Advanced Multi-Domain Combat Training

What is it? And how can it be done?

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Preface

In this report, I look at the challenges of advanced training facing the U.S. and allied forces.

Advanced training is a key weapon system. It is a crucail tool set to ensure that the force can both distribute and integrate to conduct effective multi-domain operations in a full spectrum crisis management environmet.

Wheat are the challenges?

And how can they be met?

This report highlights discussions with USAF, U.S. Navy and USMC officers as well as with Paul Averna of Cubic Corporation.

Averna provided a detailed look at both the challenges and paths to be followed in meeting those challenges.

As Averna put it: “Understanding how rapidly to integrate and deliver multi-domain effects, particularly when those capabilities are distributed is a critical feature of the needed skill set.

“For the last 20+ years we have had the luxury of conducting operations at will from a persistent sanctuary.

This battlespace sanctuary afforded us the time and space to observe, target, mass effects, and assess results in a manner with little concern for the threat’s ability to disrupt, degrade, or otherwise hold us at risk.

“When facing a peer threat, we will have to consider how to create sanctuaries dynamically in both space and time as a precursor to or in conjunction with our afore mentioned operations. That adversary will work to constrict or pressure the blue side “sanctuary” understood as a maneuver force.”

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Introduction

As my colleague Ed Timperlake often reminds me, the legendary Admiral Arleigh Burke underscored that training started with the core requirement – know your platform. Training clearly must start with ensuring that the warrior knows how to fight effectively from the ground up with the platform he operates from.

But training today, knowing your platform is clearly not enough. What the U.S. military is shaping is a distributed but integratable force. They are taking their resources, dispersing them and operating with a mix and match modular task force capability. Learning to fight with a distributed force is part of the new training challenge. Being able to cross-link platforms within evolving task force packages is another part of the challenge.

In a 2020 interview with Lt. Jonathan Gosselin, a P-8 Weapons and Tactics Instructor at the Maritime Patrol Reconnaissance Weapons School, during my visit to Jax Navy, the challenge of learning cross-platform targeting was highlighted as an example of the new training challenge posed by shaping maritime kill webs. When he first deployed, the P-8 was an anomaly. Now it is deployed to all of the COCOMS worldwide. The P-8 global fleet provides ISR, ASW, and Surface Warfare products to the combatant commanders. In his current position, he serves as an innovation, cross-functional team lead where he works with innovation experts, defense industry, and the Navy to shape projects which are then generated for implementation by industry. He works as well on process changes where advances in TTPs can be enabled as well.

For Lt. Gosselin, at the heart of the effort is really understanding, training for and executing third party targeting. He argued that moving from a stove-piped mentality where one is both the sensor and the shooter, to a kill web perspective where the P-8 could provide the sensors for a firing solution, or whether the P-8 would deliver a weapon provided by another asset to perform the firing solution is at the heart of the change.

In effect, dynamic targeting across a distributed integrated force is the goal. As Lt. Gosselin put it: "We're talking about taking targeting data from one domain and quickly shifting to another, just like that. I have killed a target under sea. I am now going to go ahead and work the surface target and being able to understand the weapon-sensor pairing network and being able to call in fires from different entities using commander's intent to engage the target. That's what we're trying to do. Get our operators to understand that it is not just a one-piece answer. There may be a time when you have to transfer the action to another shooter."

To do so, he is engaging significantly with the Triton squadron as well to shape a way ahead for kill web dynamic targeting. Lt. Gosselin noted: "With the P-8 and Triton we are able to expand our envelope of SA. We can take that and now take the baseline concepts from what the P-3 did and apply them to a more advanced tactics, techniques, and procedures in the form of integrating with the B-21, the B-1, the F-18's, the F-35 joint strike fighter in a dynamic targeting kill web."

And with regard to the cultural shift, this is what he added: "It's important to talk not about how can I defeat this target, but really it should be, how can we defeat this target? Let's break ourselves out of this stovepipe and understand that I may not always be the best shooter. I may be the best sensor, but I'm not be the best shooter."[1]

Another key focus going forward for the joint and coalition force is learning how to leverage flexible basing as a key requirement for distributed integrated operations. For example, with the return of the high-end fight, and the challenge of delivering tailored military capabilities to ensure escalation dominance in the maritime domain, a broadened focus on maneuver warfare in the maritime space has emerged For North Atlantic defense, Second and Sixth fleets are working with

[1] Robbin Laird, "O.K. I am a P-8 Operator: But How do I Train to Work in a Kill Web," *Second Line of Defense* (June 29. 2020), https://sldinfo.com/2020/06/o-k-i-am-a-p-8-operator-but-how-do-i-train-to-work-in-a-kill-web/.

the joint force and allies to shape distributed forces which can integrate to deal with various Russian threats, from the hybrid to the gray zone to high-end warfare.

But distributed operations which can deliver an integrated effect is an art form which requires significant training as well as capabilities to deliver C2 at the tactical edge. But they also provide for connectivity among the pieces on the chessboard to provide for the kind of escalation dominance crisis to full spectrum crisis management. With the development of flexible multi-mission platforms, there is an ability to flex between offensive and defensive operations within the distributed battlespace. It is clearly challenging to operate such a force, delegate decision making at the tactical edge, but still be able to ensure strategic and area wide tactical decision-making.

The strategic thrust of integrating modern systems is to create a grid that can operate in an area as a seamless whole, able to strike or defend simultaneously. This is enabled by the evolution of C2 and ISR systems. By shaping an evolving ISR enabled C2 systems inextricably intertwined with platforms and assets, which provide for kill web integratable forces, an attack and defense enterprise can operate to deter aggressors and adversaries or to conduct successful military operations.

How do you train to do this effectively?

Part of the answer is given by training through exercises and then cycling lessons learned from exercises back into the evolving training regime. But the nature of the systems being built and integrated into the force create another problem. Systems like the F-35 outpace and outreach physical training space. And shaping a kill web approach to cross-linking platforms to deliver the desired crisis management or combat effect needs to be part of training as well. How much do you want to show the adversary in exercises? And if you do not do that training in an exercise, where are you doing so?

Air Marshal (Retired) Geoff Brown put that challenge succinctly in an interview I did with him in 2019. “I believe it’s safe to say it is impossible to deny an adversary entirely of the ability to shape aspects of the information environment, whether it’s through spoofing or sabotaging ICT-based warfighting systems. As a result, our goal should be to sustain military operations in spite of a denied, disrupted, or subverted information environment.”

He underscored the challenge this way: “The requirement is that warfighters need to be able to fight as an integrated whole in and through an increasingly contested and complex battlespace saturated by adversary cyber and information operations. But how to do this so that we are shaping our con-ops but not sharing them with an adversary in advance of operations? The battle for information control needs to drive our training needs much more than it does at the moment. We need to provide warfighters with the right kind of combat learning.”

We then discussed current approaches such as at Red Flag and how we might change the approach to get closer to the kill web capability. “During large-scale exercises like Red Flag, cyber training is often employed in parallel with traditional kinetic training programs and is not fully integrated. Non-cyber war fighters do not necessarily experience the effects of “cyber play” while it is ongoing.

“When cyber effects are integrated into live training events, my experience is that they are often “white carded.” Although this does provide war fighters some insight into how their systems or platforms may be affected in the event of a cyberattack, the lack of realism precludes them from experiencing and subsequently troubleshooting that attack.”

He cautioned that there are good reasons why this is not done. “The integration of these effects into a live training environment could sabotage the other goals of the exercise, present safety risks to war fighters, and reveal platform vulnerabilities to inquisitive adversaries.” In spite of the limitation, “these live training challenges can’t preclude us from training for a future contested and complex battlespace.”

He argued that “We definitely need to train as we fight—so we need to develop tactical level cyber and information effects for simulators and to develop adversary cyber and info effects into our evolving concepts of operations.” In other words, Brown argued that live training remains very significant for organizing a strike and defense force and working the physical

pieces of the task force or air group. But the virtual world is now a key area in which you will shape, work on and exercise your information force concepts of operations.

"One of the foundational assumptions I've always had is that high quality live training is an essential to producing high-quality warfighters but I believe that's changed. Even if you don't take cyber into account and look at an aircraft like an F-35 with an the AESA radar and fusion capabilities, the reality of how we will fight has changed dramatically.

"In the world of mechanically scanned array radars, a 2v 4 was a challenging exercise—now as we have moved more towards AESAs where it is not track while you scan, but its search while track, it's very hard to challenge these aircraft in the live environment. And to be blunt about it, the F-35 and, certainly the F-35 as an integrated force, will only be fully unleashed within classified simulations. This means that we will achieve the best training outcomes for aircraft like the F-35 only if we have a more comprehensive virtual environment."[2]

Another key skill set is to operate in a C2 environment where both the decision at the edge and at the strategic level operate in a very fluid and dynamic way. On the one hand, tactical decision making at the edge is being empowered by new capabilities such as F-35 wolfpacks. On the other hand, C2 at a more strategic level is crucial to shape the deployment (long lead-time) tasks and evaluate overall combat effects.

How do we train to ensure effective decision making at the edge and a strategic level as well?

The C2 and ISR revolution we are now facing is reversing the logic of platforms to infrastructure; it is now about how flexible C2 and available ISR systems can inform the force elements to shape interactive combat operations on the fly. That is, the new capabilities are enabling tactical decision making at the edge and posing real challenges to traditional understandings of how information enables decision making.

It is about learning how to fight effectively at the speed of the network to achieve combat dominance. This obviously requires rethinking considerably the nature of decision making and the viability of the classic notion of the OODA loop. If the machines are fusing data or doing the OO function, then the DA part of the equation becomes transformed, notably if done in terms of decision making at the tactical edge. The decisions at the edge will drive a reshaping of the information about the battlespace because actors at the tactical edge are recreating the information environment itself. In effect, chaos theory becomes a key element of understanding of what C2 at the tactical edge means in terms of the nature of the fleeting information in a distributed combat space itself.

The new C2 and ISR infrastructure enables new warfighting approaches which need to be shaped, exercised and executed, and in turn affect how the forces train for the high-end fight. How indeed do you train these skill sets?

In an interview with Lt. Col. (Retired) "Juice" Newton, a combat veteran, test pilot, and airpower expert, highlighted the nature of the impact of the kill web on skill sets for combat dominance. What is required is the capability to dominate an adversary through distributed engagement. Such a capability allows the blue side to multiply the effects which they can have for the time necessary to gain tactical and strategic advantage over the red side. And by gaining a key advantage, then leveraging that advantage for escalation control and dominance.

For example, by gaining control of spectrum through distributed kill-web engagements a force may freeze the adversary's ability to detect and respond. In other words, that force can blind and dominate that force for critical periods of time.

Mission command guides a diversity of modular task forces which deploy into the areas of interest and provide engagement density. Sensor networks and C2 enable the modular task force to execute its mission and to do assessments to ensure that the

[2] Robbin Laird, "From Legacy Training to Training a Crisis Management Force: 5th Gen and the Kill Web," *Second Line of Defense* (April 4, 2019), https://sldinfo.com/2019/04/from-legacy-training-to-training-a-crisis-management-force-5th-gen-and-the-kill-web/.

mission effect is being achieved. How do you train to shape such an outcome? How do you learn to use the evolving sensor networks, and to make C2 decisions rapidly enough to shape the desired combat effect, and to have rapid battle damage assessment to ensure that they dynamics of the combat situation are working in your advantage?[3]

In short, the challenge of preparing and engaging in full spectrum crisis management requires new skill sets and capabilities. The training challenge is to shape such skill sets and capabilities.

The Perspective of the Former Commander of the 57th Wing, Nellis AFB, on the Training Challenges

I first met Brigadier General, retired, Robert Novotny at RAF Lakenheath in 2016.[4]

There we focused on the coming of the F-35 to the base after the Brits would deploy the aircraft onboard their new class of carriers. We discussed the broader implications of being able to integrate F-35s throughout the region as well.

After that assignment he went to Air Combat Command at Langley AFB and then on to his last assignment which was the command the 57th Wing, Nellis AFB.[5]

As the Wing's website described their focus: "The 57th Wing, as the most diverse wing in the Air Force, provides advanced, realistic, and multi-domain training focused on ensuring dominance through air, space, and cyberspace. The 57th Wing builds innovative leaders in tactics, training and high-end warfighting to ensure world-wide combat air forces are prepared for tomorrow's victories, while overseeing dynamic and challenging flight operations at Nellis Air Force Base, Nevada.

"The 57th Wing is comprised of the United States Air Force Weapons School, 57th Maintenance Group, 57th Operations Group, USAF Aerial Demonstration Squadron (The Thunderbirds), and the USAF Advanced Maintenance and Munitions Operations School (AMMOS)."[6]

In building out a series on multi-mission training, it obviously made good sense to get the perspectives of the recently retired commander of the key training wing in the USAF, notably after having visited PACAF and discussing their focus on reshaping USAF and joint force capabilities in the Pacific.

It is clear that in dealing with the post-land wars focus of the USAF, that advanced training is a key weapon system.

Here is how BG (retired) Novotny put it:

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[3] Ed Timperlake and Robbin Laird, "Kill Webs, Engagement Density and Escalation Management," *Defense.info* (April 26, 2021), https://defense.info/re-shaping-defense-security/2021/04/kill-webs-engagement-density-and-escalation-management/.

[4] Robbin Laird, "Synergy and Building Out Extended NATO Defense," *Second Line of Defense* (July 31, 2016), https://sldinfo.com/2016/07/synergy-and-building-out-extended-nato-defense/.

[5] Robbin Laird, "Bringing the Future Forward: Accelerating U.S. and Allied Combat Power," Second Line of Defence (November 15, 2017), https://sldinfo.com/2017/11/bringing-the-future-forward-accelerating-u-s-and-allied-combat-power/.

[6] https://www.nellis.af.mil/About/Fact-Sheets/Display/Article/284155/57th-wing/.

"I think the good news is that the Air Force does find significant value in training. We find it not only significant in the virtual world, the war gaming world, but in particular, in the live fly scenario. There we put all of the relevant assets together in a formation, and we stress the human being component within the combat force. How does the air combat force integrate and operate and communicate in that kind of environment where there's so many platforms and so many weapons systems?

C2 is clearly a key weapon system when working complex multi-mission combat integration.

Novotny put it this way: "How do we ensure that the communication architecture can do what we need it to do? How survivable is it when we stress it? Nellis and the 57th Wing are the crown jewel of the USAF for all testing and training. And I think you've seen in the last year, even the last two years, the explosion of the colored flags scenarios to broaden how we train as well."

He then discussed the expansion of the training envelope as seen from the evolution of the training flag exercises. "Red Flag is a large force training exercises built upon some of our failures in Vietnam and is designed to get that young airman into those stressful situations, communicating mission planning, exercising, communicating debriefing in package formations that we think we might use against a conventional threat.

"Then we've created Green Flag, which is more focused on air-to-ground integration with our partners at the National Training Center and the Joint Readiness Training Center, both at Fort Irwin and in Fort Polk.

"But now you see the Orange Flag series of exercises, which is really an operational test integration scenario. We've been doing those for a long time. We've just finally put a name to them and where we bring yet to be released capabilities and systems and software and data links.

"And we put those systems into what we like to call deep end testing. It is a philosophy of throwing the child into the deep end of the pool and seeing if they swim. Instead of doing an iterative software release where we fly it for 12 months and we get it to near perfection, but never really stress it. And then we wind up fielding it to the combat air forces and find out it's really insufficient for what we needed it to be.

"With the Orange Flag approach, we do deep end Orange Flag scenarios. And then I think most recently you've seen the announcement of Black Flag and Emerald Flag, which again are integrated test and training events really focused on getting after the highly contested environment with new and emerging technologies. Do these technologies work the way we want them to?

"From a training perspective, it helps us look over the glare shield into the future. How are we training today? And with these new tools that are coming to a new toolkit, are retraining properly for future warfare for future weapon systems, or do we need to change that?

"Nellis has the right mindset and the right vision. The USAF has the right vision. What we lack is consistent funding and an ability rapidly to upgrade those infrastructures. It is also the case that our weapons systems have out outpaced our current infrastructure.

"For example, I grew up on the Nellis Test and Training Range in the mid-nineties.

"And the threat we trained to was a North Korean MiG-29, who could only shoot me at about 12 nautical miles.

"Now we're trying to train against what could be a J-20 Bravo low to almost zero RCS threat with an advanced electronic attack with surface air missiles that can shoot you at 400 miles. And we don't have enough space. We don't have enough geography to set up those kinds of scenarios.

"As a result, we've moved a lot of stuff to Alaska and even Alaska has significant restrictions while it has more room to try to exercise the systems. And you can only really fly up there predictably for about four to six months. Otherwise, the weather becomes problematic, both on the ground and in the air.

"This means that we are migrating a lot more work into the virtual world, which it is really good for exercising systems and the data links and the communication portfolio, but unfortunately alleviates all of the stress and pressure and that combat tempo of live training that we tried to create when we started Red Flag. The challenge is to find the best ways to combine the two as we train for the evolving challenges of the high-end fight."

The virtual side of training is becoming important as well to train to the evolving threat envelope as well, as both the Blue and Red side add new capabilities.

By modeling a new capability and inserting into the virtual side of live virtual constructive training, the approach is to anticipate how a new red side technological capability changes the combat equation.

We closed by discussing a crucial near to midterm opportunity to ramp up U.S. combat capability.

Whether in the North Atlantic fight involving the Russians or the Pacific fight involving the Chinse, Russians or North Koreans, finding ways to ramp up air-maritime integration is crucial. The U.S. Navy is focusing on ways to fight more effectively as a fleet; the USAF is working on ways to shape a more effective integrated distributed combat force built around fight generation capability.

But why do the US Navy and USAF not train as an integrated force? As Novotny put it, each force faces significant challenges to adapting to the new realities.

"We're consumed by the tyranny of the present. I have to create this many pilots, I have to create this many wingman and flight leads etc. One problem is the constant threat of pilot retention. The never-ending demand signal from Central Command of deploying forces. Reconstituting forces needing our own internal training requirements and more. This is why training jointly, which is the way we're going to fight today and, in the future, seems to be the first thing that falls off the plate, which is maddening.

"I can't tell you how many times that when we do those training exercises, for example, a Valiant Shield or a Northern Edge exercise, we find out how great those training experiences are because of what we learn.

"But then we immediately fall back into our comfort level, which is to train internally because my fleet is so inexperienced. My airplane fleet health is challenged right now. And I have many internal pressures from our own service to meet certain training requirements and checkpoints and due dates, coupled with deployments that I just can't get to a point where I can go do those large joint or coalition training exercise. And that's troubling."

I suggested that one way around the chokepoint of the present is to leverage the coming of the B-21 to the Pacific. Clearly, the B-21 as a weapon system will have its major impact as an air-maritime combat capability. Why not build a training system into the B—21 program now that would shape joint maritime-air operations in the Pacific?

This would not solve all the challenges facing force integration but would be a powerful building block which would drive change immediately when out of the box. And if the new bomber were to operate from Alaska and or Australia then working the Navy's distributed maritime approach with the USAF's approach to agile combat employment would drive significant change from its first appearance in the Pacific.

The Training Challenge Viewed from Second Marine Air Wing

During a July 2021 visit to 2d Marine Aircraft Wing (MAW) I talked with LtCol J. Eric Grunke and LtCol Jessica Hawkins. Grunke just relinquished responsibility to Hawkins for the Marine Aviation Training Systems (MATS) ecosystem within 2d MAW; encompassing all aviation simulators and the necessary infrastructure. There is a MATS Site at each of the major 2d MAW air stations; MCAS Cherry Point, MCAS New River and MCAS Beaufort.

In order to remain America's Force in Readiness, the Marine Corps must continue to adapt as the world changes.

Force Design 2030 is focused on designing the Marine Corps that will be needed 10 years from now.

Major General Michael Cederholm, Commanding General (CG) 2d MAW, emphatically believes that training must evolve exponentially to strengthen the Marines enduring advantages, and allow them to prevail in strategic competition with China or any other nation.

Keeping with this vision, the CG directed the integration of multiple, disparate platform simulators along with command and control (C2) systems to better prepare his force and support II Marine Expeditionary Force missions.

China has fundamentally transformed the operating environment and the Marine Corps must modernize the force and its capabilities in order to continue to deter adversaries.

A key element of the combat learning process is integrating live, virtual, constructive training; a technique that combines simulation with real-world flights and ground maneuver. This technique is a force multiplier when shaping tactics and concepts for new and emerging technology like the F-35.

War gaming is a time-tested element of the planning process for informing a commander of the strengths and weaknesses in an operational plan.

However, advances in modeling, simulation, and workforce integration provide an alternative to the traditional war game.

Commanders that leverage the advancing capabilities in virtual and constructive environments are provided with a dynamic operational environment that truly exercises real time risk and force employment decision making at all levels.

More importantly, it will allow commanders to engage a "thinking" enemy and the associated friction often lacking in a static set of assumptions used by traditional war gamers. Ideally, thereby providing a more accurate assessment of an operational plan's efficacy.

LtCol Grunke's experience in Operation ODYSSEY DAWN (OD) provides an example of the operational plan not playing out to script.

LtCol Grunke was flying Strike Coordination and Reconnaissance (SCAR) sorties in support of the OD, when he had to quickly change mindset and serve as the on-scene commander for an innovative downed pilot recovery effort using a combined flight of Ospreys and Harriers.

The team launched from an amphibious ship to rescue a downed USAF pilot in record time.

His actions were a potential war changing event war game modeling can easily overlook.

Much of my discussion with LtCol Grunke and LtCol Hawkins focused on how to enhance integrated training and increase pilot proficiency against enemy aircraft and weapons systems.

To address the pacing threat, the Marine Corps is evolving and innovating as part of the larger naval expeditionary force.

One theme we discussed is the 2d MAW effort to improve realistic, wing-level training.

One critical step is having real pilots operating in their platform specific simulators (e.g. a qualified Cobra or Harrier pilot flying in the simulators) and integrating with the Marine Aircraft Control Group (MACG) to conduct coordinated missions in support of the exercise scenario.

This concept was recently tested in 2d MAW's COPE JAVELIN exercise.

An April 29, 2021 article by 1stLt Michael Curtis of 2d MAW highlighted the exercise as follows:

"COPE JAVELIN," which took place last month, was a simulation that followed a fictional operational scenario that could easily take place in the real world. Marine aviators from various unites across 2nd Marine Aircraft Wing strapped into flight simulators for different aircraft that were located at different bases across eastern North Carolina.

"They were able to connect across different simulation systems and work together to defend against a fictional enemy force. They communicated with each other and integrated forces in order to accomplish a mission without ever getting into the cockpit of a real aircraft.

"This integration of multiple simulation systems gives Marine pilots and Marine Air Control Group 28 Marines the opportunity to accomplish hard, realistic training without leaving their respective bases and saves a tremendous amount of money in fuel, ordnance, maintenance and various other costs associated with conducting this training in real time.

"The brains of this innovative and unique training is LtCol Eric Grunke, the director of aviation training systems for 2nd MAW. He saw the need to integrate all Marine Air-Ground Task Force assets in a virtual training environment in order to improve aviation combat training.

"Linking [systems] is not new, but we are taking it to a new level by incorporating [command and control Marines] training on their own equipment, and we are using a common scenario developed by the Training Support Center – normally a ground-centric agency."

"Prior to this integration, the command and control Marines of MACG-28 who would be located in the Direct Air Support Center and the Tactical Air Operations Center would run separate simulations with simulated pilots and aircraft.

"Conversely, when a pilot is conducting simulator training, he or she would normally be speaking to a single pilot who would be acting as both the DASC and TAOC.

"While that training is effective, COPE JAVELIN provides additional opportunities to have key roles within the command and control structures manned by Marines who have the requisite skills to act in those specific billets. Normally, two to three integrated systems allow the pilots training in the simulator to conduct realistic communications, albeit with a makeshift TAOC or DASC outside of the simulator.

"Now, they can integrate more than ten simulators that bring together integral parts of the MAW, further allowing the MAW to be more effective in providing the six functions of Marine aviation."[7]

Achieving this level of integration was described by LtCol Grunke as a crawl, walk, then run process.

"The crawl phase was to get a Cobra pilot in their sim and a Harrier pilot in their sim and make sure they share the same visual representation to both fly and see the same terrain. They can then work together in that common operating picture."

"The walk phase is to take that pairing and work with a Joint Terminal Aircraft Controller in their sim to execute a single sortie in the simulator. In that phase we still did not have the MACG (the C2 arm of the wing) fully virtual. They were purely constructive and travel to the various sites to participate. They were sitting in our simulator center just talking on the radio, doing their jobs, but not on their own equipment, and not in their own space."

"The run phase which was seen in COPE JAVELIN was the C2 element at the DASC controlling the close air support assets coming in and out of objective areas on their own gear, while Harrier pilots in their sims and Cobra pilots in their sims participate in the engagement."

"The goal here is to shape readiness at the wing level – Marines must be ready for anything, anywhere, especially when the nation is the least ready."

LtCol Grunke highlighted the focus of effort as follows: "This is a working mission rehearsal.

"What I want to happen is a force-on-force exercise.

"We have a red team acting as the Russian commander; they do as they please with their forces.

"I want to ensure no telegraphing to the blue side of their intentions.

"The Harriers and the other air assets get their targets assigned and then the red force take force-on-force action appropriate to the enemy mission.

"This is how we truly achieve a force-on-force event; where we basically get to see whether our tactics work or not, given our assumptions, as the scenario unfolds."

"They're met with limited success in really achieving a true force-on-force, which is something we'll want to work on for the next time."

A second theme discussed was the challenge of networking individual platform simulators to deliver a more integrated operating space for the training effort.

When I visited Jax Navy, the challenge there is linking MH-60 Romeo with MQ-4C Triton and P-8 simulators, which is crucial as these three platforms operate as an integrated system to deliver a coordinated set of effects.

A similar challenge faces the trainers at 2d MAW.

[7] 1st Lt. Michael Curtis, "Marine Aviators Use On-line Gaming Concept to Enhance Training," (April 29, 2021), https://www.marines.mil/News/News-Display/Article/2589537/marine-aviators-use-online-gaming-concept-to-enhance-training/.

As LtCol Hawkins put it: "We are working to streamline the data flow across not only the different flight simulators, but the other simulation systems as well, in order to run a more effective exercise.

"All of these systems have been developed somewhat independently and speak their own language.

"To work around that problem all the networking information has to run through a Distributed Information System (DIS) bridge which essentially interprets the various coding languages used by each simulation device, processes and converts it into usable language for each to understand.

"With the scale of COPE JAVELIN, the number of virtual and constructive friendly and enemy entities, the DIS bridge can become rapidly overwhelmed."

A third theme discussed was training in the environment where operational plans are intended to be executed.

As LtCol Hawkins underscored: "We need to obtain a more comprehensive visual data base in order to conduct true mission rehearsal exercises.

"All of the different platforms, represented by their own program offices have purchased visual imagery databases based on their own assessed priorities. This has resulted in a disparity between the platforms; they don't all have the same images.

"For example, a MV-22 might be able to go to Northeastern Europe in the simulator but the Harrier may not. The Cobra might be able to go to the Horn of Africa, but another platform might not. These are problems Aviation Training Systems are working through."

A fourth theme discussed was how the training way-ahead will allow warriors to drive innovation beyond traditional war-gaming outputs.

As LtCol Grunke put it: "Instead of war gaming, let's train for a real war.

"Let's get into the areas where we expect to fight, with the actual terrain in a simulator, with the G/ATOR where we think it's going to be, where we think the force is going to launch from, and see how we do.

"There's no reason why we can't do something like that, so long as all the imagery is unified in all the trainers, and we can see the effects of operations from the various simulator locations...."

Training, Skill Sets and the High-End Fight

Training is focused on TTPs, or the Tactics, Techniques and Procedures which the force is being shaped to deliver. But really it can be understood somewhat differently with the shaping of a kill web enabled crisis management force that can scale up through the full spectrum of conflict: what skill sets are crucial to deliver the desired combat or crisis management effect with the distributed integrated force?

How do we measure or assess our ability to deliver the full spectrum of options for the Combatant Commander?

How do we conduct training against the backdrop of a capable adversary and their changing behaviors in a crisis up to and including during the high-end fight?

How to we execute effective decision-making at the proper point of combat effect?

These are all considerations of what needs to be an effective and adaptive training regime for today's combat force.

To understand the nature of those skill sets or proficiencies, I talked recently with Paul Averna from Cubic Mission and Performance Solutions. Averna is an experienced naval aviator who has worked on training systems for many years, and he supports the U.S. Navy and Industry's strategic development and transition of the next generation Synthetic Inject To Live LVC capabilities for the DoD Air Combat Maneuvering Instrumentation (ACMI) systems, an upgrade for US and Coalition partners to train to the High End Fight (his biography is found at the end of this article).

Averna highlighted some key features of the skill sets required for training in the new strategic environment. The first is the team nature of delivering the desired combat effect. According to Averna: "Force capability is taking the key elements of the force and blending them together to deliver the desired effect at the right time and the right level. And to be able to anticipate reactions from the red side, and to evaluate how the red side has been impacted by the combat effect delivered."

The challenge is to not only work proficiently with one's platform but to be able to work in an integrated, coherent, mutually supportive manner in delivering the desired combat effect while staying inside the reactive enemy's ability to respond. The peer fight revolves around the competition to disrupt each side's ability to aggregate, integrate, and deliver effects enabled by secure C2 and ISR networks.

The use of Joint and Coalition exercises as a training venue is a key part as well. The goal of exercises expressed in training is to demonstrate to adversaries the blue sides capabilities to operate effectively in the high-end fight. As Averna put it: "Training is a lever for the combatant commander because he is able to selectively demonstrate that he can deliver effects when and where he wants with a team which is both U.S. and coalition in character.

"Understanding how rapidly to integrate and deliver multi-domain effects, particularly when those capabilities are distributed is a critical feature of the needed skill set. For the last 20+ years we have had the luxury of conducting operations at will from a persistent sanctuary. This battlespace sanctuary afforded us the time and space to observe, target, mass effects, and assess results in a manner with little concern for the threat's ability to disrupt, degrade, or otherwise hold us at risk.

"When facing a peer threat, we will have to consider how to create sanctuaries dynamically in both space and time as a precursor to or in conjunction with our afore mentioned operations. That adversary will work to constrict or pressure the blue side "sanctuary" understood as a maneuver force."

How to aggregate effective force within dynamic sanctuaries? Operating within sanctuaries to be able to generate force to get a desired combat or crisis management effect requires integration of non-kinetic and kinetic capabilities and an ability to operate with resilient and effective C2 and ISR connectivity. A significant part of the fight as the blue side sanctuaries operate as a maneuver force is keeping combat integrity and disrupting the peer competitor's ability to fight while maintaining signature control and superior understanding of the environment.

Another core skill set is to be able to deliver effective dynamic targeting.[8] As Averna put it: "a key challenge for operations in the sanctuary context is to be able to develop effective targeting. The goal here may not be to destroy kinetically , but to disrupt, and disaggregate the adversary's ability to fight. It is not just a classic kill chain; it is dynamic targeting within a kill web."

As Averna highlighted "I may not want to destroy, I may want to just disrupt and degrade him long enough for the crisis management situation to de-escalate. This is a huge problem for lots of the people I've talked to who are still thinking the

[8] Robbin Laird, "The Strategic Shift and Dynamic Targeting: Meeting the Challenge," *Second Line of Defense* (May 28, 2020) https://sldinfo.com/2020/05/the-strategic-shift-and-dynamic-targeting-meeting-the-challenge/.

goal of the kill chain is a kinetic kill. And in an all-out war, I get that. But if we're really talking about is crisis management and controlling the escalation, we need to train for cross domain effects appropriate to control the crisis."

An additional set of required skills is learning how to operate your platform within the context of flexible and agile modular task forces. Rather than working a set piece task force, the platform operator needs to become accustomed to working in almost Lego block-like task forces which may well contain ground, air, space, cyber, and maritime elements to deliver the desired combat or crisis management effect.

As Averna noted: "We are now able to aggregate information from a variety of air, sea, land, and space platforms to give us a better picture of what's going on in the environment and to shape effectively the grand scheme of maneuver and leverage capabilities such as the electronic order of battle that will determine the limits of my operational sanctuary? How quickly can I aggregate capabilities and deliver the desired effect, and then measure whether or not I was successful in delivering that effect?"

Another key skill set is to operate in a C2 environment where both the decision at the edge and at the strategic level operate in a very fluid and dynamic way. On the one hand, tactical decision making at the edge is being empowered by new capabilities such as F-35 wolfpacks. On the other hand, C2 at a more strategic level is crucial to shape the deployment (long lead-time) tasks and evaluate overall combat effects.

How do we train to ensure effective decision making at the edge and a strategic level as well? The C2 and ISR revolution we are now facing is reversing the logic of platforms to infrastructure; it is now about how flexible C2 and available ISR systems can inform the force elements to shape interactive combat operations on the fly. That is, the new capabilities are enabling tactical decision making at the edge and posing real challenges to traditional understandings of how information enables decision making.

It is about learning how to fight effectively at the speed of the network to achieve combat dominance. This obviously requires rethinking considerably the nature of decision making and the viability of the classic notion of the OODA loop. If the machines are fusing data or doing the OO function, then the DA part of the equation becomes transformed, notably if done in terms of decision making at the tactical edge.

The decisions at the edge will drive a reshaping of the information about the battlespace because actors at the tactical edge are recreating the information environment itself. In effect, chaos theory becomes a key element of understanding of what C2 at the tactical edge means in terms of the nature of the fleeting information in a distributed combat space itself.

The new C2 and ISR infrastructure enables new warfighting approaches which need to be shaped, exercised and executed, and in turn affect how the forces train for the high-end fight. **How indeed do you train these skill sets?**

By focusing on the sanctuary concept, Averna explained that C2 operating within a sanctuary or managing several operational sanctuaries is a core capability which needs to be built, trained to, and evolved as well. According to Averna: "Who's going to be the battle commander and be able to have the confidence that they have the full picture of information. In some cases, the F-35 may have better situational awareness than say on the E-2 or the Wedgetail. Who's going to make that call?"

In an interview with Lt. Col. (Retired) "Juice" Newton, a combat veteran, test pilot, and airpower expert, highlighted the nature of the impact of the kill web on skill sets for combat dominance. What is required is the capability to dominate an adversary through distributed engagement. Such a capability allows the blue side to multiply the effects which they can have for the time necessary to gain tactical and strategic advantage over the red side. And by gaining a key advantage, then leveraging that advantage for escalation control and dominance.

For example, by gaining control of spectrum through distributed kill-web engagements a force may freeze the adversary's ability to detect and respond. In other words, that force can blind and dominate that force for critical periods of time.

Mission command guides a diversity of modular task forces which deploy into the areas of interest and provide engagement density. Sensor networks and C2 enable the modular task force to execute its mission and to do assessments to ensure that the mission effect is being achieved. How do you train to shape such an outcome? How do you learn to use the evolving sensor networks, and to make C2 decisions rapidly enough to shape the desired combat effect, and to have rapid battle damage assessment to ensure that they dynamics of the combat situation are working in your advantage?[9]

In short, the challenge of preparing and engaging in full spectrum crisis management requires new skill sets and capabilities. The training challenge is to shape such skill sets and capabilities.

The Shift in Training

Training still proceeds from the core importance of learning to operate your aircraft and to master the core skills required to operate your platform in demanding combat situations.

What is being added is that as the multi-mission capabilities of aircraft expand into multi-domain warfare, the aperture of training needs to expand. And that aperture is wider than what a single or even cross-linked physical training ranges can provide.

Additionally, with the adversary's capabilities to engage the blue side air combat force significantly beyond visual range, accurately replicating those threats is becoming increasingly difficult on training ranges as well.

As the blue side works its own capabilities to fight via kill webs, a wide range of the capabilities being shaped, trained, and forged need to be done so in ways that the red side will not get significant information and knowledge about how the blue side wishes to evolve its cross-domain warfighting capabilities.

As a Weapons School instructor during his time flying the F-14 in the Navy at NAS Fallon, and later at MCAS Yuma as a MAWTS-1 instructor, Averna noted that Top Gun was set up initially to close a performance gap uncovered in the Vietnam War. "When we got to the Vietnam War, we saw a very uneven level of competency from one squadron to another, and we saw some individual aircrew that were extremely successful at the complex environment the Vietnam air battle presented, including the introduction of technology like radar guided missiles and integrated Surface to Air Missile systems.

"With the reliance on Beyond Visual Range (BVR) weapons and tactics, highly perishable Basic Fighter Maneuvering (BFM) skills atrophied, and aircrew were making too many mistakes in maneuvering against more nimble opponents. And as a result, the kill ratio went down dramatically. This led to the formation of Top Gun, to deal with the challenge of the inconsistent proficiency in the fleet aircrews.

"The focus was upon training the trainer. Select individuals who are very competent in their aircraft, but also have the ability to teach, to help their fellow squadron mates learn how to perform in a building block manner to the point where they can go out and be an effective instrument of national policy when it came to the counter air fight.

[9] Ed Timperlake and Robbin Laird, "Kill Webs, Engagement Density and Escalation Management," *Defense.info* (April 26, 2021), https://defense.info/re-shaping-defense-security/2021/04/kill-webs-engagement-density-and-escalation-management/.

"And to complement the new focused Air-to-Air training curriculum, new tools were fielded like the Cubic air combat maneuver instrumentation system, or ACMI system.

"And why was that important? You needed to understand where everybody was in time and space to be able to reconstruct what happened. We each have a different mental image of what we did in a particular environment because we're looking through the heads-up display through the canopy bow out over the nose of the airplane.

"And to the extent that I can turn my head around that perception is good probably up to about 10 miles with a limited number of participants.

"But if I have to keep track of multiple players that are well beyond visual range doing interesting things that I can't directly see, I have a much more difficult time reconstructing what happened. And it's in that, the accuracy of what happened that helps us develop the correct learning points out of that flying event.

"And that's the way that we have trained pilots predominantly from the 70s into the 80s and into the 90s, and that is based on understanding the building blocks that it takes to be able to deliver the right effect for particular missions.

"For example, in an air-to-air syllabus, one would start out with basic fighter maneuvering, learning how to maneuver and max perform my airplane.

"Then one would look at how to max perform my airplane versus an opponent's airplane.

"Then one would start working in sections and learning how to employ as a section, and then as a division against a limited number and then a larger number to an unknown number of potential adversaries.

"We were focusing on the skill sets to work the mission against a relatively unsophisticated threat or a near peer threat, but certainly not one that was capable of meeting us in terms of quality and density of a fight."

What Averna described as the training focus was occurring on a physical range, with adversary aircraft or aggressors flying physically against the blue side. With the impact of both what the blue and red side can operate now, physical ranges are a necessary but not sufficient capability, and the red side is not well represented by flying aircraft like F-5s.

Averna put his assessment this way: "We face a physical range constraint problem, but there's also the challenge of using weapons that we want to use. We don't really want people to know what we're doing with our weapons nor seeing what our tactics are so that we maintain an element of surprise if we need to operate in combat.

"And we have another limitation to our ability today to train well. Even if I was able to find a current contemporary threat system that I might face in a peer fight, I'm not finding it at the local hardware store or the local department store. I'm going to have to acquire it through some means, I might have to decompose it and make sure that I understand all the operating modes on it so that I can present its affects correctly to the aircrew or the team. And that we are interacting the right way in order to defeat it. We don't have that luxury of acquiring those things, they're extremely expensive, very rare when we do get our hands on something like that. So very few people are actually able to work with it."

Expand beyond visual physical ranges are difficult and expensive. Managing training space, ensuring the right kind of training, and getting adequate training time poses the question of resource allocation. How does the DoD and its Collation partners drive down cost and expand capabilities to train effectively?

One way to do so is the arrival of synthetic training systems, which can target training time to the skill set levels of individual pilots. The arrival of adaptive training systems allows for calibration of the training time needed for individual pilots.

Averna explained this capability as follows: Let's say that Pilot A is extremely good at low-level flying, and he doesn't need to spend all that much time in doing a lot to train for this skill. Pilot B on the other hand has problems with speed rush baseline and needs more time for the low altitude training environment.

"Yet the way that we designed the syllabus is that both get the same amount of flying before they get the proficiency check. Where we are going is a recognition that people learn at different rates and people retain skills at different rates.

"By moving to an adaptive training environment, we can target the skill sets which those two different pilots have and can tailor training times to generate the required proficiencies."

In other words, it is about making training more targeted and more effective.

We then discussed the multi-mission challenge for training. Earlier, aircraft were more narrowly focused on mission sets than the new aircraft. Those legacy aircraft would be used for single or a smaller set of missions than later aircraft which are multi-mission focused. The Super Hornet entered the force as a multi-mission aircraft, but the challenge has been to train pilots to be able to switch missions using legacy capabilities.

With the F-35's new sensor packages, data fusion and 360-degree situational awareness expands the pilot's capability to operate in a multi-domain environment. But how to adjust training to be able to maximize this skill set?

These new capabilities impact many facets of the mission, from the way we mission plan, brief, execute, and debrief. Just take a moment to consider a concept such as mutual support between a flight lead and their wingman. This is how Averna highlighted this change: "We've actually started to think differently about concepts like mutual support. If you ask somebody in the early 1990s what's the definition of mutual support, they'd probably say something along the lines of a mile to a mile and a half and 2000 feet of step up or step down. And that was visual mutual support. You're not in the same plane but you're close enough that you could check your lead or your wingman's tail to make sure there was nobody coming up behind them. That was an integral part of your visual scan of the airspace around you.

"Now with F-35 or F-22, mutual support is several miles plus, and the pilots will not see each other's planes visually. If we can appropriately identify the objects and the space in front of us, and we have the ROE to engage, we're going to take those shots well beyond visual range.

"And that's where the main training problem exists. We don't expect to ever get into the kind of dogfights we saw in Vietnam. It's now much more about targeting, shorting, getting the off-board queuing, processing that and figuring out how to stay low observable, and yet maintain that dynamic sanctuary we talked about the last time. It is about training to different mindset and problem set."

We closed by discussing the coming of Live Virtual Construction (LVC) systems to the training effort.

As Averna put it: "When you're dealing with a peer threat and you're dealing with national system capabilities, how many operators are actually aware of those capabilities and how to aggregate those in a rapid manner to fight at the speed of a network?

"The national means such as space-based assets provide information held at high levels of security and, is this information going to be available or not? Are they going to be applied sequentially or not? How I'm going to be able to create the dynamic sanctuary, deliver an effect, assess, and as the sanctuary window closes, because the threats reacting that I can reposition securely and confidently? How do I train to do this?

"Exposure to this level of training is not going to occur on the range but will be put together in a synthetic environment or provided through LVC systems. The LVC environment is the only place that you're going to be able to train in that

environment approximating the physiological and psychological effects in the real world. Because you will not be able to replicate that all live until actual combat starts on night one."

This situation was projected in a 2015 interview we did with the head of N-9 at the time, Rear Admiral Manazir.

The ability to share information between decision-makers and staffs that are not all geographically located, is getting better and better. This allows not only dynamic combat learning but provides greater fidelity to the training process as air wings prepare to deploy.

In the past, we only sent text reports. Now we are sending full motion video. The EA-18G Growler can send actual data back to the warfighting center and say: "We have not seen this signal before, what is it?"

And then the labs can run it through their data libraries and work the problem to ID the signal and send their findings back to the deployed fleet. The F-35s coming to the fleet will add significantly to this process. It is about rapid combat learning in a dynamic warfighting environment. We are shaping the foundation for "learning airplanes" to engage the enemy.

LVC will enable us to train in a more robust environment than we are on our current ranges that are geographically constrained, and currently do not have the full high-end threat replicated. LVC will allow us to train to the full capabilities of our platforms across a variety of security environments and do so without exposing our training process to an interested adversary.[10]

Advanced Training as a Weapon System

Having just returned from the Pacific, it is clear that U.S. forces are focused on shaping combat capabilities for the high-end fight.

And to do so in the context of being able to manage crises and to provide for effective ways to deliver escalation management.

But how do you train to appropriately apply those capabilities consistent with the desired end-state?

And how do you leverage dynamic training to shape decision makers understanding of how rapidly changing capabilities provide options for full spectrum crisis management?

War games provide a snapshot of assumptions that are made about what the Blue Side and Red Side might do; they don't provide effective means to understand how shaping evolving combat capabilities through operations and training can deliver decisive effects not included in the assumptions of war gamers.

As one PACAF officer put it to me during my visit to Hawaii last month: "We operate at the speed of staff but need to work much more rapidly to the speed of the operations themselves."

And leveraging those operations generate the data which captures what actually happened in the real-world interaction between Red and Blue forces and to translate into the synthetic environment to leverage for the kind of combat learning crucial to delivering the desired crisis management or combat effect.

[10] Robbin Laird and Ed Timperlake, "The Sea Services Prepare to Prevail in the Extended Battlespace: An Interview with Rear Admiral Manazir," *Second Line of Defense* (December 15,2015), https://sldinfo.com/2015/12/the-sea-services-prepare-to-prevail-in-the-extended-battlespace-an-interview-with-rear-admiral-manazir/.

Training which leverages operational dynamics is a combat weapon.

Getting better at being able to shape dynamic combat learning provides a tactical and strategic advantage.

I continued my discussions with Paul Averna to understand how this process is underway.

According to Averna: "We're leveraging training to be able to develop better, more responsive effects that accommodate for the dynamic nature of the future fight.

"And being able to shape exercises and training in an area like the Pacific is a lever.

"Exercises are designed, in many respects, to make sure that people can operate their systems as they need to when the time comes.

"That being said, obviously, if you don't train with your systems all that much, you're not going to be proficient and be able to deliver to the capacity that the system could provide and do so in the many creative ways one will need to shape an effective combat force."

In my discussions in Honolulu, a key point that was evident was that finding ways for the fleet to operate much more effectively with the Air Force and to leverage the USMC transformation as a linkage force for both is crucial to get more combat capability from the force we have now.

To do so means cross domain operations, which in turn, are enabled by dynamic, cross domain training.

How to conceptualize what needs to be achieved and how to do so?

What one is trying to achieve with the integrated force are the desired crisis management or combat effects and to do so with dynamic evolving sanctuaries.

The challenge is to work ways to shape exercise and training environments which enable cross-domain capabilities to deliver the desired combat effects within dynamic sanctuaries.

With the operation of several multi-mission platforms, and an ability to reach out to ISR systems like Triton or space-based systems, how does one as a platform operator leverage multi-domain capabilities?

How do I train to do so?

This is how Averna put it: "What you are trying to achieve is analogous to chess as a construct. You are moving capabilities on the chessboard, to maneuver to position yourself for dominance while thinking several moves ahead as well.

"If we are working the ability of the Navy and the Air Force to work together, we are working beyond sequential or parallel operations to integrated operations.

"Traditionally, we going to operate in lanes and de-conflict in time and space so that we can just deliver effects in sequence, or maybe in parallel, but not integrated.

"The Air Force is very heavily focused on fifth gen, even though the preponderance of their CAF aircraft are fourth gen. They view the first night of operations as being one of being all fifth gen environment.

"The Navy, in the meantime, is exactly opposite. It's predominantly a fourth gen force. You're going to have a very limited number of fifth gen platforms, at least until the mid-30s and maybe beyond.

"How you integrate those disparate capabilities together is a key training focus.

" But where do you build that kind of environment?

Where can you train to that kind of capability?

We are largely focused on doing so on exquisite ranges, like the those at Nellis, or the Fallon Training Range, or the JPARC range in Alaska, or the Delamere range in Australia once they can secure it.

"Those are the environments where we traditionally would say, "Okay, we're going to put all that live hardware into the mix here, but we still have that problem that we are emulating the threat and making assumptions about the threat." A lot of the presumptions that we're making may in fact be wrong, or that we're not gaining the right lessons learned out of those training events."

The synthetic environment is a key part of folding in what is learned from operations, to shape ways to understand how to become more effective.

The challenge is that the synthetic world is not up to the level where we need it to be to deliver the desired outcomes.

But it does provide a key pathway to expanding what a platform operator can train to be able to work with capabilities which are not present in a live training environment.

Averna underscored that even though the synthetic training environment is not fully where it can be, it does provide an opportunity for real operators to work through how they would tap into multi-domain capabilities which can explore real options for enhanced combat capability.

"The benefit of LVC actually is in the fact that you're injecting the actual live capabilities into a common synthetic environment.

"Your ability to play out how operational outcomes can vary as one works in an integrated manner with specific assets can be tested by real operators.

"Assumptions that would be made in a war game or replaced by the findings of real operators working in a synthetic environment with diverse platforms to deliver a variety of combat effects.

With regard to training, it is crucial for the operators to understand and know their platforms. The cross-domain integration piece requires experimentation in interacting across the domains to understand where the strengths and weaknesses can be found to deliver the desired combat effect.

He argued that cross-domain learning is not new, but what is new is the level of integrated effects which can be delivered by a truly joint force. He cited his own experiences working at MAWTS-1 where he flew his F-14 and worked with the Marines in training to the six functions of Marine Aviation to include working with the Marine logistical and strike integration approach to achieving those functions.

He argued that such varsity training required "an ability to put all of the pieces together, end to end, where you have a more mature ability to plan effectively, because you understand how all the assets work together, how they don't fit together as much as how they do fit together.

"We can actually provide that kind of capability through LVC to bring in all of the new capabilities that are out there into a cross domain environment."

For example, the USAF is planning to bring the new bomber, the B-21 into the Pacific AOR in the next few years. But the bomber is not simply a platform it is a weapon system.

But to get the full value from the B-21 insertion into the Pacific AOR, there is a clear need to have a training system which trains the air combat force how to integrate the tactical fighters with the new bomber.

There is also a need from the OUTSET to build it's unique capabilities into fleet operations.

Why wait till it arrives to build a training system to shape which combat effects the bomber as an integrated asset could deliver?

Or put another training is a weapon system.

Without an integrated training approach or solution set, the B-21 will be a new platform, not an integrated combat capability for the air-maritime force.

The Three Ts: Training, Tactics, Techniques and Procedures Driving Combat Innovation

Training is becoming an advanced weapon system. So much so that the classic formulation of Tactics, Techniques and Procedures upon which training has been built is expanding to now be informed by advanced training that reshapes tactics, techniques, and procedures for the future fight. Multi-domain training encompassing the synthetic environment with a full role for the digital warriors is becoming a key requirement in shaping a 21st century high-end fighting force able to operate in rapidly changing combat conditions.

In my recent visits to forces stationed in the East Coast of the United States and in the Pacific, finding ways to understand the evolving capabilities of the adversary and weaving those into blue side multi-domain warfighting techniques and approaches is increasingly challenging but also indispensable. Whether a Marine operating from an expeditionary base employing advanced sensors and needing to understand how the adversary operates and thinks, to pilots operating against highly integrated multi-domain systems, the challenge is the same: how to spoof, how to deflect, and how to defeat an evolving adversarial force fielded by a peer competitor.

To understand how to shape such a way ahead, I continued my discussions with Paul Averna of Cubic Corporation on the evolution of advanced training. According to Averna, we need to start with the ability to present a realistic threat environment to our Blue team. To do so requires a significant shift from how we have done training in the past two decades.

Averna: "Previously, we've been able to approximate red capabilities with fairly inexpensive or lower cost solutions. In other words, we haven't had to fly our current blue aircraft against one another to get quality training. We could get by using earlier generation platforms because what we were focused on was training fundamentals of blocking and tackling in the air problem, or the air to surface problem on the physical ranges with the infrastructure that we've had. After executing a rollback phase, we were able to operate from a relatively static sanctuary to deliver effects in the battle space. We're facing a paradigm shift. We have peer competitors that make it very difficult to establish a secure combat sanctuary and to hold that sanctuary for an uncontested period of time to dominate the battlespace.

"When you overlay the geographic challenges in the Pacific, it becomes a much more challenging problem. We can solve some of that by prepositioning. And we're talking about the doctrinal concepts that the Marine Corps is espousing to get forward and to be able to deliver ISR and kinetic effects from a dynamic sanctuary. That's the direction that we're going.

"How do you bring a relevant threat emulation to the training environment so that we can be confident that the tactics, techniques, and procedures we are training to can deliver the right solution in a timely manner?"

I pointed out that with the kinds of mission data we are collecting with systems like the F-35, it is important to be able to translate that information into training usable simulated capabilities as well.

Averna underscored how important such an effort is to shape a more effective force. "We're collecting some interesting information. But how does that translate into the emulation of the dynamic threat environment that we are facing?"

There is also the question of the evolution of software within both the Blue and Red systems and the challenge of then translating those changes into a simulated training environment as well.

Averna added: "The systems that we're able to put into place have traditionally been singular emulators of a specific system without the ability to rapidly update those system's capabilities. When software changes are made to the threat system, we don't have that corresponding ability to rapidly update and emulate the new techniques which can leverage those software changes."

The question of evolving technologies is one part of the equation. But the other is understanding of how various peer adversaries use their equipment or how their TTPs are evolving as well.

Averna underscored how significant this challenge was and how the training environment needs to change to deal with this challenge. "The way that we have built our emulation of the peer threat to date is not something that translates forward because of the rapid nature of the Red side's ability to change their capabilities combined with the quantities of specific advanced systems that can be fielded.

"For example, if you have a software defined radio, I can operate a wide variety of waveforms within particular brands, and they will look different. Does our system recognize that it's a different waveform? Those are the kinds of things that we are going to ultimately have to decide. That's new. That requires a different response. We have to have a faster way of doing this for both the blue and red sides.

"Part of the benefit of an effects-based LVC training environment is that you can actually update the models that are used to emulate the threat very quickly. You don't have to have that particular update feature tied to the longer development cycle of an OEM operational flight program that has traditionally had an embedded training capability built into it, which is tied to a longer OFP build cycle. We need to look at how do we update the red side threat presentation better, faster, cheaper than we have traditionally done."

In my view, this is why there is a strategic shift in training required to shape dynamic advanced warfighting. The third T needs to lead the traditional TTPs or perhaps it is AT or Advanced Training driven by integration of the simulated with the live environment with an expanded role for digital warriors within the training enterprise.

Averna: "I just want to revisit that last point that you're making before we talk about how we do the emulation of the red threat. And that is in the TTP definition, the classic acronym, is tactics, techniques, and procedures. But to your point, there should be a training front end highlighted because this actually changes the way that we fight."

We then discussed how LVC can provide new ways to get to the AT led dynamic to shape a way ahead for warfighting. According to Averna: "When you have an LVC training capability where Live, Virtual, and Constructive entities interact in a common synthetic environment, you can actually exercise capabilities, not constrained by the physical ranges, to open up the aperture, and have actual operators evaluating or assessing the impacts of what they're doing in real time, and then debrief what they have learned.

"I can get fidelity on my systems for the beyond visual range fight in an LVC environment. I can have virtual or other live players who are guising as the red threat show up on my systems as they would in combat. And that's the real point where

we need operate. We need to provide pro realism with regard to the red side threat to the operators so that they can actually assess in real time how well they're executing their game plan.

"We will build game plans based on our best knowledge of the threat and our best knowledge of how to employ our systems. But being able to train to that game plan and understand when the game plan is working poorly or proceeding as we intended, that's the essence of high-quality training.

"In terms of training, we need to be able to recognize multi-domain impacts. I don't typically control multi-domain effects on a single 4th Gen tactical platform, although I might be able to, dependent on the classification and capability of a bespoke system. The fifth-gen systems are much more in that multi-domain capability space. But traditionally, in fourth gen you are typically delivering in a singular lane of effect.

"How you recognize those other participants that are delivering multi-domain effects in concert with what you're trying to do traditionally, has been about timing coordination / synchronization. At this point in time, this thing should be turned off, whether kinetically or non-kinetically. And therefore, I will have sanctuary to go in and do what I want to do.

"After a certain period of time, if I can expect them to bring that system back up, and then I'm back into a less than optimum sanctuary consideration, and I have to maneuver or do something different. Those are the type of events where we've driven predominantly onto a time-hack model.

"But when we talk about a dynamic sanctuary, it's about maintaining operational advantage across a window of time. And being able to then assess and apply different techniques to achieve or sustain the desired effect. That's what we want to be able train to."

Another key aspect which LVC brings to advanced training is the ability to use guising as part of working the red side. As Averna explained it: "In the virtual world, there are different protocols of how we exchange data about the participants. We call them entities. An entity can be a platform. It can be a weapon. It can be a sensor. It can be an effect. And each entity has a whole slew of characteristics, or attributes, such as electromagnetic properties.

"And that drives the interaction between someone in a man in a loop simulator, and constructive participant. And we already do this in that we can generate a constructive participant to look like anything we need them to look like. And because of the way that they are built, they will appear across our systems in the virtual world as an intended threat.

"Let's say hypothetically I am an F-15E aircrew in a Tactical Operational Flight Trainer (TOFT) working in a Beyond Visual Range (BVR) training event against a constructive F-16. As I am flying around in the virtual world, I see an F-16 out at range on my systems. Well, that F-16 doesn't exist. It's an entity. And that entity has a whole slew of attributes. And then correspondingly, on my systems I'm going to detect him at a certain range, and I'm going to be able to see him with a variety of sensors at a given range, target aspect, whether he's in full afterburner, or at idle, whether his radar is emitting, etc.

"In my virtual representation of my actual platform, models of sensors, effects, and weapons approximate the real-world capabilities of my aircraft. The radar cross section, as an example, of that F-16 in the real world against a real-world radar. I will see him in a certain range, assuming the atmospherics are nominal and that is when I expect to detect him in the TOFT during the training event.

"What I really want him to look like though is a SU-27. The radar cross section of a SU-27 is different from an F-16. And as a result, I would see him at a different range than I would the actual threat that I'm targeting. Why is that important? From a timeline perspective, the distance and the closing rate matters because it gives me a range of options that I have when I'm going to shoot and how many I'm going to shoot at him at that given range.

"If I can show on my Live blue platform' systems an SU-27 coming at me, a couple things happen. First, I'm getting the realistic engagement, ranges, and profile with him. And that drives how I am going to be able to do tactics well. I have real-world physics being applied on me and my platform that impact my physiological and cognitive performance. There's also that psychological element to it, which is I'm going up against a real bad guy as opposed to somebody that I see as a friendly F-16. That is a very important element of realism.

"The science behind how you change the physical characteristics, the IR properties, the other electro-magnetic emissions of all of the participants, whether they're live, virtual, or constructive, and how you show those altered properties in your system displays for training is what the advanced guising capability is that we've figured out during the SLATE ATD and are improving upon during flight validation event here at Pax River at the end of September as we're having this interview. In essence, we now have the ability to overcome the physical limitations of our current training ranges and deliver the threat environment our operators need for realistic training."

In short, TTPs need to become TTTPs to get to where we need to go with regard to advanced warfighting. In that shift, the training piece expands the role of the digital space and of the role of digital warriors in evolving the warfighting capabilities of a multi-domain blue force facing an evolving red multi-domain force, changing both in terms of technology and in terms of concepts of operations.

Appendix: SLATE

Secure Live Virtual Constructive Advance Training Environment: Air Force Research Lab

The Secure Live Virtual Constructive (LVC) Advanced Training Environment (SLATE) training is filling major training gaps for our pilots.

This Advanced Technology Demonstration was established in March 2015 as a 40-month effort with the specific direction to evaluate critical enabling technologies required to field a live, virtual, and constructive (LVC)-capable training system architecture and structure.

This is a complex AFRL program touching multiple technology areas as well as the Air Combat Command, Air Force Life Cycle Management Center, Secretary of the Air Force, Headquarters Air Force, National Security Agency, Office of the Secretary of Defense, and the United States Navy. Program vendor partners include Cubic Corporation, Boeing, L-3 Technologies, Rickard Consulting Group, Inc., and Massachusetts Institute of Technology-Lincoln Labs.

An LVC capability is seen by many as a potentially cost-effective, realistic and secure approach to satisfying major documented training gaps for air, land, space, multi-service, and multi-national users. The goal of the SLATE ATD is to demonstrate, evaluate, analyze, and report the current technology readiness levels of these 'LVC critical enabling technologies,' so that the USAF requirements and acquisition communities will be informed as LVC capabilities are processed for fielding to the warfighter.[11]

Cubic and SLATE

[11] https://afresearchlab.com/technology/human-performance/secure-live-virtual-constructive-advanced-training-environment/.

Cubic's live, virtual and constructive (LVC) solution is driven by decades of work with aviators from every service. It creates a realistic, cost efficient, dynamic training environment for our nation's military and allied nation allowing the Department of Defense (DoD) and its coalition partners the ability to securely train, test and measure combat readiness like never before.

SLATE Proven. Flight Tested. In Fighter Cockpits Today.

As the industry's leading integrator for the Air Force Research Laboratory (AFRL) Secure LVC Advanced Training Environment (SLATE) Advanced Technology Demonstration (ATD), our cutting-edge technology has demonstrated a fully capable TRL 7 LVC solution for both the F-15 and F/A18 aircraft.

SLATE-ATD recently showcased the integration of live fighter aircraft, man-in-the-loop simulators and hundreds of constructive air and ground entities, in a single training environment, at Nellis Air Force Base, validating the following technologies:

Operational Fleet platforms using modified OFPs, Fleet MITL Simulators and Constructives leveraging existing ACMI infrastructure at LFE scale (validated eight years ahead of DoD roadmap and acquisition plans)

Offboard and pod-borne LVC processor for Tethered and Untethered operations

5G-ATW US Gov't owned LVC datalink ported in podded Software Defined Radio

Multiple independent levels of security (MILS) with NSA certified encryption

Advanced Guising of participants to provide highly realistic training environment

LVC architecture designed for 5th Gen platforms and DoD training networks (DMON / NCTE)

While cost and capacity currently constrain live air combat training, our system delivers a scalable and affordable LVC capability. Its high-fidelity, multi-domain focus accurately challenges warfighters who train in complex kill webs. They can now truly "Train as they fight!"[12]

Gina Marie Giardina, Air Force Research Laboratory

From an October 10, 2018 article published by the AFRL.

WRIGHT-PATTERSON AIR FORCE BASE, Ohio (AFNS) -- The Secure Live Virtual Constructive, Advanced Training Environment, program in the Air Force Research Laboratory's 711th Human Performance Wing, concluded a 40-month effort with a Phase III capstone demonstration in September at Nellis Air Force Base, Nevada.

This final phase, just one of three two-week demonstrations that began in June, showcased live United States Air Force F-15E and U.S. Navy F/A-18/F aircraft; virtual F-16 and F/A-18 simulators; and constructive computer-generated entities within a highly secure virtual environment.

[12] https://www.cubic.com/solutions/training/air-combat/advanced-training-environment.

Figure 1 The Secure Live Virtual Constructive Advanced Training Environment LVC pod is attached to an F-16 with the 64th Aggressor Squadron during an Electromagnetic Interference/Compatibility test at Nellis Air Force Base, Nevada, during Phase I of the demonstr

"This training capability will allow pilots to train like they fight against realistic threats in a secure, high fidelity training environment by combining synthetic and real-world air combat training," explained Dr. Winston "Wink" Bennett, AFRL's 711th HPW technical advisor. "Until the SLATE demonstrations, there were only limited and constrained LVC integrated evaluations. The three Phases of SLATE allowed us to fully demonstrate technical capabilities and alternatives to reduce risk for LVC as a future readiness concept."

Bennett lauded the successful demonstration, but also alluded to future improvements in the training, if necessary.

The team was able to record mission performance and enterprise functional data at a level of quality and quantity that has never been done before, Bennett said. "We were also able to get solid feedback on what works and needs further work in the concept if it is to move forward."

He also spoke of a specific event during the last phase of the demonstration that was particularly exciting for the future of pilot training and LVC.

"One of the things we demonstrated was something we call 'untethered LVC.' What untethered allows us to do is conduct realistic live and constructive training anywhere we need to. This is because the modified aircraft and pods can host and distribute specific scenarios we can program into the pods with or without a range infrastructure," Bennett explained. "Moreover, we were able to demonstrate in Phase III that the untethered mode can supplement their actual live training even if the range infrastructure goes down or air to ground infrastructure slows down. One of the aircraft can serve as the host and the other aircraft as clients, but they can all see and tactically work through the same scenario in real time anywhere."

This Advanced Technology Demonstration was established in March 2015 with the specific direction to evaluate critical enabling technologies required to field a live, virtual and constructive-capable training system architecture and structure.

Figure 2 The live aircraft, such as the one shown on the screen, were able to see and interact with the virtual players like Simones during the demonstration.

"There are two major pieces of SLATE," explained Bennett. "The first is the secure piece – we want to be able to train realistically and not give away the things that make us the best in the world to the bad guys. So it has to be a secure way of transmitting information back and forth. The second major piece is the LVC – live, virtual and constructive. The live aspect is the military members actually flying in their operational airplanes, driving in their operational truck or vehicle on the ground, remotely piloted aircraft – they're using their operational equipment. But we're able to tie that to a virtual environment which is a simulation of that operational equipment. And the constructive environment which is computer generated models and entities that allow us to create realistic threats, realistic bad guys and behaviors that our folks can actually go after."

Although managed from AFRL's 711HPW, SLATE is a Department of Defense program that leverages expertise in other AFRL directorates, Air Combat Command, Air Force Life Cycle Management Center, and the United States Navy, among others.

"For the last 40 months, the team really pushed hard on the 'state of the art' in terms of some key technologies that were needed to make SLATE a successful demonstration," Bennett said.