Military Utility Assessment of the Advanced Collaboration Enterprise Services (ACES) October 29th, 2021

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I. Prologue

"The Department of Defense lacks the digital foundation necessary to execute Multi Domain Operations (MDO) in support of the National Defense Strategy" (General Goldfein, CSAF). A significant source of friction in developing this digital foundation is our acquisition system itself. "A lot of the [innovation] bureaucracy imposed comes from the people who are not in the chain of command [for creating effects in the battlespace] but who are stakeholders of some type who want to protect their equities or institutional interests, [or are just plain risk adverse.] This diversity and density impose huge burdens on the chain of command responsible for delivering [effects – the warfighters]" (Secretary Frank Kendall).

For over a decade, one of the Joint Staff's highest priorities has been investing in the digital foundation for Nuclear, Command, Control and Communication (NC3) and Joint All Domain Command and Control (JADC2). The USAF's Advanced Collaboration Enterprise Services (ACES) represents a proven breakout achievement as an enabling foundation for weapon system modernization, filling capability gaps, and providing interoperability for the Joint Force and coalition partners.

Command and Control, Advanced Battle Management, or Joint All Domain Command and Control is much more complex than finding the right information system. Our operational advantage is derived from our ability to see, decide, act, and assess from an uninterrupted flow of information across a myriad of networks, classifications, operating systems, and devices. The key here is to be able to process this uninterrupted flow of information and make it relevant to teams and decision-makers.

ACES is a ready, TRL-9, cost-effective, ultra-low latency, mixed reality environment for tactical to strategic users. ACES also is employed for everyday in-garrison, conference room, and mission planning roles. The ACES design makes it versatile over high bandwidth or disadvantaged networks. Its simple, elegant, multi-user interface immerses distributed teams in a visual panoramic arena allowing warfighters to put applications and information on any screen, wall display or device anywhere, anytime. But what's most important is that teams in the same room or halfway around the world are connected, seeing the same information at the same time regardless of application, operating system, domain classification, network, or device.

In any fight, the ability to find and exploit a seam represents a significant game-changer in winning. Today, information is the currency of Multi Domain Operations. Unfortunately, we are still faced with access limitations and archaic TTPs at no fault of the warfighter. We are forced into trying to configure our mission or battle rhythms based on IT limitation and constraints. It does not matter what technology is involved – 5th generation fighters, hypersonics, or even the elusive "quantum computers." Whether we're talking about shortening kill chains or speeding up Boyd's OODA loop, we still need to make information open and accessible to the people who need it. There has been a lot of talk about where we need to go and millions upon millions of

dollars spent, and we're no closer now than 15 years ago, and I fear we won't be any closer five years from now.

In the era of great power competition, the Air Force charged squadrons to foster innovation that makes the most significant impact. Squadrons do this by cultivating innovation at the edge that leads to revolutionary concepts. As a result, ACES started small and scaled fast. The ACES team consists of an eclectic mash-up of warfighters, expert industry partners, Air Force Research Labs, and academia. We would be hard-pressed to find a more dedicated a team who can rapidly prototype and deliver capabilities that meet AOC Capability Development Document (CDD) and Joint Staff C4MAP requirements as this ACES team has delivered. The following report summarizes the latest AFWERX backed, direct to phase II Small Business Innovation Research (SBIR) effort that successfully concluded ten months ahead of schedule, culminating in a third Military Utility Assessment conducted at Tinker AFB October 25–29, 2021.

This integration effort buttresses against the backdrop of our urgent need to evolve our systems for the 21st Century. As stated by CSAF General Brown: "Our Air Force must accelerate change to control and exploit the air domain to the standard the Nation expects and requires from us. If we don't change – if we fail to adapt – we risk losing the certainty which we have defended our national interests for decades. We risk losing a high-end fight. We risk losing quality Airmen, our credibility, and our ability to secure our future. We must move with a purpose – we must Accelerate Change or Lose."

I see ACES as a linchpin of future USAF systems and a test case of our ability to execute General Brown's sentiments: It is excellently engineered, easily acquired, and ready to deploy. It bridges our legacy systems to allow disparate teams and tools to talk to one another while also providing a model for how future systems should work. We have a lot of excellent capabilities that are stovepiped, many of which are proprietary. ACES allows us to bring them all together in a visual arena with almost zero integration cost. With ACES, we can take apps or images and move them to any device, any screen, anywhere. Making all existing tools easier to use is how ACES shortens the kill chain and reduces human error.

ACES has been ready for broad deployment since 2014, back when I originally wrote the requirements for ACES at HAF A2I. Since then, ACES has checked every box:

- \checkmark Completed a JCTD with a four-star command.
- \checkmark Conducted two MUAs (one with a four-star command)
- ✓ Deployed ACES to a TS/SCI environment at an interagency environment supporting realworld operations.
- ✓ Fielded ACES as the backbone for multiple National-level Cyber exercises.

This document will show how the recent effort to integrate ACES with AWACS systems has again validated ACES' potential. Yet despite these successes, ACES remains in the "valley of death" of DoD's technology transfer process. ACES is a mature technology that is ready for fielding to the enterprise. It needs to be put into the hands of warfighters immediately.

Matter mis

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1. Executive Summary

The MUA was conducted the week of October 25, 2021, at Tinker AFB, Oklahoma. Operators from the 513th ACG and 552nd ACW ran five vignettes for this MUA. The goal of this MUA was to characterize the effectiveness and suitability of ACES to the AWACS mission and begin the development of tactics, techniques, and procedures (TTPs) for AWACS on ACES. ACES demonstrated military utility by easily sharing information among all AWACS operators. This sharing of information also permitted each user to review, manipulate, and save that information at any time.

The assessment demonstrated that ACES should be deployed more broadly to air platforms and air operations centers to shorten the kill chain and reduce user error within air operations units.

2. Laboratory

513th ACG headquarters includes an ACES-powered conference room installed as part of a separate 2019 effort. Foundational to this MUA are two simulated Primary AWACS Display (PAD) banks that were set up in a conference room adjacent to the ACES conference room. Together, these two rooms simulated the core functions of an Air Operations Center (AOC) and Control and Reporting Center (CRC), respectively. The full PAD training software was installed and made available to participants as six PADs in virtual machines (VMs) to make the MUA scenarios as realistic as possible.



Above: One of the two PAD banks representing the C2 component of the AWACS node at the 513th ACG (U.S. Air Force photos by Capt Caleb Wanzer)



Above: 513th ACG Conference Converted into an ACES enabled mock AOC/CRC. (U.S. Air Force photo by Capt Caleb Wanzer)

ACES includes a self-contained infrastructure-as-code platform known as Carthage, capable of generating digital twins of complex legacy software environments and modern systems. The infrastructure for these scenarios was developed and managed by Carthage. Developers used Carthage to set up the PAD infrastructure on both a VMware vSphere cluster in the cloud and a local vSphere server on a small-form-factor edge computing device at the 513th ACG Headquarters. This aspect of the exercise infrastructure demonstrated the flexibility of ACES, which was able to integrate both PAD infrastructure setups and toggle between them seamlessly.



Above: Example Carthage console used to manage and maintain the MUA PAD VM infrastructure.

3. Scenario

Airmen from the 552nd and 513th developed a comprehensive scenario based on US Forces' summer 2017 shootdown of a Syrian Su-22. The scenario was developed to run from the AWACS sim PAD training simulator, overseen by a White Cell of 552nd ACW and 513th ACG personnel. Nine members of the 552nd ACW participated in five 90-minute simulations for three days, providing feedback and developing TTPs for ACES.

AWACS personnel simulated an AWACS Data Fusion Team and Battle Management Area Team. Each team had a Section Lead (SL), Mission Systems Operator (MSO), and Air Battle Manager (ABM). Additionally, one Air Battle Manager each at the simulated AOC and CRC fulfilled all roles there.



Above: Members of the 552nd ACW, 513th ACG, and Hadron Industries develop the MUA scenario. (Photos courtesy of Hadron Industries)



Above: A working storyboard document slide for one of the use cases covered in the MUA.

Throughout the scenarios, all user interactions with AWACS systems were performed through ACES. AWACS controls were made available via ACES-powered virtual machines, and the data from shared with other ACES-powered systems within the network. We simulated voice communication with a push-to-talk phone system. ACES additionally allowed participants to:

- > Seamlessly take and share screenshots of their PAD displays
- ➤ Collaborate on shared notes
- > Organize the incoming flow of information in a visual and intuitive manner
- Seamlessly share and collaborate on information with the AOC and CRC nodes by simply dragging information onto the screens located at those simulated locations using the ACES control console



Above: One of the PAD banks during scenario execution. (U.S. Air Force photo by Tech. Sgt. Lauren Kelly)

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Above: Example screenshot of an ACES control console during the scenario execution

Over the course of the six scenario runs, participants also began the development of TTPs for using ACES to make their mission more effective. Some of the TTPs developed included:

- The use of time and origin meta-data on all screenshots to aid in sorting, confirming, and prioritizing information
- The use of ACES 'virtual' workspaces to organize incoming information by source and priority
- The use of ACES 'virtual' workspaces to make clear 'Inbox/Outbox' containers for the flow of information between the PAD Banks, and with the AOC/CRC
- The use of the ACES enabled triptych screen above each PAD bank for passing images, pdfs and virtual machine terminals between PAD bank members, and for immediate visual collaboration between all members
- The use of dynamically tiled video walls to provide overwatch on all the PAD VMs used in the exercise



Above: White Cell video wall tiled with all participant PAD VMs. Left is the DFT bank, center the WBMA bank, and on the right are dynamically arranged information and live video feeds. Foreground are the AOC and CRC stations.

Throughout all scenarios, ACES-enabled systems showed a substantial qualitative improvement to the kill chain. ACES also demonstrated an ability to shorten the kill chain. For example, in dueling scenarios, an AWACS crew was tasked to execute a Combat Search and Rescue (CSAR) mission with the baseline environment. In contrast, a different scenario performed a similar task using an ACES-enabled environment. The iteration with ACES was consistently two to three minutes (~20%) faster than the one with the baseline environment.

In summary, the MUA utilized a realistic scenario on practical tools, validated the enormous utility ACES has for the AWACS mission and began developing actual TTPs for integration. This MUA also validated an additional "white force" capability. Because ACES allows us to perch strategically, viewers and assessors can watch all activity in a scenario (for example, via the video wall of all PAD VMs), and VMs are used as collaborative spaces. In this training environment, white cells have real-time visibility into all activity and a faster ability to modify and run multiple iterations of training scenarios. The team tested operational simulations where the crews provided battle management and command and control of dynamic targeting and personnel recovery operations, both with and without ACES software. Testing determined that ACES software can reduce kill chains in these mission sets by 2 to 3 minutes depending on operator proficiency.

4. Participant Evaluations and Feedback

Thirteen participants provided their assessments of the scenarios on a series of 10 statements:

- 1. The information displayed was relevant to the mission at hand.
- 2. Using this capability to share information improved our ability to synchronize efforts.
- 3. Once information was shared by another site, the displayed information appeared on my screen in a timely manner.
- 4. I had full capability to rearrange or customize my screen layout as desired.
- 5. The information displayed was displayed at the appropriate time.
- 6. The accuracy of decision supported by sharing information with this capability was acceptable.
- 7. The timeliness of decisions supported by sharing information with this capability was acceptable.
- 8. The relevance of decisions supported by sharing information with capability was acceptable.
- 9. The information exchanges using this capability were effective.
- 10. The decision making process using this capability was effective.

The average recipient response is shown in the following table:



Average Participant Response

Participant Comments

"ACES Software provides real-time interoperability between Battle Management crews at the tactical and operational level and across multiple domains. As we look to bring the future faster ACES will be a major capability."

– Maj Daniel "Doc" Watson

"The coupling of ACES Software with the modernizing space and cyber infrastructure will lead to a precursor to the unified C2 framework. Photon is the answer for multi-domain information sharing. This application shows great promise in laying out the groundwork for greater interoperability and could lead to a foundational capability for ABMS."

- Capt Brandon "PigPen" Woods

"I could have really used this when I was working with Kessel Run last year at the CAOC. If I could say, 'Hey Kessel Run, look at what I'm looking at right now.' I could share that bug report directly instead of having to describe the problem in an email."

- Capt Indiana Janssen

"Extremely fast and seamless. I was never delayed by the Photon system. It creates an extremely quick avenue to pass information with practically zero delay or detraction from situational awareness or mission objectives."

- 1st Lt Dan Colton

"Made it extremely easy to pass info and files from the ground to the jet with speed and accuracy. Overall, the system increased SA and allowed for efficient file sharing and data sharing that increased the team's ability to gather, manipulate, and extrapolate data that enhanced the team's efforts. Getting visual information from external sources real-time was really helpful. This system would not only help with data, but enable a faster kill chain. Recommend if able to use with multiple platforms."

- Capt Matt Hunter

"Overall I feel ACES is very effective in allowing C2 players the ability to shorten the kill chain via real time collaboration of vital data/information sharing."

– Maj John "Wes" Holsinger

5. Conclusion and Next Steps

This third military utility assessment showcased an unprecedented collaboration capability that developed entirely new TTPs from theories once penned by scholars and warfighters on how future commanders will use new information systems to better visualize, interact, and understand the operating environment.

Command and Control, Advanced Battle Management, or Joint All Domain Command and Control is much more complex than finding the right information system. Our operational advantage is derived from our ability to see, decide, act, and assess from an uninterrupted flow of information across a myriad of networks, classifications, operating systems, and devices. The key here is to be able to process this uninterrupted flow of information and make it relevant to teams and decision-makers.

Our current IT systems, weapon systems, and networks are overwhelming our cognitive abilities. Whether from the velocity and variety of information or the antiquated weapon systems' baselines, we are suffering the consequences of cognitive deficits and information overload.

ACES supports the integration of legacy and next-generation applications and is a game-changer, enhancing human cognitive abilities while assisting commanders in understanding the environment. When commanders are freed up to use their experiences and intuition, we can then see and exploit seams and gaps.

My 26 years of experience is inducing frustration at the glacial speed of innovation and the adoption of disruptive technologies. ACES is a SBIR effort developed for the government using government and private funds for warfighters to do their jobs and win battles. It's time to transition ACES for a broader adoption in the Joint Force. Get ACES into the hands of our warfighters.

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