A USAF F-15C takes off on one of the first 'Northern Edge' 2015 LVC training missions. F/A-18s sit on the ramp and aircrew in the simulator.
Northrop Grumman: 1635569

Virtual construct: LVC strides toward reality

Truly integrated live, virtual and constructive (LVC) training is a holy grail promising to simultaneously promote cost efficiencies and increase the value of training. **Julie Tilson*** assesses its progress

In many examples of training today, virtual and constructive elements can be linked together fairly easily, but it remains more of a challenge to integrate live elements into and with the virtual world.

To put that plainly, 'virtual' simulators can be – and regularly are – linked together and made to interact in controlled environments with simulated 'constructive' forces stimulated by real people. This has provided benefits, but has not replaced live training – some roles can still only be trained for in the real world – and it remains difficult to blend those approaches. For example, is it possible (or necessary) to generate live battlefield effects for troops moving around an instrumented exercise area also occupied in a virtual sense by tank crews and fighter pilots raining down explosives from their networked simulators within a simulated constructive environment?

Like several other services around the world, the US Air Force (USAF) and US Navy (USN) have good examples of VC training in place, and both are working to integrate the live aspect into a fully operational LVC capability that aims to ultimately enable cost savings while providing better, more realistic training.

Integrating the three LVC domains offers the opportunity for more complex scenarios and the chance to optimise the time spent in the operational platform with the hope that this type of training will also ultimately yield increased proficiency for the warfighter. For certain, integrating LVC elements adds levels of complexity to the training scenario that cannot easily be found elsewhere.

Definitions of what LVC actually involves vary widely. Chip Gilkison, director of strategy for Live, Virtual and Constructive at Rockwell Collins offered his interpretation as, "a blended training media solution to allow you to realistically train as you fight in an immersive environment." The key is that the training must be immersive and highly realistic.

Gilkison added, "in a true LVC-enabled environment, you're not going to know who's live, who's virtual and who's constructive. So a pilot in a live aircraft will look at the display and see 10 contacts he is fighting against. Some might be live, some might be simulators and others might be computer generated. All that pilot knows is that it is his job to eliminate the adversaries."

Lieutenant Colonel Richard Martino, Commander, 705th Training Squadron, USAF put a slightly different nuance on the definition as the USAF Air Combat Command (ACC) views LVC as a subset of live training. He told *IHS Jane's*, "The VC training environment is already robust in terms of participants, activities, and combat situations that can be replicated. Live training through the addition of more complex scenario elements will be the primary beneficiary of LVC. The applications envisioned are related to missionised training scenarios – those resembling combat tasking."

In addition to the cost benefits that can be realised through the increased use of simulation, the next step of integrating LVC offers training benefits, ultimately enabling it to more closely resemble real-world combat. In the real battlespace, teamwork plays an integral role and the capabilities that LVC provides enable that

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level of teamwork to be present during training, whether it be at unit level training or a large-scale force-on-force exercise.

LVC environment

The need for LVC integration will increase as fifth-generation aircraft come online. According to Captain Wes Naylor, commanding officer of the Naval Air Warfare Center Training Systems Division (NAWCTSD), "there is a realisation now of what can be garnered in this at the individual unit level. If we could construct an LVC environment that had a persistent, consistent capability we could get so much more training out of it for our warfighters. And with the next-generation aircraft, their capabilities are too broad to fit inside our ranges."

Captain Craig Dorrans, programme manager for PMA-205 agreed. "LVC would benefit anything from unit level training to a large-scale exercise, which brings in multiple DoD [Department of Defense] services to participate. One of the problems we have today is the size of our training ranges.

"When you start looking at the large force exercises, they take place over hundreds of miles and you have blue and red forces converging together. The size of our training ranges today are just too small to contain that big of a force. That's where LVC provides a terrific capability. It lets us virtually expand the boundaries of our training ranges and add complexity to the exercise without increasing the size of where we need to be. So, we wouldn't be treading out of our airspace. We'd be able to conduct all the training we need within our airspace even though virtually we've gone well outside the bounds of the physical range."

However, Capt Dorrans asserted that, "It's not about a reduction in flight hours. It's about an elevation in proficiency by presenting more complex scenarios than we have the capability to do today."

Lt Col Martino concurred from an air force perspective, "Air Combat Command does not trade a live exercise for one done in a VC environment – we plan for and execute both."

There are certain aspects of training that can only be done in the aircraft, so practicing the routine procedures in a simulator enables aircrew to focus on more complex aspects of training when flying live assets. Capt Naylor concurs, "Ten years ago, you would've had a pretty tough argument. People would have looked at LVC and simulators as a threat to flight hours. I think today everyone realises that there is some unique capability that comes with having that high-end simulation available. We need to take advantage of it so we can really maximise that precious time we get in the aircraft for training."

One area where LVC can provide a particular cost advantage is to provide simulated adversaries for the live aircraft. "You could inject constructive adversaries rather than actually having to fly those aircraft and you could practice the same skills over and over in this LVC environment without having to expend the fuel or flight hours for adversaries. And maybe the students at that particular time in their syllabus aren't quite ready for the live adversaries to be out there. It gives you a capability to practice that we don't have today," Capt Dorrans said.

Negative training

The benefits aside, there are also some pitfalls to be avoided, as well as challenges to reaching the full LVC capability.

One very important consideration is the careful planning of training scenarios, as a misrepresentation in the VC or LVC domains can lead to negative training in the real world. Mike Aldinger, Mission Integration department manager at Northrop Grumman told *IHS Jane's*, "You need to be careful what components of live you integrate because there are things you can't do between live aircraft and virtuals with today's technology. So you don't integrate all aspects of it."

Aldinger gave an example of a live four-ship of F-16s along with a four-ship of virtuals. "Even though the datalink will show up correctly and you'll see them on the datalink, you cannot get a radar contact on those virtuals. There is no metal out there for the radars to pick up. So the guys in the live planes are going to see some information on those virtuals, but they won't show up on the radar screens. So that would be very bad training."

Capt Dorrans also spoke of this challenge. "We have to get it right. If in putting LVC together, we make technical mistakes and we present inaccurate scenarios then that would lead to negative training. That's why LVC is not easy. We need to ensure that if we're using constructive entities instead of live adversaries, we have absolutely 100% correct presentation so when they get out there and fly against the live adversaries, it looks exactly like the scenario we presented in the VC environment."

Live aircraft are not routinely being injected into training scenarios, particularly during training undertaken daily.

Nick Scarnato, marketing and strategy director at Rockwell Collins told *IHS Jane's* that, from his perspective, creating the architecture or framework that will ultimately enable 'plug and play' is one of the main obstacles that has to be overcome, along with providing multiple levels of security between different entities. Rockwell Collins has made significant steps in advancing this capability. The company has received National Security Agency (NSA) certification for its Joint Secure Air Combat Training System (JSAS). This system enables participants with various security classifications to train together in one environment.

Gilkison elaborated on the issue of security classification and realism in LVC, particularly when considering the addition of fifth-generation fighters. "The F-35 has a level of security classification that the F/A-18 doesn't have access to, so they can't share data without multi-level security. So if they are training on a range, the F-35 will tell the range training officer over the radio that he's launched a weapon at the F/A-18. The range training officer will look at the display and verify whether it was a good shot and communicate that back to the F/A-18. That is not exactly realistic training." It is necessary for guards to be in place to separate the varying levels of classifications and blend them in a way so that all participants can get a full mission debrief based on their level of classification. That capability is not widely available today, but Rockwell Collins is hoping to change that with JSAS.

Northrop Grumman, as part of its work on the USAF Distributed Mission Operations Network (DMON), also developed the LVC Experimentation, Integration and Operations Suite (LEXIOS) as an interface enabling integration of LVC components. According to Aldinger, "it allows us to bridge all the live data into the DMO world. It is through this interface that the devices communicate, so it is not some big set of disparate systems that you have to tweak every time."

In another example, Northrop Grumman developed the Multifunction Advanced Datalink (MADL), which has the potential to bridge the gaps between live and virtual elements. According to Martin Amen, director of Satellite and Network Operations at Northrop Grumman Information Systems, "this could be the LVC waveform back-up to the aircraft."

Amen noted that the timing involved to modify the Operational Flight Program (OFP) for an aircraft in order to add training capability that will enable the software to interact with the VC inputs can be significant. "For LVC it is critical to get more capability up through the aircraft itself and that involves modifications to the OFP. This is typically a lengthy process and can take up to seven years to achieve."

LVC in practice

US Air Force

During Exercise 'Coalition Virtual Flag 15-4', the DMOC was able to link an E-8C Joint Surveillance Target Attack Radar System (JSTARS) simulator located at Kirtland AFB to the live fly 'Red Flag' at Nellis AFB.

Lt Col Martino said that by "utilising the existing infrastructure of the Nevada Test and Training Range [NTTR], information on live vehicles equipped with a GPS tracker was translated into a simulation data message format to display them on the virtual JSTARS scope. The DMOC team developed constructive vehicles on known lines of communication that moved to a position where the live vehicles were located.

"The JSTARS crew created Link 16 land point/track messages for the movers that were translated to a live Link 16 picture and displayed by aircraft flying over the NTTR, as well as at the Combined Air Operations Center [CAOC] – Nellis. Based on the movers, the CAOC developed time-sensitive targets that were transmitted to a live airborne E-3 Airborne Warning and Control System [AWACS] for targeting by live strike aircraft."

Lt Col Martino told *IHS Jane's* of another example from 'Virtual Flag 13-4'. "Live C-17s from Joint Base Lewis-McCord were added into the scenario with a US Army Fire Brigade team loaded with the M142 High Mobility Artillery Rocket System [HIMARS]. Two aircraft went to two different landing zones [one in California and one in Washington state] as part of the scenario. When the aircraft landed, the HIMARS were off-loaded from the C-17. The HIMARS crew was able to send a radio frequency [RF] link to CAOC-Nellis, which fed into Advanced Field Artillery Tactical Data System [AFATADS].

"The 17 Fires Brigade team at CAOC-Nellis was then able to send a fire order to the HIMARS unit at the landing zones.

"When the HIMARS team pushed the fire button, the RF signal of the fire mission in flight was sent back through AFATADS at CAOC-Nellis to Kirtland AFB (the DMOC) where a constructive missile was flown out to the desired target. When the missile hit, a virtual aircraft providing full-motion video [FMV] 'watched' the missile impact with resulting damage to the facility.

"As part of the scenario, the Distributed Ground System at Kirtland AFB received the FMV to conduct initial battle damage assessment [BDA]. This type of highly integrated scenario is extremely difficult to reproduce in a fully live environment, but our ability to use LVC provided high-level training to all participants."

Northrop Grumman's LVC Experimentation, Integration and Operations Suite (LEXIOS) is an interface 'gateway' that enables live and virtual elements to operate with each other.

Northrop Grumman: 1635570

Rockwell Collins

The company conducted a demonstration of a successful LVC air-combat training flight utilising the JSAS. This included an L-29 aircraft (emulating a fifth-generation fighter) out of the University of Iowa Operator Performance Laboratory along with a constructive entity generator.

The live aircraft was flying with an F/A-18 simulator as a wingman, and was operating against three computer-generated MiG-29s. According to Gilkison, "the live aircraft and the sim appeared on the screen as if they were flying together. They conducted a simulated weapon launch and took out the lead MiG-29. This was all done with real hardware."

After the first phase of the demonstration, the scenario was reconfigured and a Joint Terminal Attack Controller (JTAC) in another location called for fire. The same aircraft and simulator dropped simulated ordnance on the ground. According to Gilkison, "All the entities were looking at a simulated location and they all saw a simulated weapon explode."

The exercise, reconfiguration and second exercise were all conducted in a matter of 30-45 minutes.

Gilkison indicated, "If you were going to fly both those missions today you would have to fly one mission, come back, reconfigure the pods, debrief and then go fly the Close Air Support [CAS] mission. It would all take about 5-6 hours and a lot of fuel. It took us 45 minutes – so that shows the power of LVC."

Northrop Grumman

Northrop Grumman demonstrated an LVC capability during Exercise 'Northern Edge' 2015 at the Joint Pacific Alaska Range Complex (JPARC).

Aldinger explained, "with Northern Edge, we had 10 virtual Mission Training Center locations integrated into that event. We also integrated the Mobility Air Force network, and the DMO network into that event, which was the first time that had ever happened. There were platforms from those networks supporting the LVC event with the live fly aircraft in 'Northern Edge'."

The live range data related to threats and entities was pushed to the Rivet Joint crew located at Offutt AFB, which populated the displays and enabled the crew to assess the ground threat status on the JPARC. The crew could then push that information to the live aircraft via datalinks and radio communications – just as if the Rivet Joint was actually flying over the Alaska ranges.

"This is a large event," Aldinger said, "with over 100 live fly platforms integrated with 20-30 virtual players and well over 100 constructive entities. It's a very complicated battlespace, but all standardised."

The LEXIOS system enabled the LVC integration in this example.

Integration challenges

Lt Col Martino also touched on this issue regarding the challenges to further LVC integration. "First, it's about warfighter training, so the simulators have to be concurrent with the aircraft. This requires a commitment to keeping existing simulators up to date with the systems and upgrades on live aircraft. Next, as the USAF brings LVC to fruition, the challenges will revolve around the ability to move the necessary volume of information between the aircraft, live range infrastructure, ground-based V and C generators, and data capture/feedback methods."

The USAF has made considerable progress in integrating LVC in its training programmes, and in its 'Strategy 2015 – Securing the High Ground' document, the USAF Air Combat Command stated that the use of DMO simulators has doubled over the past five years, although this is caveated by the acknowledgement that improvements must still be made in integrating LVC training environments.

In the recently released 'Air Force Future Operating Concept – A View of the Air Force in 2035', one of the implications of the future concept is documented as a need to develop LVC elements to improve training realism, conserve resources, and facilitate collaborative solutions.

The USAF already has a robust VC training capability through its Distributed Missions Operations Center (DMOC), which is run by the 705th Combat Training Squadron at Kirtland Air Force Base (AFB) along with DMOC-Space at Schriever AFB.

The primary mission of the DMOC is to support three 'Virtual Flag' exercises and one 'Coalition Virtual Flag' each year through the creation of a virtual battlespace where participants can exercise a wide range of capabilities in a high-fidelity environment that cannot be replicated with live training alone. In addition, the DMOC also supports some squadrons at the USAF Weapons School for training Air Battle Managers, Electronic Warfare Officers, Intelligence Officers, and HH-60 pilots.

"The DMOC is a critical part of the air force LVC vision and a repository of subject matter expertise from which the USAF can build an even more robust LVC capability," Lt Col Martino said about the DMOC's role within USAF goals for further integration of LVC.

The Combat Air Force Distributed Training Center (CAF DTC) at Langley AFB, Virginia, underneath Air Combat Command, also provides VC training to the CAF, which include forces in ACC, PACAF, and USAFE.

The CAF DTC executes daily Large Force Employment (LFE) training events on a persistent basis and enables anywhere between 9 and 36 virtual aircraft to train in realistic simulated combat training scenarios on a recurring basis. These advanced missions fulfill training requirements established by the MAJCOM. The CAF DTC has had initial success in linking VC with the live environment, by providing a VC input to PACAF's Exercise 'Northern Edge'.

Lt Col Martino indicated that the role of VC integrated training for readiness activities will expand as VC capabilities continue to mature.

Currently, individual simulators can be linked together and then connected to a network such as the DMON operated for the USAF by Northrop Grumman. DMON provides focused, on-demand global inter-team training on a daily basis by linking two or more sites of simulators of different weapon systems. The DMOC takes this a step further by enabling complex scenarios with multiple weapon systems in a challenging environment. This could even include participation from joint and international forces, as well as integration with live flying.

"VC is complementary to live training and will never replace it, but what it provides is an arena to experiment, take risks, and test advanced technologies and tactics in an environment that will not harm equipment or operators and where the enemy does not have an opportunity to exploit [it]. Once developed and implemented, LVC will take its rightful place in the CAF's training tool kit. The only disadvantages are the inherent fact that 100% fidelity is never truly possible and that there are costs associated with developing and sustaining these LVC systems," Lt Col Martino added.

According to Amen, DMON is primarily associated with VC training, but it will be a core enabler for the USAF to achieve the LVC vision, facilitating worldwide training for the USAF. As part of the DMON 2.0 contract, Northrop Grumman manages the overall lines of communication, the interoperability standards, the cross-domain solution and the network operation centres that control the network. The network interfaces with Mission Training Centers through portals or gateways; Amen believes that the DMON is front and centre to enabling LVC, "It brings to bear those virtual and constructive assets that play with the live."

Aldinger said that as the operations and integration contractor as part of the DMON 2.0 and MAF DMO contracts, it is Northrop Grumman's responsibility to make sure that all the systems talk to one another. This is no small challenge, considering that most of the platforms bring their own constructive elements to the DMON. He added, "I think interoperability is something that was not given enough consideration early on. Now people are seeing how critical that aspect is and the level of engineering that is involved."

Naval vision

US Naval Air Systems Command (NAVAIR) is working to bring together its LVC domains. The current training solution is focused primarily on VC and its simulators are linked with constructive entities through the Navy Continuous Training Environment (NCTE) network. These Fleet Synthetic Training (FST) events are the first step toward a more robust LVC capability.

The long-term vision for NAVAIR is to enable connectivity at the training ranges. This would link live aircraft with constructive and virtual entities pushed from the ground into the cockpit of the aircraft flying on the range. According to Capt Dorrans, in order for this to become a reality an encrypted training datalink must be developed.

"We link our aircraft on ranges to the ground with our Tactical Combat Training System [TCTS]. That's not an encrypted capability, so the aircraft themselves, other than carrying a pod that shows the position of where they are on the range are not connected. It's not integrated into the airplane. When we develop encryption, which is our follow-on increment – TCTS Increment II – then we'll have the ability to connect the aircraft system to the datalink to the ground and we'll be able to send up VC entities from the ground into the aircraft and vice versa."

A new development called the Naval Aviation Distributed Training Center (NADTC) is under way to provide a centralised hub for NAVAIR simulators to connect to. Connecting simulators in the current "point-to-point" manner has become unwieldy and difficult to control, and the NADTC will alleviate that problem. A prototype of the NADTC has been built in Orlando and has been used for some connected demonstrations.

In fiscal year 2017, the first fleet NADTC will be built at NAS Oceana. The NADTC will provide scheduling for exercises and scenario planning, as well as facilitating connectivity to the hub, distributing and running the scenario and providing the top level debrief. The NCTE network will be used to link NADTC to the various simulators and ultimately to link training ranges to the VC environment. When TCTS Increment II is fielded, it will provide the link from the NCTE located at the ranges to the aircraft itself.

Capt Dorrans said of the path toward full LVC, "NADTC will provide that centralised hub for naval aviation. That's one of the

resources we believe we need to really set up a robust LVC exercise.

"The second is the network itself, the NCTE. And then finally, we need that link that gets from the NCTE at the range out to the aircraft itself. TCTS II will be our initial foray into LVC and then, as requirements are codified, we will determine if TCTS II can be modified to continue to provide that link or whether we need to go down a different path".

He went on to say that, while the initial plan for the NADTC addresses the VC aspects, a longer-term look envisages applications where the NADTC would include the live element where the centralised hub is on the ground at the training range and the aircraft is connected to that hub. "That hasn't been planned out yet as part of NADTC, but I can certainly see that being part of where we expand to. And then we get from VC and LC to an LVC capability. I believe the NADTC will be a major driver for LVC as we connect simulators to training ranges and live aircraft."

From a naval aviation perspective, he estimated that 2020 and beyond is the soonest there is likely to be a full LVC capability that is available for daily fleet use.

One of the most important aspects for future robust LVC capability is the development of standards.

Platform synchronisation

Capt Naylor told *IHS Jane's*, "You've got a lot of people who are working their solution because that's the way these types of challenges are funded. We don't necessarily have a Program Office for LVC. So the F/A-18 people have part of the solution, the P-3 people have part and [so does] the surface ship. Those are all funded via stovepipes of individual platforms because that's the way money comes down. So the real issue is trying to synchronise all that so you get a consistent, coherent product across all platforms."

DMON presents a good example of the benefits of standards. According to Amen, this provides nearly 100% reuse of capabilities. Aldinger further explained that there is a list of requirements that must be met in order for participants to join the network. "We currently support Pacific Air Forces [PACAF] on their live ranges – that's what we interface with. They also implement a standards-based architecture on the live side. Standardised solutions with LVC are essential; otherwise, every time you execute an event, you have to reintegrate everything all over again. When you have a standards-based solution, you do it once and you can go back and train that scenario again two weeks later because you know the state of the systems that are going to be in that event."

USAF: 1635567

Members of a coalition Air Support Operations Center during Exercise 'Coalition Virtual Flag 15-4'.

The DMON will be a key element to pulling in the live aspect, "We're continuing to provide more fidelity and better security, continuing to evolve different sites and working on pulling in navy assets," Amen explained.

A clear definition of the requirements is a necessity for developing the standards and realising full LVC capability. For NAVAIR specifically, an analysis of alternatives and capabilities-based assessments is under way to ultimately determine what the stated requirements for LVC should be. Once the requirements are established PMA-205 will determine what specific training systems are needed to achieve that capability.

The long-term vision for LVC on all fronts is to provide an on-demand, plug-and-play training capability.

Capt Naylor said, "If we could come to a place where we could provide a virtual world that was there 24/7 that you could plug in a one versus one or a battle force versus battle force because that was the training needed at the time, that would really be getting us where we need to go. That is the unified vision that the services have all talked about, but now we're trying to figure out how we really flesh that out." ■

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Comment

There is no question that developing a full LVC capability depends on a robust partnership between government and industry. A great deal of time and effort continues to be directed at solving this training challenge – both on the government side as well as industry. The next few years will probably see ongoing and future efforts resulting in a more robust, fully developed LVC capability.

The path to full capability is also a delicate balancing act, as Capt Dorrans said of the areas of focus going forward, "We have a responsibility to both the warfighter and the taxpayer. So we can't deliver high fidelity at an unlimited cost. Everything has to be balanced between capability and cost and that's no different for LVC. If the objective for LVC is cost avoidance by not having to fly as many aircraft or adversaries and it costs us billions of dollars for that capability, then we haven't achieved our goal."

Industry partners working on LVC solutions share the same sentiments, as Scarnato explained regarding the cost-fidelity balance, "Typically when you increase fidelity it's going to cost more to develop. But the affordability issue is not just the initial acquisition – you have to look at total cost of ownership."