applications, in this case simulations, are delivered via the cloud to low-cost end point user devices (known as SIMaaS). These user devices can be thin clients, zero clients, tablet computers, or even smart phones. Thin clients generally are end point devices with their own operating systems, connected remotely to a desktop that is hosted on a Virtual Machine either on a server or in the cloud. Zero clients are similar but have no operating system and no non-volatile memory. Further, because SIMaaS delivers simulations that are agnostic to the operating system on the users' end point devices, tablets and smart phones can be Android-, Windows-, or Apple-based. SIMaaS can facilitate high-fidelity training in locations with little infrastructure and computing hardware. By providing customers with graphics-intensive applications via the cloud, significant cost savings and greater control of their simulation environments can be realized.

SAIC cloud and simulation engineering, combined with VMware Graphics Processing Unit (GPU) virtualization technology, provided a view of the OBW 2015 warfight using VT MÄK's simulation applications. This was a significant breakthrough because previous efforts to deliver engaging applications via the cloud failed because GPUs did not virtualize well. SAIC and VMware partnered together on delivering an innovative solution where simulation applications requiring the GPUs were able to have the entire solution delivered via the cloud. Our original plan was to provide both VR Forces and DI-Guy-based Enhanced Company Operations Simulation (ECOSim) to OBW, as well as non-OBW simulations, via our cloud server. As will be explained later in this paper, DI-Guy had to be dropped from the mix. VR Forces was fully functional on zero clients and thin clients, interoperable with other OBW participants.

> In the simplest terms, cloud computing means storing and accessing data and programs over the Internet instead of your computer's hard drive. The cloud is just a metaphor for the Internet. It goes back to the days of flowcharts and presentations that would represent the gigantic server-farm infrastructure of the Internet as nothing but a puffy, white cumulus cloud, accepting connections and doling out information as it floats. (Griffith, 2016)

## DEFINING CLOUD COMPUTING

There is a lot of uncertainty in defining what cloud computing actually is; in fact, it was a recent DoD Inspector General finding that "the DoD Chief Information Officer (CIO) *did not establish a standard, Department-wide definition for cloud computing."* (DoD IG, 2015) The National Institute of Standards and Technology (NIST) has defined cloud computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources" (Liu, et. al, 2011) This definition is important in that it is the model and mindset of on-demand access to resources that is important, not the underlying technology of virtualization of computational resources and data access. Cloud computing is a service environment where the user has pre-negotiated service access, usually at a fixed cost for capacity or use, and uses those resources on an on-demand basis. It is the on-demand and fee-for-service characterization which defines cloud computing.

### Defining Cloud Types and Services

There are four types of clouds and three categories of services within cloud computing. The four types of cloud computing are Private, Public, Community, and Hybrid. The three categories of cloud services are Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

The types of clouds are differentiated by the means and limitations upon user access to the services. A Private Cloud is established and provisioned for the exclusive use by a single organization comprising multiple consumers (e.g., business units or separated branches). Such a Private Cloud might be established within a major corporation. A Public Cloud is one that everyone can access and use; such as the commercial clouds established by Google, Apple, and Microsoft. A Community Cloud is one provisioned for the exclusive use by a specific community of consumers from organizations that have shared concerns. The OPTUM™ Cloud Services for the healthcare industry is an example of a Community Cloud. The cloud established for OBW 2015 would be considered a Community Cloud. Finally, there is the Hybrid Cloud which uses parts of two or more of the other cloud types.

The categories of cloud services are differentiated by what they enable the cloud computing user to accomplish. IaaS provides the physical machines, servers, virtual machines, network data storage, the physical network, cloud communications, and the technical management of load that ensures the users always have sufficient resources within the limits they have contracted for. PaaS enables the cloud computing user to access a complete working computing platform with operating system, application loads, and all necessary databases, all within a web server on whichever type of client the user specifies. SaaS is at the heart of the cloud computing economy. It is SaaS which enables any cloud computing user to sit down at a client station and access, on-demand, any software package to which they have permissions, whether proprietary or Commercial off the Shelf (COTS). Cloud services are graphically depicted in Figure 1.

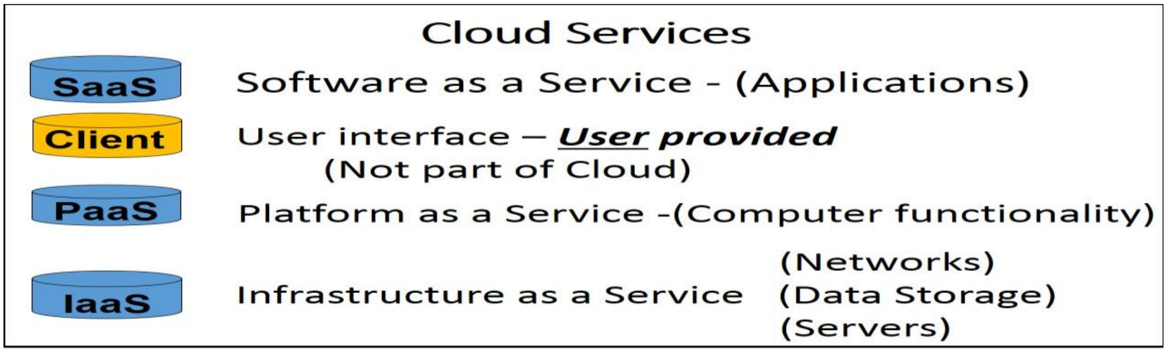


Figure 1. Cloud Services

**Defining SaaS**

SaaS is an overarching term for receiving, through the cloud environment, the applications and tools required by the user. SaaS is the concept that the person using an application does not provide the hardware, software, and network infrastructure for a simulation event, but rather uses the provisioning of another servicing entity, the vendor, as the user requires. The intent is that a local computing facility, whether a simulation center, training center, or education facility, no longer maintains application software, updates versions, provides computational hardware, and builds out an application event on various machines. Instead, it operates solely at the user interface level, what could be called the Graphic User Interface (GUI) level, such as those available from thin client applications accessible from a web browser. SaaS is commonly divided to a greater degree of into SIMaaS, Training as a Service (TaaS), Instruction as a Service (IaaS), and Development as a Service (DaaS). The first three are sufficiently alike, although different user categories, that they can be defined as a block. DaaS, however, requires additional discussion.

SaaS has as its core definition that the user software is delivered, in user-ready form and format, directly to the client GUI. In practice, when a unit or user group shows up at a simulation center, neither they nor the facility staff load the simulation software and scenario files, wire computers in local networks, determine how many computers are need to handle the simulation load, or make sure all the peripherals are properly connected and operating. They just sit down and start the event. In the same way, using SIMaaS enables the simulation center, whether a battle simulation training center, an experimentation Battle Lab, or a training or education facility, to move out of the complex event setup and integration process, as well as the care and feeding of a large computer hardware and software inventory, and merely become the providers of desks and tables with simple web browsers (GUI) pointed to the appropriate cloud provider. The cloud provider, through cloud services, provides the application software and databases; hosting virtual machine; computational, graphics generation, and memory functionality; and software licenses required, all to the simple web browser GUI.

DaaS has, as its core definition, the provision of a software (product) development environment, delivered to a client GUI, again in a simple web browser. What separates the DaaS from SIMaaS is that rather than being delivered as a user end product, DaaS provides a development environment. This may include software compilers, editing tools, configuration management software, and raw data bases, or COTS products, from which a user-ready software package is developed and prepared to be placed within the user software library. DaaS is also a virtual machine provisioned remotely by the cloud provider, negating the need for developers to either maintain an expensive and complex hardware and tool facility, or travel to one, but can access that virtual facility from wherever the developers are located.

Within the definition of SaaS, consideration must be given to the use of COTS software products in both “as-is” and tailored versions. Whether a commercial simulation product such as VR Forces™ or DI Guy™, or a commercial immersive educational or tutorial product, SaaS enables these products, with specific data sets or instructional content, to be available on call, as needed, anywhere that has network reach and Information Assurance (IA) approvals to connect. Once they are established within your cloud product library, either as is with a specified dataset or with tailored content, using DaaS, they are always available by a simple selection, without requiring local configuration of hardware or loading of application software.

**Advantages of SaaS**

From the beginning of contemporary cloud availability, the primary driving advantage has been the lower cost of doing business. “The SaaS model ultimately provides the same type of products as a software licensing model—but with a better economic model, one that is lower in cost to the customer and structurally inclined to keep getting better for the customer with every new release.” (Sehlhorst, 2008) Organizations can reduce the size of their IT footprint in their simulation centers. The reduction of the numbers of servers, the software cost, and the number of staff can significantly reduce IT costs without impacting the organization’s training capabilities. By using cloud computing, the delivery hardware can be thin clients, zero clients, tablets, or even smart phones, all cheaper alternatives to laptop or desktop computers. However, the advantages of cloud SaaS do not rest merely with cost savings, but with a wide range of benefits which include Scalability, Accessibility, Upgradeability, and Resilience. (McClellan, 2013)

As the need for more software grows, whether application packages, operating systems, or virtual machines, scalability allows more software licenses to simply be added to the service contract rather than requiring investments in additional hardware systems to host the software, with their related operating systems, IA packages, and user products.

Accessibility is a major advantage as more and more simulation, training and instruction is being done by mobile devices or at deployed locations. Simulations are available for training at the point of need anywhere in the world with internet connectivity. Trainees can access training and education at home base, in the barracks, at deployment sites, and even Forward Operating Bases as long as they have an internet connection.

The upgradeability of SaaS is also a major advantage. Not only are COTS products regularly upgraded, usually without user cost when SaaS is used, but for the user application products, the actual simulation, training, or instruction package is upgraded with the related datasets. End users have access to the most current version of the simulation. The latest enhancements, models, and functionality are immediately available. Upgrading is done using DaaS, and the single reference model becomes the template for all additional instantiations of that package, without need for manual loading, and with substantial savings in software storage requirements. (Lacks and Rieger, 2014)

Resilience, or more properly, reliability, gains as the cloud providers invest in multiple accessible locations for the hosting services, and load sharing across facilities in a virtual environment prevents single point of failure crashes. Most cloud providers are extremely reliable in providing their services, with many maintaining 99.99% uptime. (Coles, 2015)

A last advantage, particularly for government users, is that IA becomes much less challenging. Not only does the IA burden of constantly upgrading and managing various hardware platforms and operating systems fall on someone else, but the physical and virtual access concerns are greatly lessened, especially where the constant change of user software loads are concerned within a simulation or training facility. Rather than reconfiguring and loading the new software, which might include wiping of hard drives and changing operating systems, the simple browser GUI is pointed at a pre-configured URL, and the instantiations of the new software load are automatically instantiated from the single reference version, negating the need for IA configuration control checks.

**The Concerns, Limitations, and Pitfalls of Cloud Computing**

The number one concern of Cloud Computing is security (McClellan, 2013). This includes both the IA issues, and ensuring that the cloud vendor protects the data and software compliant to government equivalent standards, but also the physical security of determining who can access your software and datasets to read or to copy. "Because Cloud Computing represents a relatively new computing model, there is a great deal of uncertainty about how security at all levels (e.g., network, host, application, and data levels) can be achieved and how applications security is moved to Cloud Computing" (Rosado, et. al, 2012). However, a recent survey of 209 Information Technology (IT) professionals indicated that 64.9% believe cloud computing is as secure as or more secure than on-premises software (see Figure 2) (Cloud Security Alliance, 2016).

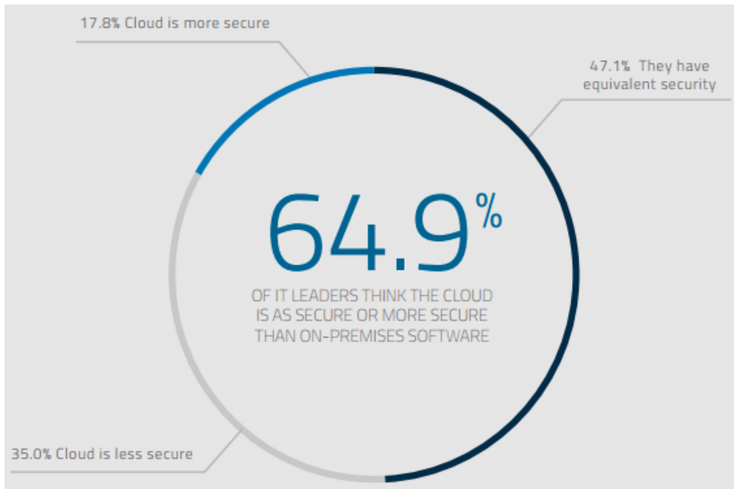


Figure 2. Survey of 209 IT Professionals (Ibid.)

Closely related is the loss of control of your software and data, as well as your hardware. Someone has all your assets, and you are dependent upon them to complete your mission. By its very nature, cloud computing requires that local users relinquish control of computing systems to the cloud provider. Tied in with the loss of control is the reliance on another activity for your reliability and responsiveness. This concern includes the very real challenge of Configuration Control and Configuration Accounting in a cloud environment. Using COTS under SaaS may require you to comply with the vendor's software change schedule, including where the level of change may trigger an IA-forced significant change threshold. The flip side of that is that required changes to your proprietary software, which may include COTS, may no longer be at your own schedule, but may be limited by the cloud provider or their IA compliance process.

Cloud computing is internet-based; therefore, delivery of SIMaaS is dependent on an internet connection. Internet outages will result in downtime. System failure is always a concern, although hardware redundancy minimizes this concern. In fact, "most cloud providers are extremely reliable in providing their services, with many maintaining 99.99% uptime" (Coles, 2015).

## LESSONS LEARNED

### Software Integration and Testing

Incorporating VT MÄK's VR-Forces (see Figure 3) and DI-Guy-based ECOSim (see Figure 4) simulations into the SIMaaS environment went very smoothly, although it had to be done several times as software upgrades were released by VT MÄK in preparation for I/ITSEC. This actually points to one of the strengths of SIMaaS: these software upgrades would have been completely transparent to an end user and would have eliminated the need for local simulation administrators to deal with configuration management. Further, demonstrating these simulations in our test environment proved 100% successful delivery.

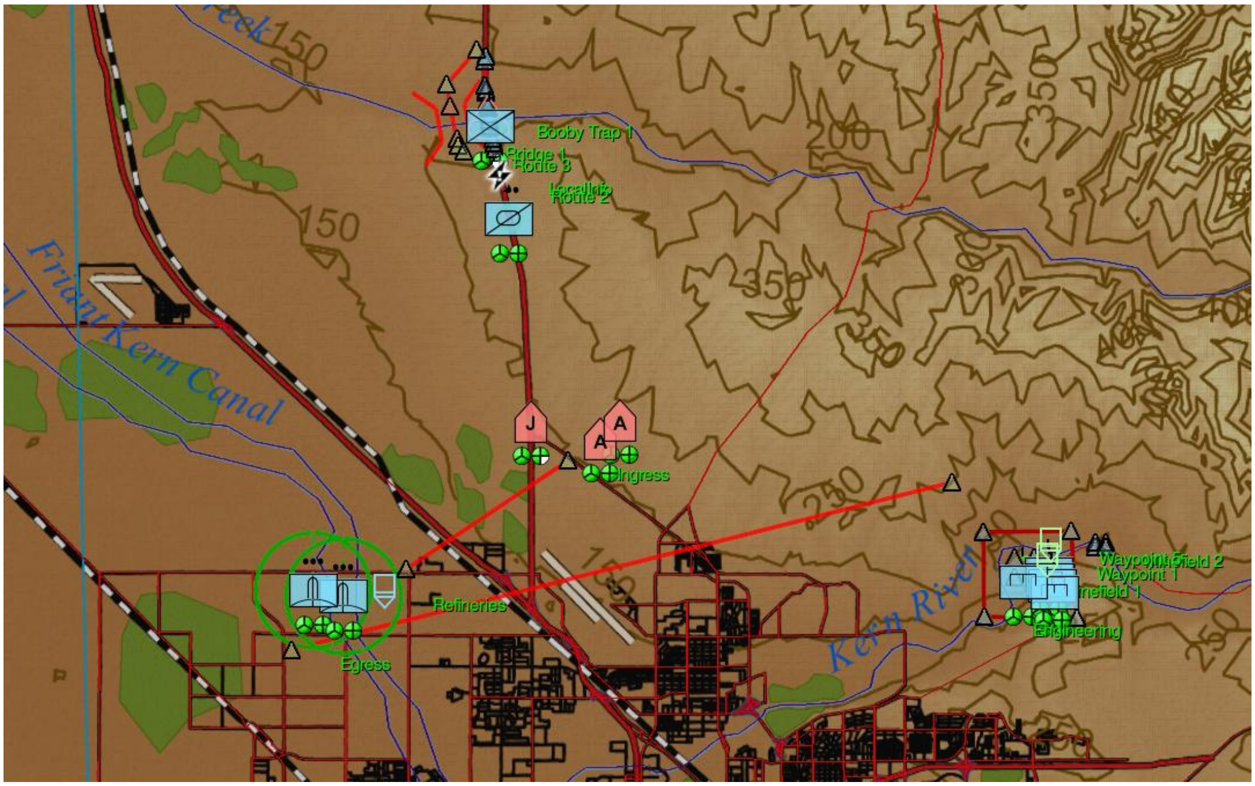


Figure 3. VR-Forces (VT MÄK, 2016)

Figure 4. DI-Guy (VT MÄK, 2016)

In addition to the software specifically for OBW 2015, we loaded several other simulations on our cloud for demonstrations. These included the Army Corps of Engineers' Missouri River Basin Balancer game (see Figure 5) and I-SIM, a high fidelity ATC simulation suite from Kongsberg Gallium (now Kongsberg Geospatial) (see Figure 6). The total amount of time required to load all of the simulations into our cloud environment was approximately 60 hours.

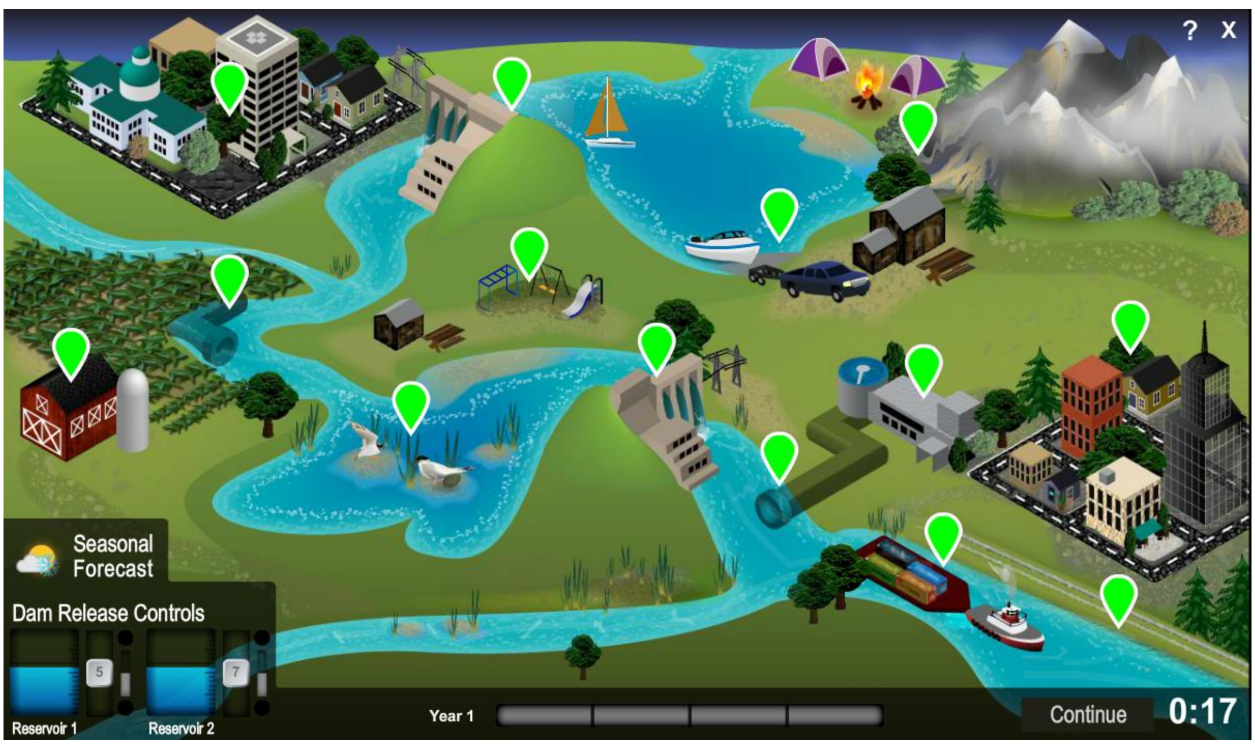


Figure 5. Missouri River Basin Balancer (USACE, 2016)


Figure 6. I-SIM (Kongsberg Geospatial, 2016)

During the official OBW integration event, integration of the cloud computing capability was complicated by the LVC network setup requirements that were established by the Naval Air Warfare Center Training Systems Division (NAWC TSD) OBW network and Distributed Training Center (DTC) concept. By the end of the integration event, all network settings had been determined and coordinated between the participants to ensure that on-site integration at I/ITSEC would be flawless (or nearly so).

Although VT MÄK's ECOSim was incorporated into the cloud environment, VT MÄK made the decision to pull it out of the amphibious assault vignette because of terrain database (synthetic environment) issues. With less than a month to go before I/ITSEC, VT MÄK had not received an OpenFlight terrain with features. As a result, they could not create a preliminary scenario for the amphibious assault vignette, which included the "Nuclear Storage Facility," a feature-rich environment, and ECOsim's role involved maneuvering in and around buildings. This was actually a larger interoperability issue, not a SIMaaS issue, as all simulations in the network were operating on the same Distributed Interactive Simulation (DIS) standard – DIS 6 – and could pass the appropriate DIS Protocol Data Units (PDUs) indicating simulation information such as Entity State, Collision, Fire, and Detonation, among many others. However, without a common synthetic environment (terrain database), the physical locations of entities, terrain features, and man-made objects were not correlated, thereby making a "fair fight" impossible.

VT MÄK did use ECOSim in the Convoy, Medical Evacuation (MedEvac), and Close Air Support (CAS) vignettes, which took place in the Las Pulgas Canyon area and had less feature data that would impact the simulation. They were able to create their part of the scenario using the terrain skin that was available prior to I/ITSEC and then switch to the final OBW OpenFlight terrain. VT MÄK also supported the amphibious assault vignette with VR-Forces, using streaming terrain and features.

**OBW 2015 Execution**

Throughout OBW 2015, we provided VT MÄK's VR Forces without any downtime to the OBW federation (as well as the other simulations within our own I/ITSEC booth), with VT MÄK controlling the simulation from their I/ITSEC booth using a thin client. VT MÄK led the Maritime Threat vignette and supported many others. The company's VR-Forces Computer Generated Forces platform provided naval vessels, civilian shipping, pirate boats, and a rotary-wing UAV search and destroy mission. For the final three vignettes on the last day of I/ITSEC, the amphibious assault and air-to-ground strike package, VT MÄK provided all ground and unmanned vehicle threats. VT MÄK had complete access to the scenario development tools within VR-Forces to provide a flexible, scalable Opposing Force. All of VT MÄK's interactions with the federation were executed via the cloud, entirely invisible (other than the simulation entities, of course) to the audience observing the event.

In spite of the great success of OBW 2015 in general and our participation in particular, there were a couple of negatives that we need to address for OBW 2016. Because OBW 2015 required a closed network, we weren't able to use a long-haul (internet) connection to our cloud servers. This necessitated physically locating a cloud server in our I/ITSEC booth. While functionally identical to connecting with our cloud servers in Reston, Virginia, having the cloud server in our booth reduced the impact when discussing our capabilities with potential clients. The other issue that we encountered was that, by its very nature, our SIMaaS was essentially invisible to the audience. Obviously, an important factor for any company exhibiting at I/ITSEC is marketing. In this case, we provided VR-Forces to OBW, which is what the audience saw, generally without realizing that it was been provided as SIMaaS via our cloud.

## FUTURE ENHANCEMENTS

In order to address the shortfalls of OBW 2015, we will be taking the following actions to make our participation in OBW 2016 even better:

- We will be providing SIMaaS from our long-haul cloud network in Reston, Virginia. We have begun discussions to ensure that we will be able to use the internet to reach our cloud.
- We will be adding more simulations. We have already had discussions with Bohemia Interactive Simulations to add Virtual Battlespace Simulations 3, a "First Person Shooter" military simulation.
- We have had discussions with the OBW team to enhance the marketing value of participation for all of the companies participating in the event.

We look forward to OBW 2016!

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