Fake Data—Real Operations

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ABSTRACT

The problem of Joint All-Domain Command and Control (JADC2) is a data problem. Data from sensors, emitters, and weapons, attached to platforms in all domains, must be collected, categorized, correlated and sent to the right place so that the key decision makers have target-quality data in front of them when they need it. Over the past three years, CAE USA has been directly addressing that problem by repurposing technology developed for aircrew simulator training for Intelligence/Surveillance/Reconnaissance (ISR) platforms to create a cloud-based set of software tools to synthetically generate complex tactical and operational scenarios, complex red and blue forces with automated doctrinally-correct behavior, and the C4ISR data that would come from the collection and C2 assets in large force operations. CAE USA then took this tool set to three different Large Force Exercises (LFEs) focused on the operational process of ISR collection management, targeting, and decision making, identified a series of questions to investigate, and collected data to determine the potential value of this type of tool set. The results indicate that the ability of the US and coalition partners to develop new capabilities, processes, doctrine, and techniques to improve the speed and effectiveness of targeting can be dramatically improved through the use of this technology. This paper will review the development of this tool set, the demonstration of it in several large force exercise, and some improvements to the ISR collection and targeting processes that have resulted.

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C2ISR Problem Statement for Training, Planning, and Mission Rehearsal

On any given day, at any given hour, at several of the world's hotspots, national and NATO reconnaissance units are conducting missions in support of NATO operations. These may be MQ-9s belonging to the US or another NATO member. They may be the NATO Alliance Ground Surveillance RQ-4 platform. They may even be ground troops with tactical sensors tasked to perform operational Intelligence, Surveillance, and Reconnaissance (ISR). But in all these cases the operations crews carrying out those missions would be conducting some level of intelligence exploitation and analysis of the ISR data they collect—a first level of ISR exploitation.

But in most NATO ISR operations, there is a second level of exploitation—a team of intelligence analysts receiving that ISR data in real-time or near-real-time and fusing multiple streams of data from multiple sources to provide a more detailed and actionable intelligence assessment of potential targets, threats, and other entities in the battlespace. This analysis and production of intelligence products would likely be part of a "Federated" Processing, Exploitation, and Dissemination (PED) operation whereby any of the PED cells allocated to the NATO Joint Task Force (JTF) by member nations can be tasked by alliance to exploit data from any ISR sensor—regardless of nation or domain (Thiele, 2018). And beyond the intelligence assessment, the data would move downstream to drive a targeting decision, and then provide operational and tactical Command and Control (C2) guidance to the tactical units that will ultimately act on the decision—whether it is to engage with weapons, non-kinetic action, or continued ISR collection.

The ability to exploit the data from any sensor—in any domain—and drive a joint targeting decision at the operational level, is at the heart of the Joint All-Domain Command and Control (JADC2) problem. And while the technical means to collect and distribute that data is one aspect of the problem, the deployment and employment of a ready C2 team proficient in the Tactics, Techniques, and Procedures (TTPs) to conduct rapid targeting is perhaps a more significant aspect. NATO expects this problem to be solved by the nations. In fact, it expects that contributing nations will provide C2ISR personnel who are trained by the nations—in accordance with NATO standards—who are ready to commence operations on the first day they are tasked (Haider, 2015).

While there have been a number of NATO Standardization Agreements on C2ISR training tasks and standards—and in stark contrast to other training problems such as that for aircrew or ground forces training—there is no standard NATO or member nation JADC2-oriented training capability identified to achieve this state of readiness. In fact, across the alliance, C2ISR training is characterized by a lack of any dedicated training capability at all.

Since 2017, CAE USA Inc. has endeavoured to address this gap by drawing on previous investments in training for ISR collection platforms to create a dedicated training capability for ISR PED analysts, targeteers, and other downstream users of C2ISR data. This paper will review the training problem faced by NATO C2ISR professionals, describe the development and fielding effort for the CAE solution, recount CAE's participate in several Large Force Exercises (LFEs), and provide some recommendations to improve future JADC2 training across the alliance.

Alliance C2ISR and the Synthetic Data Gap

A fundamental premise of NATO operations is that forces contributed by member nations comply with the agreed-upon NATO standards and that those forces will not require extensive support, training, or other enablers to carry out their assigned missions. And to a point, the NATO allies have been successful at contributing trained intelligence analysts, targeteers, and planners to NATO operations—either in the form of augmenting personnel for NATO headquarters and command centers, or entire C2ISR units allocated to NATO operations. In the cases of NATO combat operations in the last twenty years—from Kosovo, to Libya, to Afghanistan—NATO targeting has been sufficiently effective to achieve operational and tactical objectives. The tactical success of the operations being the main evidence.

However there continue to be long-standing gaps in C2ISR manning and skill sets of available personnel. For example, during Operational Allied Force in Kosovo, it typically took the joint team 3-4 hours to prosecute a target from initial detection to weapons delivery—due to both a slow target identification and approval process as well as a lack of proficiency in the coalition targeting process. As noted by a RAND study after the conflict, "One realization driven home by these and other shortcomings was the need for planners in the targeting cell to train together routinely in peacetime before a contingency requires them to react at peak efficiency from the very start." (Lambeth, 2001)

Thirteen years later, during Operation Unified Protector, challenges remained. Participants in that operation noted that to carry effective targeting inside the Combined Air and Space Operations Center (CAOC) in Italy—a C2 center intended to provide a standing capability to conduct operations—required "…major augmentation of US personnel—specifically targeting specialists…" (JCOA, 2011). Another participant observed that NATO personnel working the CAOC targeting functions "…had no experience, training, or qualifications to do so." (Greenleaf, 2013)

To provide additional intelligence, analysis, and targeting skills and expertise to NATO member nations, NATO has set up various training courses at different venues. These courses, such as the N2-02 NATO Intelligence Course, or the N3-17 NATO Joint Targeting Staff Course—both at the NATO School in Oberammergau, Germany—provide a combination of classroom and simulation-based training to establish core intelligence skills. However courses like this are limited in scope, duration, and capacity (courses are typically one week long), and cannot provide the entirety of skills need, knowledge, and experience for an individual analyst or targeteer to function effectively at a NATO-supporting intelligence or C2 center. That burden still falls on the member nations.

Within those member nations, skills development for intelligence analysis and targeting to support tactical operations is still done mostly via on-the-job training—even for those nations with the largest intelligence enterprises. For example, in the US, despite an extensive course at the Intelligence Technical school to provide the initial intelligence skill set, the United States Air Force (USAF) relies extensively on On-the-Job Training (OJT) to bring an analyst student from apprentice status to full qualification. Likewise, inexperienced analysts have very few opportunities to participate in Large Force Exercises (LFEs) to gain the experience needed.

To further examine the USAF as an example, there are 22 intelligence positions in a USAF Distributed Common Ground Station (DCGS), each with their own position-specific training tasks applicable across the entire spectrum of conflict. But since the USAF or NATO as a whole lacks an intelligence-dedicated mission training simulator akin to aircrew simulators for all airborne platforms, there is no specific technology dedicated to training each of those positions.

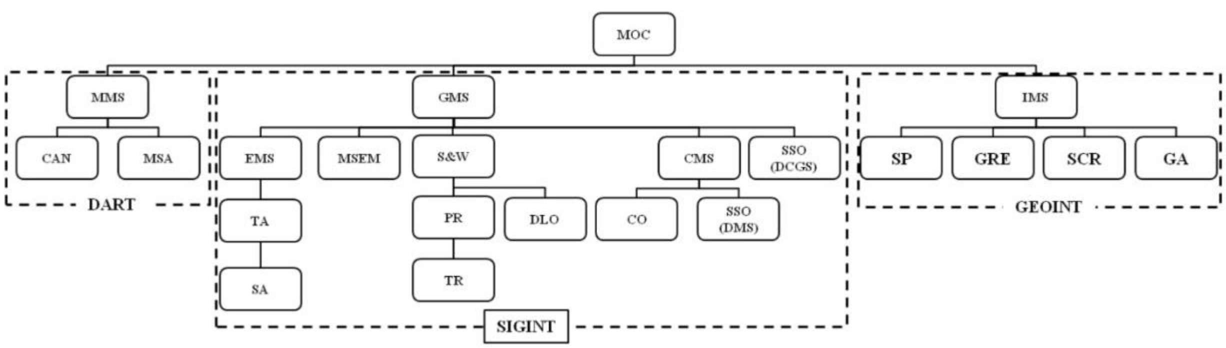


Figure 1: USAF DCGS Intelligence Crew Positions

Considering the breadth and depth of the NATO Coalition C2ISR enterprise, and the current distributed nature of NATO operations, creating new stand-alone training solutions is not the answer. The USAF alone has 27 DCGSs and over 5,000 analysts assigned to them. The embedded and institutionalized nature of OJT would also make it difficult to change to a completely different approach to operational training.

In 2016, a development team at CAE USA, Link Training & Simulation saw this as an opportunity to leverage off-the-shelf capability from other programs to create a new dedicated training capability for analysts, targeteers, and other downstream users of C2ISR data who work on a network. This system was initially called Virtual ISR, and now is known as the Virtual ISR Training Application (VISTA).

VISTA to Generate Synthetic Data

The CAE team had significant virtual training capability available to address the problem. Over the years, large investments have been made in developing high-fidelity ISR sensor simulation capability as part of aircraft tactical flight and mission training. The MQ-9 Mission Training System (MTS) is a primary example.

In the MQ-9 cockpit, the Pilot and the Sensor Operator must work together to not only maneuver and position the aircraft, but to employ the sensors on board the aircraft to achieve the desired effects and collect the required ISR data. Typical MQ-9 sensor flown by NATO members include Electro-Optical, Infrared (both near- and short-wave), low light, Synthetic Aperture Radar, Ground Moving Target Indication, and even some signals intelligence. To effectively employ these sensors, the Sensor Operator of the MQ-9 must be able to train to full manual control of each sensor and be able to maximize the quality of ISR data. To do that, it was necessary developed a series of high-fidelity sensor simulation modules to incorporate them into the MQ-9 mission simulation. Figure 2 below provides some examples.

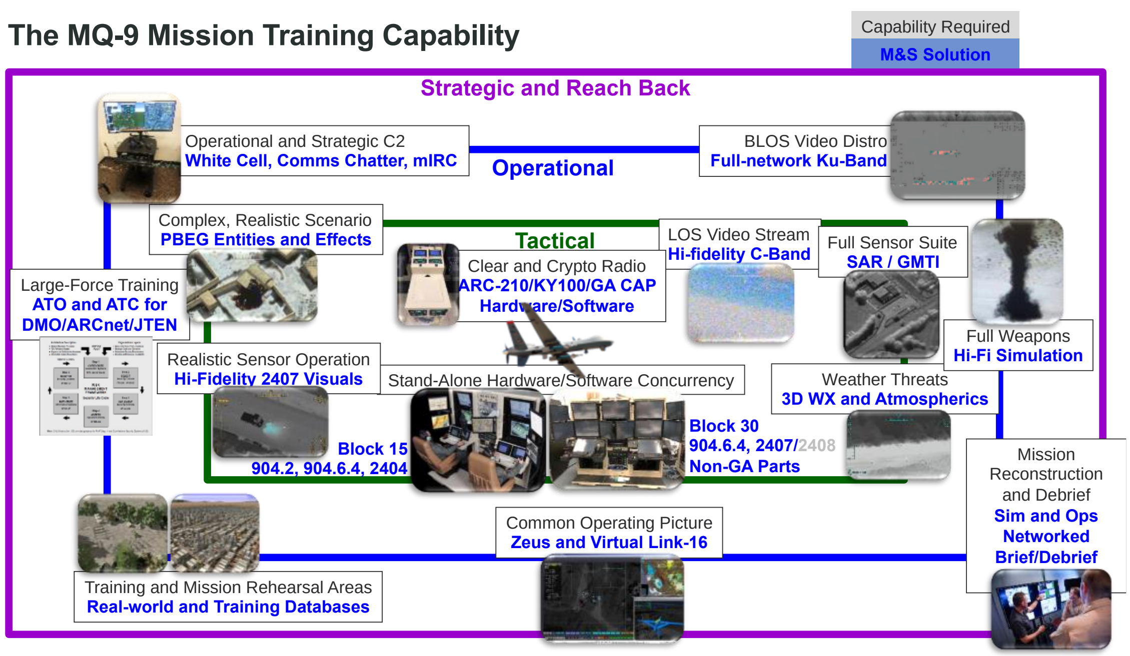


Figure 2: M&S Capability to Leverage from the MQ-9 Mission Training System

In addition to the sensor models, the CAE team also drew upon both internally-developed and commercially available tools to create both the physics based virtual environment for tactical training events, but the joint and coalition forces as well as the targets that could be represented in simulations. The idea was to enable ISR instructors to create the same dynamic scenarios—to be scripted ahead of time or adjusted dynamically in real time—that aircrew have taken for granted for many years. Rather than be dependent on live mission data flowing into their network from live ISR collection platforms—and therefore being limited to the missions those assets happen to be flying—C2ISR students and instructors should be able to create their own complex scenarios to meet their own training objectives.

To do this, the CAE team incorporated existing imagery/scene generation tools as wells as a Semi-Automated Forces system capability of creating whatever ISR collection platforms, red and blue forces, targets, weather conditions, and terrain needed for any training scenario. This technology also provides a high level of terrain and atmospheric fidelity so that Infrared, Synthetic-Aperture Radar (SAR), and highly level imagery would appear correct and realistic so that students can train to target recognition and analysis as they would with live imagery.

Scalability and Modularity

The solution also needed to scale to operational networks and avoid the cost and limitations of stand-alone training systems. The CAE team therefore incorporated cybersecurity and network standards compliance into the VISTA system. This enables the system to connect to operational networks (at any level of classification) and also to interface with other modeling and simulation systems for integrated network training. Sensor simulation modules produce the embedded sensor data along with raw imagery or Ground Moving Target Indictor (GMTI) dots. This means that when the VISTA is connected to an operational network, the data it produces can be processed and manipulated by existing operational tools as if it were live data. ISR students can therefore train on their operational systems with no need to switch to a more limited training system.

The result is a scalable, cost-effective solution that enables the entire Task/Collect/Process/Exploit/Disseminate (TCPED) and Command, Control, Communications, Computers (C4) ISR training audiences to create their own scenarios, train to their specific individual or team training objectives, connect with other virtual training systems (air, space, ground, maritime, or cyber), and dramatically increase the flexibility, fidelity, and capacity or their OJT and exercise training. Figure 3 below shows an overview of this training approach.

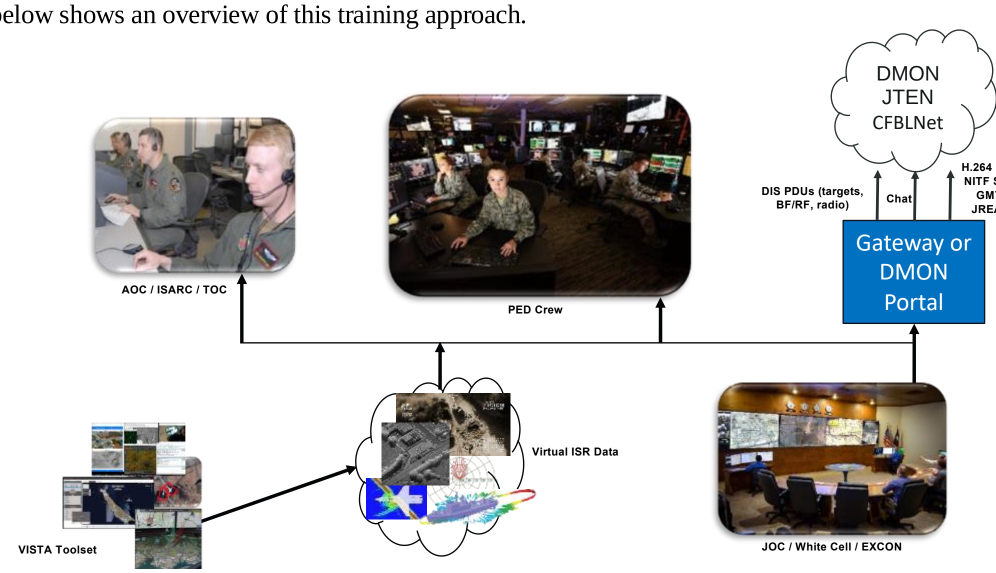


Figure 3: Operational View of the Virtual C2ISR Training Concept

Interoperability, Exportability, and Cyber Compliance

The VISTA was designed with exportability and interoperability in mind. For the later, the team ensured that all virtual ISR data produced by the system was not only standardization agreement (STANAG) compliant in the same manner as live ISR data, but that the data and meta-data format of those feeds matches live data in every possible way. For example, the full motion video produced by virtual assets like the MQ-9 or MC-12 are produced and streamed in the same H.264 format as live video. Likewise the SAR images are produced in National Imagery Transmission Format (NITF) used by the NATO AGS RQ-4 and other STANAG-compliant formats. GMTI data is provided in the STANAG 4607 standard format. VISTA then creates Joint Range Extension Applications Protocol (JREAP) messages for all Blue Force and student-identified Red Force/Target entities in the scenario. This enables the training audience to create and manipulate a tactical datalink picture on their operational network to increase training realism.

To receive approval by the US State Department to export the system for demonstration and testing purposes, and to obviate any releasability issues of the virtual ISR sensor data to NATO nations, the VISTA team opted to create their databases using commercially available source data rather than DoD imagery. They then applied the same processed used on flight simulator programs to combine that commercial imagery with commercially-available Digital Terrain Elevation Data (DTED) and create high-fidelity 3D databases of various geographic locations for use in training scenarios. This ensured that not only was any data easily released to NATO nations, but that nearly any place on earth could be built up as a training area to meet the intel training objectives of NATO and its member nations.

The VISTA team applied the same cyber compliance approach to VISTA that has been used for other networkable training systems. This included documentation of system architecture, hardware and software components, network connection protocols, the use of firewalls where needed, and a process to ensure all the most recent software patches were in place. They also conducted initial and ongoing virus and cyber-vulnerability scans to ensure there were no critical or serious cyber vulnerabilities. This documentation was provided to the cyber compliance office of the Headquarters USAF staff for training systems, who reviewed the documentation and then granted an Authority to Test certification.

This gave the VISTA team the authority to connect the VISTA system to government and coalition operational networks for testing and development purposes.

Synthetic Data Across the Spectrum

To capture the full range of NATO operations and produce constructive representations of possible C2ISR assets that could become part of NATO operations, it was necessary to identify all needed STANAG-compliant data types and add them as VISTA sensor models. VISTA is able to represent up to 6 ISR assets with imagery streams, of Full Motion Video (FMV), still imagery, and SAR images. VISTA is also able to create up to 6 ISR platforms producing Electronic Intelligence (ELINT) data, GMTI, and JREAP targeting messages. The key to the simulation is in the sensor models. Different kinds of sensors require dramatically different models and the data must comply with NATO standards (Standardization Agreements – STANAGs) for format and presentation. For example, video sensors, be they sensitive to visible or infrared energy, must comply with NATO STANAG 4609. While these STANAGs are often considered to be legacy capabilities, future XML versions of the data formats using common data elements may be developed and can then be incorporated into synthetic data production.

Streaming sensors

A number of sensors provide data in a streaming format. That defines sensors that have no defined end to the data. The data can continue as long as the sensor is operating. Streaming sensors have different data formats based on the nature of the sensor.

1. Full Motion Video: These sensors produce data in accordance with STANAG 4609, which is based on the commercial digital video standards, but has enhanced metadata to meet military requirements.
2. Ground Moving Target Indications: GMTI data is produced usually by radar systems, but in a few cases, optical systems have been adapted to produce the GMTI information. The output stream is formatted in accordance with STANAG 4607. If the data is processed into tracking data with tracks for discrete targets, the ISR ground tracking data is in accordance with STANAG 4676.
3. LINK-16 targets: Air data is generally passed between aircraft and the ground, as well as aircraft to aircraft using STANAG 5516. This data includes many different operational messages, but air tracking is one of the many messages and is used for many purposes.
4. GMTI sensor: GMTI sensors produce detections of moving objects on the surface and output a stream of “dots” – individual target detections in the form of metadata including the location, radial velocity return signal strength, and with some sensors additional information such as double doppler as received from tracked vehicles, or high doppler such as would be received from helicopter rotor blades. The data should conform to STANAG 4607, and for sensors that process the data beyond basic detections, JREAP messages.
5. ELINT sensor: Signals intelligence sensor detections are distributed using LINK-16 messages, but the current concept for cooperative SIGINT collection is called Cooperative Electronic Support Measures (ESM) Operations (CESMO). This involves the sensor data from multiple sensors being collected in a single processor which uses the multiple lines of bearing to refine the error ellipses associated with SIGINT detections to much greater precision. This data is also disseminated and uses STANAG 4658. (Note that the single processing node can easily be shifted from node to node within the SIGINT network.)

Framing sensors

Classic imaging sensors have been the mainstay of intelligence collection since the conception of aerial reconnaissance. These sensors produce an image of defined size and shape, and in the digital world are typically transferred as complete files. STANAG 4545, the NATO Secondary Image Format, provides the structure of the files. STANAG 4545 is essentially identical to the US NITF format, with the exception that the file type field (first field in the file) is “NITF” for the US format, and “NSIF” for NATO, and the second field, the file version is “02.10” for NITF and “01.00” for NATO. The only other distinction between the two is that the US allows many more extensions than NATO does. While this does not make the files incompatible – the file is structure to allow the user to skip extensions that they do not want or understand – it does in some way reduce the interoperability of the files. There are a number of sensors that produce frames of imagery including electro-optical, multi-spectral, SAR (strip, scan, spot, and polarimetric imaging), and LIDAR. All are included in STANAG 4545.

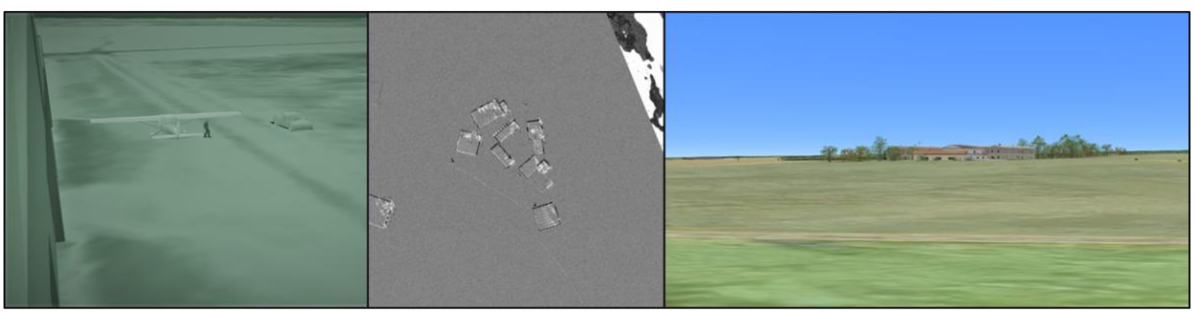
Synthetic Data in Large Force Exercises

To date, there have been three operational assessments of this capability in NATO-oriented LFEs—Bold Quest 21.2 being the most recent. The Bold Quest series exercises are specifically aimed to demonstrate JADC2 capability, with a focus on achieving data-centricity in the targeting process. According to Stuart Whitehead, Deputy Director-South, US Department of Defense Joint Staff J6 (the sponsors of Bold Quest), through LFEs like Bold Quest stakeholders have: "…learned quite a bit about datacentricity through the practical activities…" (Seffers, 2021). But it is typically difficult to assemble sufficient live C2ISR assets as such exercises to provide all the needed data to stimulate the targeting process of an entire NATO Joint Task Force.

The scenario-based, synthetic data capability can therefore be a key enabler to the development of JADC2 concepts and TTPs, and provide the C2ISR audience the opportunity to exercise the targeting cycle in an intensive way. For the Bold Quest 21.2 exercise, a VISTA system was brought to the Muscatatuck Urban Training Center in Indiana, connected to the Bold Quest NATO-SECRET mission network, and configured to provide a number of virtual C2ISR platforms such E-3 AWACS, MQ-9, P-8, and RQ-4. Figure 4 shows the setup of the control terminal.

Figure 4: VISTA Setup for Large Force Exercises

The Bold Quest and Unified Vision exercises have also called for additional sensor replication, such as Unattended Ground Sensors or Closed Circuit TV (CCTV) cameras to replicate civil support elements. The VISTA team has been able to create these virtual sensors as needed and place them in the same simulated environment as the other blue forces and targets. Figure 5 below shows some imagery examples from these efforts.



CCTV Images | SAR Images with GMTI | Unattended Ground Sensor (MASINT) Images

Figure 5: VISTA Sensor Examples from UV18

Large Force Exercises (LFE) and the Sensor-to-Shooter Drill

A key series of events in a recent DoD-hosted LFE (Bold Quest 20.2) involved a *Sensor-to-Shooter* Drill which ran through the entire targeting process to in order to develop streamlined TTPs for a faster response time. This included the integration of intelligence exploitation, operational targeting and decision-making, providing directions to a tactical layer of C2, cuing a tactical element such as artillery, and finally assessing the effectiveness of the engagement.

This full targeting process however requires a number of elements to be conducted live—including live shooters and live targets. It also requires the integration of operational-level C2ISR assets to generate the ISR data needed to drive the process (Thatcher, 2021). But in the case of Bold Quest, those assets were very limited. It was therefore necessary to generate those assets virtually via VISTA, and create the streaming synthetic data in lieu of live assets. For the LFE drills, the mission network was real. The intelligence exploitation crew, the targeteers, and the tactical C2 element, all consisted of live military players. Even the shooter was real—in the form of live artillery firing on the Muscatatuck range at the directed targets.

But the target, the ISR collection assets, and the data were virtual, generated by VISTA. This included a virtual RQ-4 and manned ISR asset to generate the imagery of the virtual target. Both streaming and framing sensor data, as well as Link-16 and GMTI, were streamed onto the mission network for exploitation and targeting purposes. And ultimately the live artillery fired at the virtual target imposed on the live range. Then the effects of the target were verified via virtual Battle Damage Assessment (BDA) from those same virtual ISR assets.

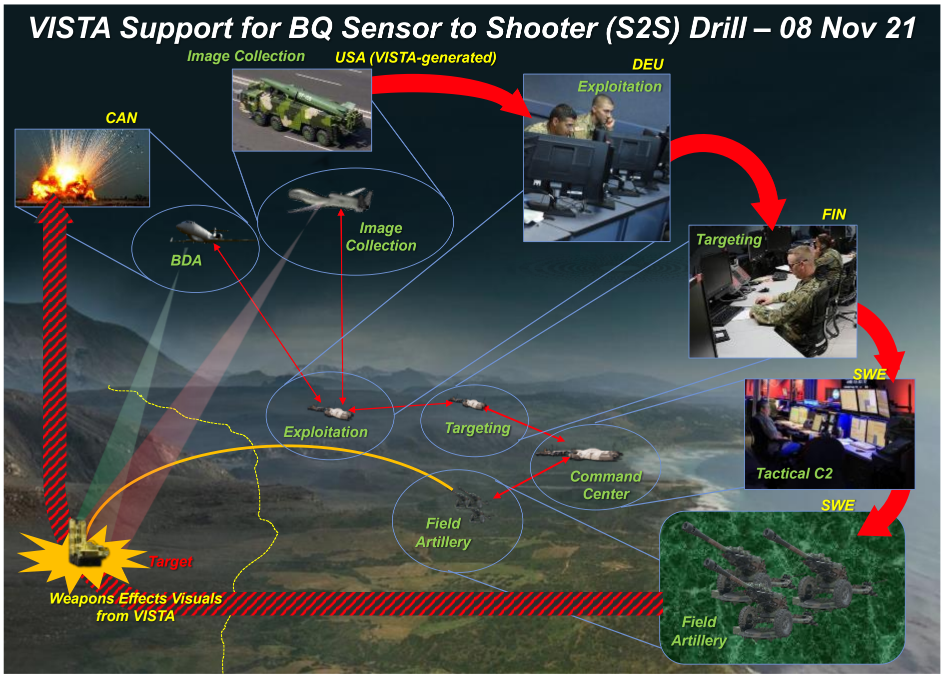


Figure 5: The LFE Sensor-to-Shooter Drill

Synthetic Data Benefits

The most obvious result of VISTA integration in LFEs and the Sensor-to-Shooter drills was the ability to stimulate the entire JTF ISR Collection Management, targeting, and C2 network in absence of sufficient live fly capacity—to include the actual ISR data needed for intel analysts to perform their roles in a complex joint environment. The fact that the data could be streamed to all players with no limitations on capacity further enabled the exercise team to run multiple vignettes and Techniques, Tactics and Procedures (TTP) tests, and ensure that all PED players were sufficiently engaged to gain value from the exercise.

Other benefits observed by the VISTA team included:

- The ability to change, in real time, the scenario inputs, virtual sensors, Red Force actions, target characteristics, and scenario pacing in a way that would be much more difficult using live assets
- The ability to represent a much larger and more variety Red Force order or battle than would be possible using live Red Force players
- The ability to show both the positive of negative outcomes of Blue Force targeting decisions
- The ability to provide focused scenario inputs to each component, unit, and even individual to meet their specific training and testing objectives
- Greater situational awareness for the exercise management team to know the difference between “sim truth” and Blue Force perception of the tactical situation

- Integration with all three operational networks used in the exercise (Mission Network, BICES, and CFBLNet) which enabled proliferation of the data for all live players and also into the CSDs
- The potential to conduct distributed LFEs reducing the need for and cost of travel

Specifically for Sensor-to-Shooter, the targeting team assembled for the exercise was able to conduct repeated, intensive, rehearsal sessions of the targeting process—with remarkable results. Since this process was highly procedural in nature, with multiple individuals required to perform each step in the process, their initial lack of proficiency led to a lengthy overall targeting cycle. But through multiple iterations, the team was able to improve their skills and speed up their response. Figure 6 below shows the decrease in time required to go from initial detection, through target identification, targeting decision, cueing of tactical C2, shooter engagement, and BDA over multiple practice sessions.

Iteration	1	2	3	4	5
Detection-to-BDA Time	2.2 hours	1.7 hours	1.3 hours	55 minutes	47 minutes
% Time Reduction from 1	0%	23%	41%	59%	64%

Table 1: Improved Performance on the Sensor-to-Shooter Drill

Individual and Team Training Benefits

These exercises also demonstrated the potential for individualized intel analyst training during where sufficient data capacity is provided. Figure 7 below shows an example of an intelligence product built by one of the analysts participating in the exercise to meet an individual training objective. Other examples include Intelligence Summaries built from multiple VISTA data streams, specific assessments made from VISTA full motion video and SAR images, as well as activity rollups from exploitation for multi-hour activity monitoring using the VISTA-generated virtual MQ-9s.

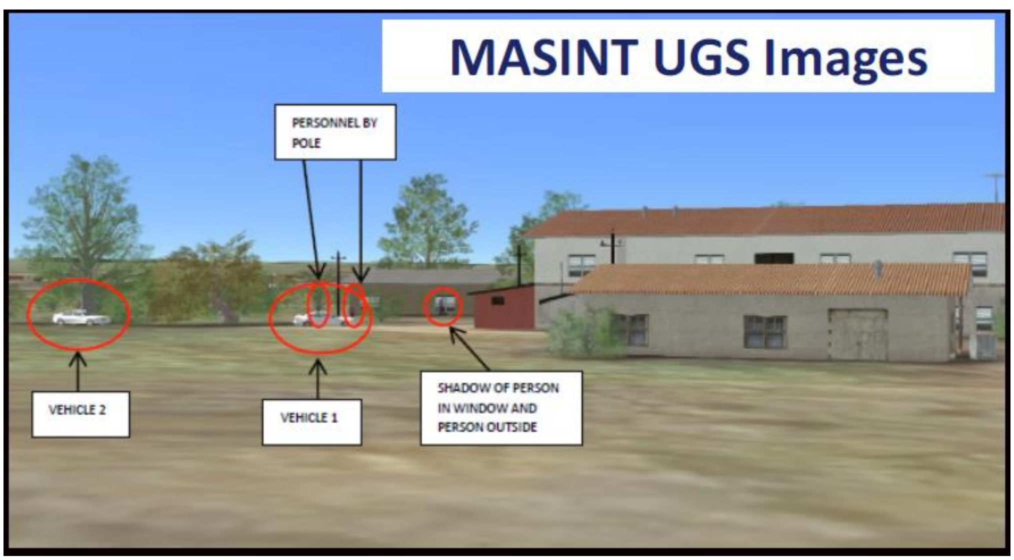


Figure 6: Example Intelligence Product Built for Individual Training Using VISTA data

This type of data-centric approach, with its ability to generate the full spectrum of synthetic C2ISR data and stimulate any needed software tools, provides for any training, mission rehearsal, or operational assessment experience needed by C2ISR operators. A full range of support can be provided for individualized training to meet specific training objectives, through LFE exercises as demonstrated in Bold Quest 21.2. Figure 8 below depicts an example individualized training experience for an intelligence analyst student.

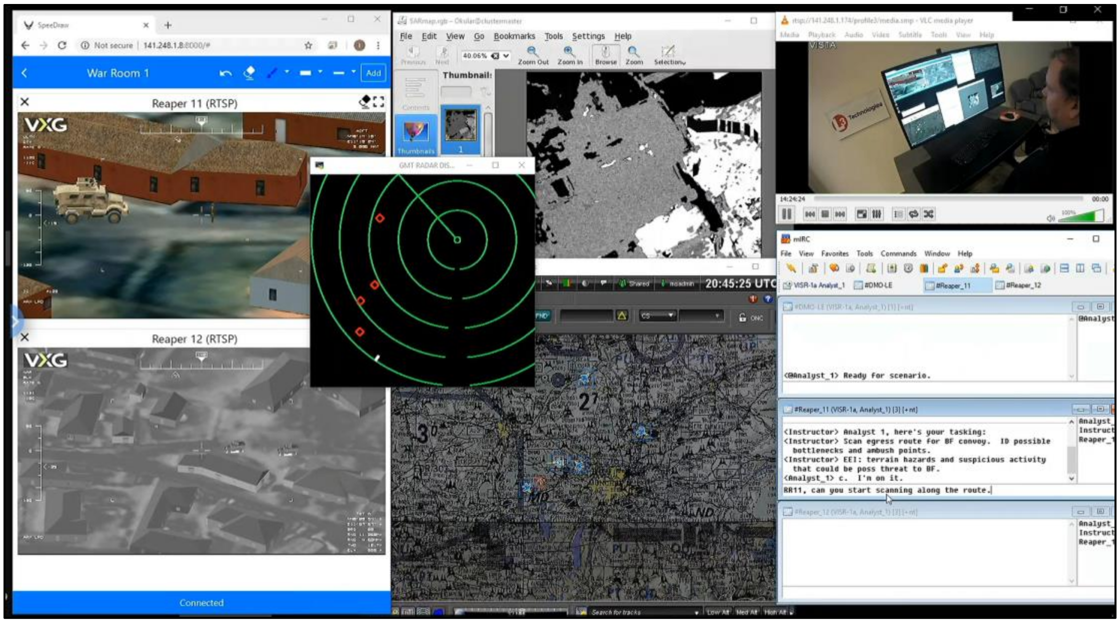


Figure 7: Individualized Web-based VISTA Presentation for Intel Analyst Students

Closing

Finally, the CAE VISTA team has also been invited by US Department of Defense Joint Staff to participate in additional LFEs this year, as well as the NATO Coalition Warrior Interoperability Exercise (CWIX) 22. We invite all interested audiences to monitor the progress of this exercise and examine the results for further evidence of the potential for embedded and dedicated synthetic data capability on operational networks for the C4ISR professionals of NATO.

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