

Digitally-Aided Close Air Support Capabilities in Simulation: Lessons Learned from a France-U.S. Effort

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ABSTRACT

Digitally-Aided Close Air Support (DACAS) is an increasingly important operational capability for many nations and Services. DACAS now allows the use of digital messages to expedite communications, rapidly build shared situational awareness, reduce human error and shorten the kill-chain. Digital systems in aircraft and DACAS ground kits provide other, previously unexpected and significant benefits that improve CAS planning and execution. For example, a Joint Terminal Attack Controller (JTAC) can now transmit digital target coordinates directly into an aircraft's weapons system before the aircraft even checks on station. However, with rare exceptions, current joint fires simulators do not provide pilots or JTACs with DACAS training that exercises basic or advanced uses of this important capability. This training often occurs only during infrequent national and international training and experimentation events.

As the scarcity of live training opportunities increases, so does the challenge of how we can provide warfighters with the most realistic environment to create and maintain their proficiency in joint and coalition DACAS missions. Building on last year's efforts (Reitz, Seavey and Mullins, 2018), this paper discusses the technical challenges faced in developing a standard methodology for DACAS capabilities in simulation to close this training gap. It also provides lessons learned from the first field test of simulated DACAS systems that allowed a Joint Terminal Attack Controller (JTAC) in a virtual trainer in France to digitally control a live aircraft operating at a range in Finland during the Joint Staff's Bold Quest 19.1 coalition capability demonstration and assessment event in Finland.

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INTRODUCTION

Joint and coalition warfighters have an immediate operational requirement for military simulations to support Digitally-Aided Close Air Support (DACAS) capabilities. While DACAS is an increasingly important operational capability, current joint fires simulators (with rare exceptions) do not support DACAS.

Joint Publication 3-09.3, Close Air Support, defines DACAS as “the machine-to-machine exchange of required CAS mission data (e.g., aircraft check-in, CAS brief, BDA) between JTAC (or FAC[A]) and CAS platform (or Command and Control (C2) node) for the purpose of attacking a surface target” (Joint Chiefs of Staff., 2014). Digital systems in aircraft and DACAS ground kits provide significant benefits that improve Close Air Support (CAS) planning and execution. Although voice transmissions currently remain the principal means of communication during CAS operations, DACAS capabilities now allow use of digital messages to expedite communications, rapidly build shared situational awareness, reduce human error and shorten the kill-chain. For example, a JTAC can now transmit digital target coordinates directly into an aircraft’s weapons system before the aircraft even checks on station. The importance of this improved precision and efficiency cannot be understated – smooth digital transmission gains a JTAC back critical time that might make the difference between mission success or failure, saving lives.

But to reach those performance levels, we must have training systems that are capable of DACAS in all required use cases, providing JTACs with a training environment that operates realistically. This need has led to nations, Services and program offices beginning to develop DACAS capabilities in simulation. It is crucial that within the joint fires simulator community we develop a standard methodology for doing DACAS in simulation to ensure future fielded simulators are interoperable. Defining a standard approach, using common technical standards, will help guide capability development efforts and ensure that future implementations are able to work together to support training and mission rehearsal.

The primary work so far in creating this baseline interoperability capability has been on developing and gaining consensus on a concept paper for DACAS in simulation. This document outlines high-level requirements as a first step toward defining a standard approach for implementing simulated DACAS. Once this approach gains community buy in, we will need to ensure that current policy and guidance for simulators, such as the JTAC Memorandum of Agreement (MOA) that governs the accreditation of JTAC simulators, reflects this methodology (Joint Chiefs of Staff, 2017). Establishing a new implementation process in the modeling and simulation community by leveraging a coalition of willing stakeholders will be a challenge. However, as already demonstrated in operational DACAS development, it is an achievable challenge and the potential practical benefits to operations make the development time a worthwhile investment. This paper discusses steps taken to test some of the proposed standardized approaches for implementing simulated DACAS.

PROJECT OVERVIEW

As described in our previous work (Reitz, Seavey & Mullins, 2018), the initial plan for 2019 was to continue our efforts to standardize emerging simulated DACAS capabilities. This plan had three phases, to include:

Phase One: The purpose of this phase was to develop a shared understanding among stakeholders of how simulated DACAS should work. This phase was achieved, and paved the way for the following two phases.

Phase Two: The purpose of this phase was to conduct distributed systems integration testing to verify basic functionality of emerging simulated DACAS capabilities. As discussed in later sections, much work remains on this phase.

Phase Three: The purpose of the third phase was to conduct an operational demonstration of one or more of the simulated DACAS solutions. The initial plan for this phase was to demonstrate several prototype simulated DACAS solutions during Bold Quest 19.1 in May 2019. Bold Quest 19.1, held at various sites and ranges in Finland, France and the U.S., provided an opportune venue for testing, demonstrating and assessing new simulated DACAS capabilities. This phase culminated in a field demonstration of a virtual JTAC in France controlling a live aircraft at a range in Finland. As described in detail below, this phase was only partially successful.

Phase One Update

The Concept Paper for DACAS in Simulation was the catalyst for building consensus among the Joint Fires and simulation communities about a standard way to implement DACAS capabilities in simulation. In this phase, we defined objectives, identified high-level requirements, documented use cases for and specified technical standards. As documented in the concept paper, we spent significant time and effort building agreement between stakeholders about the requirements, objectives, context and scope of DACAS in simulation. While work on this phase continues as new participants join the effort, much of the hard work on this phase is complete and significant progress has been made towards creating a standard for performing specific use cases of DACAS in Simulation.

The concept paper, initially distributed in early 2018, defined five use cases for simulated DACAS spanning the live, virtual and constructive domains as depicted below:

- Use Case 1: Virtual JTAC with Virtual CAS Aircrew
- Use Case 2: Virtual JTAC with Constructive CAS Aircrew
- Use Case 3: Virtual JTAC with Live CAS Aircrew
- Use Case 4: Constructive JTAC with Virtual CAS Aircrew
- Use Case 5: Live JTAC with Virtual CAS Aircrew

Additionally, the concept paper recommended DACAS messaging standards for simulated DACAS and other technical standards. It is important to note that none of the proposed technical standards are new. For both the live and simulation domain, all are current military standards (MIL-STD), Institute for Electrical and Electronic Engineers (IEEE) standards or Simulation Interoperability Standards Organization (SISO) standards. The concept paper is now in its ninth draft and approaching a point where application of the document can be considered in future exercises.

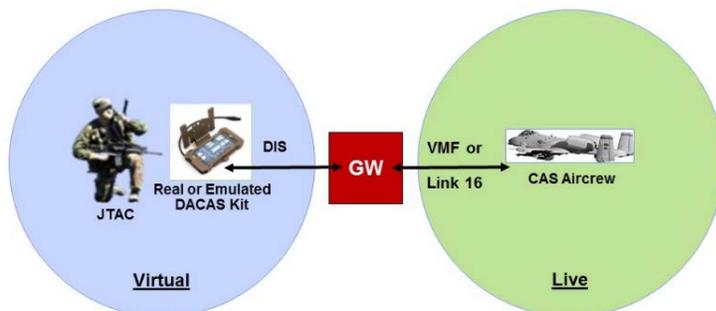


Figure 1. Virtual JTAC with Live CAS Aircrew

A significant decision made during Phase One was selecting the particular use case to demonstrate. Because program offices and vendors in the U.S., France and Australia were already working on solutions for Use Case 3, we made that use case the centerpiece of our 2018-2019 efforts. Some may reasonably argue that, in a today’s environment of reduced availability of live aircraft to support JTAC training, Use Case 5 may have higher utility. However, our decision to demonstrate Use Case 3 was driven primarily by the maturity of simulated DACAS technical solutions that supported the employment of Use Case 3.

Use Case 3 is defined in more detail as follows (and depicted in Figure 1).

- (1) JTAC is equipped with real or emulated DACAS system located in a virtual simulator; CAS aircrew is equipped with real DACAS system located in a live aircraft over a live range.

- (2) Live aircraft is instrumented so that its position data can be seen in the virtual JTAC trainer.
- (3) JTAC and CAS aircrew are connected via network with live and simulated data (including voice communications) translated between the live and virtual environments.
- (4) In this use case, training value for the CAS aircrew is improved by having access to an actual JTAC when live JTACs are not available at the range. However, there are a number of LVC interoperability challenges to make this use case effective for both JTAC and aircrew. For example, since the aircrew will not see the virtual JTAC or other simulated units on the ground, training value is low for the aircrew in discriminating between friendly and enemy units. For this reason, this scenario may be more applicable to Type 2 or 3 controls with limited friendly units on the ground. Nevertheless, this use case can still provide good training on procedural employment of DACAS.

Use Case 3, because it blends live and virtual environments, requires real world message flow to support the live DACAS system(s). Translation devices exist that can bridge between simulation-specific messaging and real world DACAS systems. However, a standard that represents a one-to-one correspondence between real world messages and simulation messages is a more general and ultimately a more interoperable solution. It is the solution that is most likely to accurately reflect real life situations/missions. Gateway designs that support non-standard implementations are generally not interoperable and may end up reinforcing closed, proprietary solutions.

Phase Two (Testing)

With our use case selected, we began dialogue with each of the development teams to gauge their readiness for distributed systems testing. These teams included the following:

- (1) French Air Warfare Center. Introduced an Alliance SOL system integrated with their Simulation for Forward Air Controllers (SIMFAC). This Alliance-based solution used Variable Message Format (VMF) messaging.
- (2) U.S. vendor sponsored by USAF's Air Combat Command. This system consisted of an Android Tactical Assault Kit (ATAK) integrated with the Modern Air Combat Environment (MACE) constructive simulation. This ATAK-based solution used Link 16 messaging. Unfortunately, while this system looked very promising, we were unable to surmount the cybersecurity hurdles to get this system on the network in 2019.

With Bold Quest 19.1 execution in mind, we targeted Bold Quest 18.2 in late October/early November 2018 for risk reduction testing. This event was conducted at Camp Atterbury, Indiana and other distributed sites. As the primary risk reduction event for Bold Quest 19.1, Bold Quest 18.2 was an opportunity to test prototypes in a controlled, distributed environment resembling that expected during execution.

Bold Quest 18.2 focused on the French Air Force solution. Accordingly, we established a test architecture, depicted in Figure 2 below, to support the testing. Participating sites included the Centre d'Expertise Aérienne Militaire (CEAM, the French Air Warfare Center) at Mont de Marsan, France; 46th Test Squadron (46 TS) and Joint Deployable Analysis Team (JDAT) at Eglin Air Force Base, Florida; and the Joint Staff's Bold Quest Live/Virtual operations cell located at Camp Atterbury. CEAM provided the system under test, a system operator and Alliance technical support personnel. 46th Test Squadron provided an A-10C Operational Facility (OPFAC) test aircraft. OPFACs are lab-based versions of a real aircraft's primary combat and communications systems running current operational flight software. JDAT provided much of the network support for Bold Quest, as well as a Cross Domain Solution (CDS) that provided interoperability between the various networks. The Bold Quest Live/Virtual control cell at Camp Atterbury managed the test.

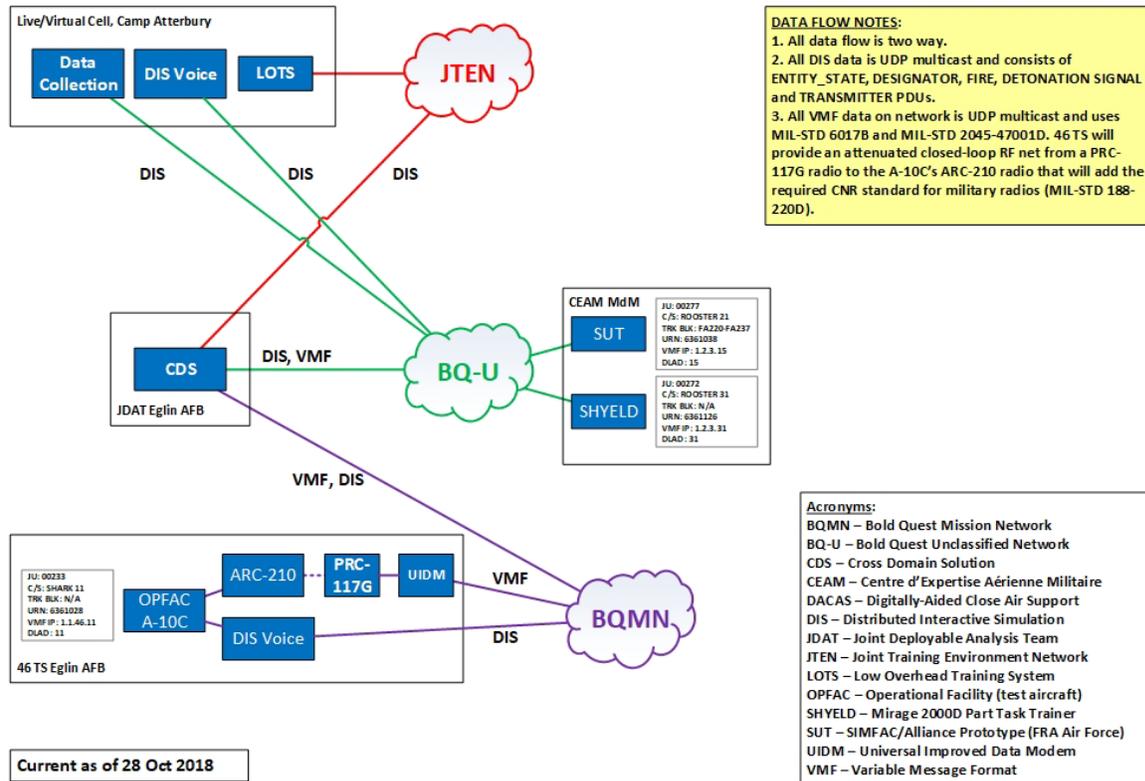


Figure 2. Bold Quest 18.2 Test Architecture: VMF Test with France

The French system was based on the Alliance SOL system, used by French JTACs in the field. This system generated the full set of VMF messages needed to support DACAS. Alliance SOL was integrated with the Simulation for Forward Air Controllers (SIMFAC) system, the French Air Force's standard JTAC trainer that uses Virtual Battlespace 3 (VBS3) as its simulation engine (see Figure 3). The French Air Force used a custom-built software package called Tupolev to provide the interface between VBS3 and Alliance. This system connected to the Bold Quest Unclassified network, which as Figure 2 illustrates meant that VMF messages from Alliance had to pass through the CDS to reach the OPFAC on the Bold Quest Mission Network.

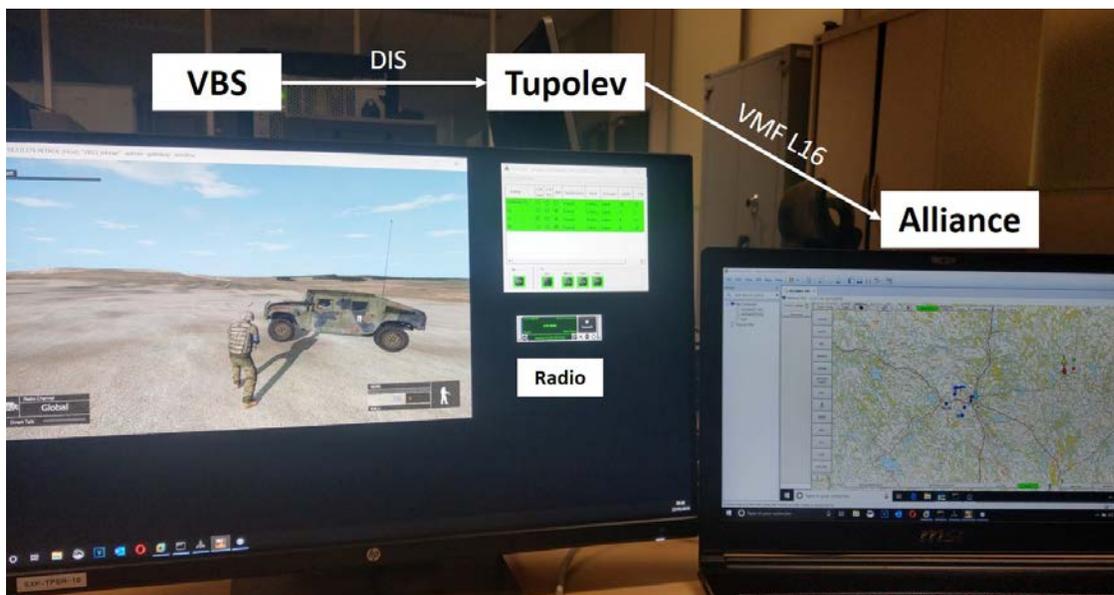


Figure 3. Alliance and Virtual Battlespace Integration

The A-10C OPFAC system at 46 TS included the primary avionics and mission systems, as well as operational flight software from a current A-10C. Our plan was to send and receive VMF messages over the network using User Datagram Protocol (UDP) multicast. To confirm message compliance with VMF standards, we used the VMF Test Tool (VTT), which is broadly used across DoD and by partner nations to confirm the conformance of their messaging to the VMF standards. Both the Alliance SOL and A-10C OPFAC implemented the following standards:

- a. MIL-STD 6017B, Variable Message Format (VMF)
- b. MIL-STD 2045-47001D1, Connectionless Data Transfer Application Layer Standard
- c. MIL-STD 188-220D1, Digital Message Transfer Device Subsystems

Despite significant effort from all participants, this testing was never successful in passing VMF messages between France and 46 TS. The French team sent a variety of different VMF messages types from Alliance. VTT received 876 messages, of which 874 were valid. Only two of the 876 were processed as invalid by VTT. Both of these were K.02.33 Close Air Support Aircrew Briefing messages that included "invalid or illegal characters." However, none of the VMF messages passed through the CDS. All errored out, some with multiple errors per message. Unfortunately, the CDS used was a "black box," in that it provided us very little useful information on why the messages were causing errors. Subsequent analysis indicated that the CDS may have implemented an older set of VMF standards and therefore did not allow current DACAS VMF messages to pass.

To resolve the issues we experienced during this test, we considered using an alternative to VMF. After internal discussion on pros and cons, we decided to move to Link 16. Since the current DACAS Tactics, Techniques and Procedures (TTP) supports both VMF and Link 16 (Office of the Director, JT& E, 2016) and since we quickly concluded the CDS could not be modified in the limited time remaining before execution, we selected Link 16 as the better option. Using Link 16 would simplify the architecture by bringing all users onto the same security domain on the Bold Quest Mission Network. Second, it would remove a key untested part of the VMF-oriented architecture, the Universal Improved Data Modem (UIDM), which was required to interface IP networks to a local tactical radio, such as the AN/PRC-117G. Third, it would mean we only had to swap out the Alliance SOL for the Alliance TOC. Unlike SOL, the Alliance TOC could do both VMF and Link 16.

To confirm our assumptions and validate the architecture, an additional risk reduction test between Alliance TOC and the 46 TS OPFAC was scheduled. Figure 4 shows the simplified test architecture for this event. During this test, all systems used the Joint Range Extension Applications Protocol (JREAP) version C. Of note, the OPFAC that participated in this test was the Link 16-capable F-15E OPFAC. This test was conducted 5-7 February 2019. Test participants included the French Air Warfare Center, 46 TS and Joint Staff J6 located in Suffolk, Virginia. Results of this test were much more positive than our BQ18.2 test.

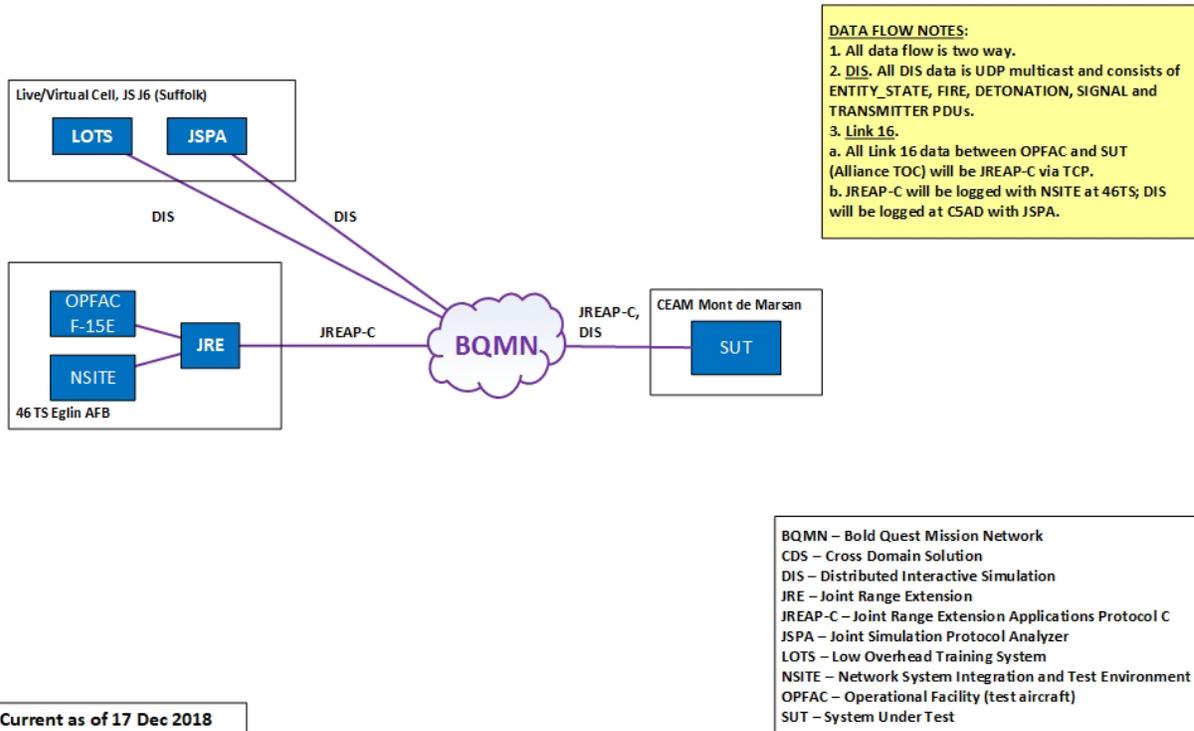


Figure 4. Bold Quest 19.1 Risk Reduction Event Test Architecture: Link 16 Test with France

First, the Alliance TOC kit in France quickly connected to the Joint Range Extension (JRE) system at Eglin and reliably supported the flow of Link 16 data. Both ends were able to exchange J2.x Precise Participant Location and Identification (PPLI) and J28.2 Free Text messages. However, Alliance TOC was not able to generate J12.6 Mark Point/Point of Interest messages, as required by the current message sequence in the DACAS TTP (Gross, Foret & Sere, 2019). We did determine that it generated J3.5 Land Points/Tracks in response to an aircraft's J12.6, but these tracks had low track quality (TQ). In fact, TQ was so low they were not processed by the aircraft's system. Additionally, the tracks were not updated, causing them to quickly time out. Alliance TOC also did not process the aircraft's J13.2 Air Platform and System Status.

In a larger sense, we discovered the Alliance TOC had very different functionality than the SOL version. One aspect of this difference was it could not generate the exact message cadence specified in the DACAS TTP. As expected from a system that was designed for joint fires control, Alliance TOC functioned more as a C2 system than a terminal control device. After much discussion, and because of the promising objectives we could achieve, we decided to proceed with the plan to demonstrate this system as part of Bold Quest 19.1 in Finland.

Phase Three (Execution)

Bold Quest 19.1 took place in May 2019 at various ranges in Finland and at numerous distributed sites around the world. Hosted by the Finnish Defense Forces, Bold Quest 19.1 was the largest, most complex Bold Quest coalition capability development and assessment to date. As part of this event, we planned to demonstrate simulated DACAS capabilities during the second week of execution. As a quick review of our objectives, we wanted to demonstrate that a JTAC operating from a virtual trainer could use an actual DACAS system (or emulated version thereof) to digitally control a live aircraft operating over a live range.

The primary players in this live demonstration included a French JTAC using a virtual training system at the French Air Warfare Center in Mont de Marsan and two U.S. Marine Corps F/A-18 aircraft from VMFA-251 operating over Observation Point 2 (OP 2) near Sodankylä in northern Finland. Additionally, two French Army JTACs served as safety observers at OP 2 during execution. Other critical participants in this event were 46 TS personnel, who operated the Joint Interface Control Cell (JICC) located at the Bold Quest Operations Control in Sodankylä, and JDAT, who provided the live-to-virtual radio bridge and live radios.

Our plan called for communications between JTAC and aircraft to consist of both Link 16 and voice. The Alliance TOC system at Mont de Marsan would send Link 16 via JREAP-C to the JICC in Sodankylä. From there, the data would be put out onto the live Link 16 network for aircraft, JTACs and other Link 16 participants. For voice communications, the JTAC at Mont de Marsan would use the Distributed Interactive Simulation (DIS) protocol to transmit and receive simulated voice radio communications over the wide area network. To provide end-to-end voice communications, we used a Voisus radio bridge, developed by Advanced Simulation Technologies, Inc. (ASTi), in Sodankylä to translate the Internet Protocol-based DIS voice to live radio communications generated by an AN/PRC-117G radio. Figure 5 provides a concept for the design of this demonstration.

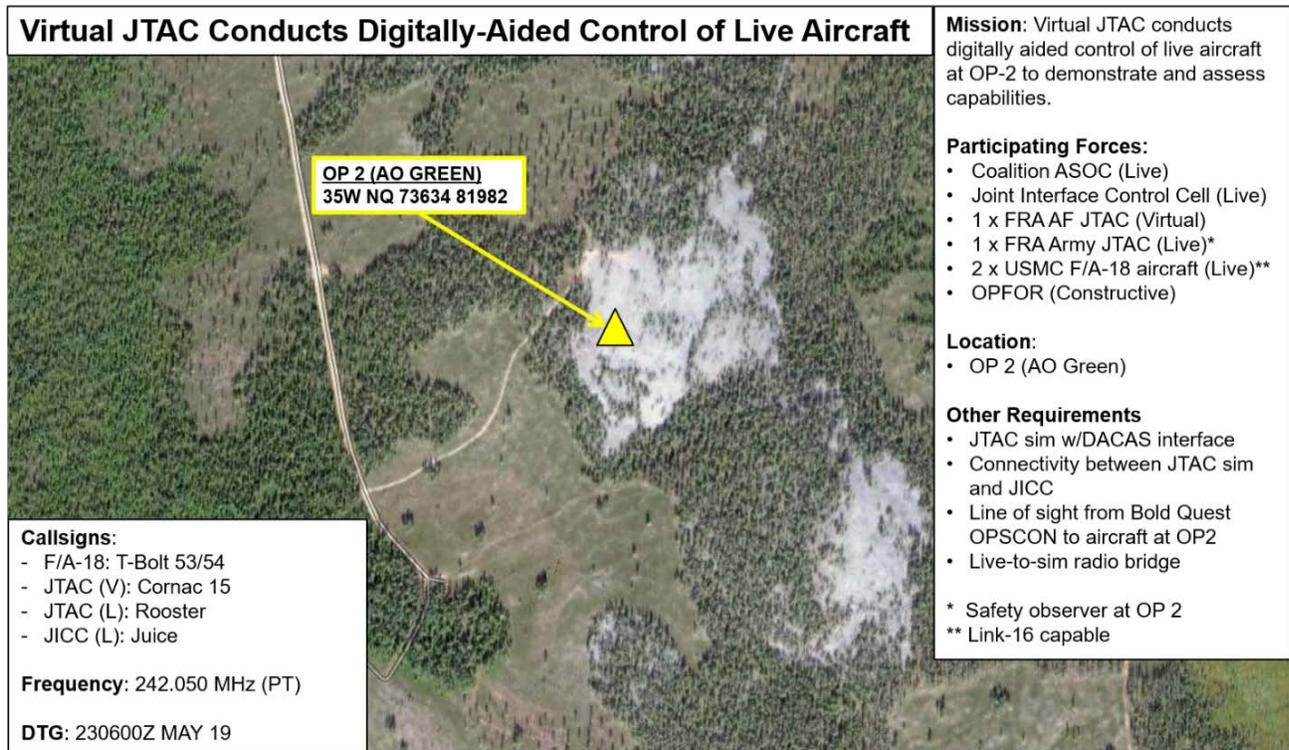


Figure 5. Concept for Simulated DACAS Demonstration

This demonstration was unsuccessful in meeting our objectives. We experienced two critical problems. First, due to technical issues with the Link 16 messaging, we had to cancel the first of our two planned execution days to ensure that Alliance TOC could generate the J.3 tracks at the required frequency and with the required track quality. This issue was resolved in time for the second day's final attempt. However, on the second day, we were unable to establish two-way voice communications between the JTAC in France and the live F/A-18s over OP 2. Since we had such a short time window to conduct this test, while simultaneously supporting live air operations, we were not able to fully troubleshoot this second problem and determine the cause. However, antenna orientation and power out were the two primary suspects. Since the Link 16 message sequence calls for a number of voice only exchanges (e.g., routing and safety of flight, weapons clearance, Battle Damage Assessment, etc.), not having voice communications crippled the effort.

We were able to exchange some Link 16 traffic, such as J2.X PPLI, J3.X Tracks and some elements of the J28.2 Free Text Messages. However, we observed anomalies with each of these. For example, the JICC received J2.X from both the JTAC and the F/A-18s, but the F/A-18s never saw the J2.0 PPLI messages from the JTAC. On the other hand, the F/A-18s did report receiving J3.5 Land Tracks from the JTAC, despite the fact that Link 16 systems normally do not process tracks without the accompanying PPLI from the reporting unit. Additionally, the aircraft reported receiving a J3.5 hostile ground track, but only lines four through six of the JTAC's Nine Line report in a J28.2 message. The aircraft also did not receive the J12.0 Mission Assignment message. Due to time, space and other constraints imposed by the live demonstration environment, the causes of these anomalies remain unknown.

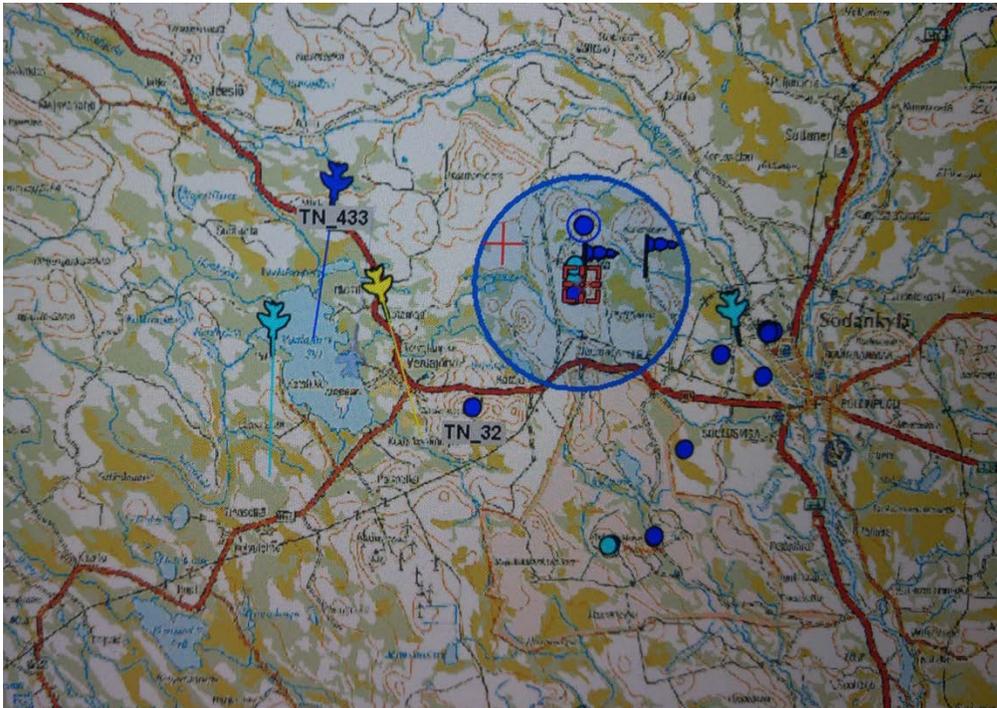


Figure 6. Simulated DACAS in Alliance

RESULTS AND LESSONS LEARNED

1. Confirmed the approach to simulated DACAS interoperability outlined in the concept paper.

During this test event, we confirmed the approach outlined in the Concept Paper for DACAS in Simulation). By focusing our approach for DACAS in simulation on live DACAS messaging, we facilitated communications (though, incomplete communications), between a simulation system and a live operational system, while accurately representing the message flow that would be performed by the JTAC during a live mission.

2. Perform more environmentally replicative Risk Reduction Testing.

The risk reduction testing we performed in 18.2, and in the event we tested in before 19.1 did not replicate all of the factors that could have possibly interfered with our final test during 19.1. While we conducted some basic tests, we did not rigorously test the simulation to live voice connection, since our experience was that this system performed reliably in other venues (Reitz & Seavey, 2014). We obviously carried a faulty assumption forward to the new operating environment in Finland. We also needed a more robust data collection plan during both testing and execution to understand better exactly why things did not work.

3. OPFACs were integral in early testing.

OPFACs provided an excellent replication of the live aircraft systems and were key to our risk reduction testing in November and February. However, during those early tests we did not know which specific live aircraft we would operate with in Finland. As it turns out, we worked with USMC F/A-18 aircraft for which no OPFAC equivalent exists. Therefore, we were breaking new ground since, to the best of our knowledge, the Alliance TOC system has never before connected via Link 16 with USMC F/A-18 aircraft.

4. Current standards are sufficient to perform simulated DACAS.

Link 16 and SADL are well supported in simulation and there is a growing capability to support VMF. The DIS standard (IEEE 1278 series, 1998) provides a flexible, interoperable way to handle tactical data links in simulation. Established DIS TRANSMITTER and SIGNAL Protocol Data Units (PDUs) are used to transport data link messages in the same way that DIS handles any radio transmission. The TRANSMITTER PDU indicates location and activity state of the radio transmitter; the SIGNAL PDU carries the message payload. The standard specifies the type of data

link used and supports multiple data link types, including Link 16, SADL and VMF, among many others. Keeping the simulated communications aligned with the live communications facilitates smooth operations between live and simulated domains.

CONCLUSION

The tactical simulator community urgently needs to improve joint and coalition interoperability across nations, Services and program offices. This issue currently has senior visibility through the Department of Defense Senior Steering Group for Simulator Interoperability (DoD SSG). The DoD SSG was chartered to address the following problem identified by the Commander, U.S. Special Operations Command (USSOCOM):

“Effective and timely joint training and mission rehearsal of conventional and SOF forces are hindered by incompatible, non-interoperable Service and USSOCOM-provided simulations and simulators. This substantive interoperability challenge results in costly inefficiencies to acquire cross-service simulators that provide adequate and fair representation of the battlespace for distributed mission operations” (OUSD ATL, 2018).

While the effort we describe here is just once small contribution to improving simulator interoperability, it highlights three key points. First, improving simulator interoperability is hard work. With multiple, competing simulation standards and protocols to choose from, it is not enough to simply specify a standard. Instead, significant work is required to agree on how participants should interpret the chosen standard. In the simulation community, this is commonly part of developing “federation agreements,” a key step in developing a simulation federation. (IEEE, 2010)

Second, this effort highlighted for us how involving mission partners early in the process of developing federation agreements can lead to secondary benefits. An important advantage for us in this effort was the opportunity for French and American simulation teams to work hand in hand to develop and codify the federation agreements for simulated DACAS. As a result of preparation and testing for this event, French JTACs and U.S. Air Force Special Operations Command (AFSOC) aircrew – mission partners today in theaters “down range” – were able to train together in virtual simulators for the first time from homestation.

Finally, the tactical simulator community needs a process for institutionalizing improvements to interoperability. As we discovered during this effort, the joint fires community has already solved this problem through a formal process called “Coordinated Implementation.” DACAS coordinated implementation (CI) was developed to address the joint fires community’s problem that “programs continue to field non-standard, non-interoperable, Service-specific digital data exchange capabilities.” DACAS CI fills the many gaps between traditional standards management and compliance activities and interoperability goals by, among many other things, defining “how” digital communications standards will be implemented. Obviously, CI has many parallels to the tactical simulator community. In the future, we will explore how we can use CI as a model for improving interoperability in the tactical simulator community too.

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