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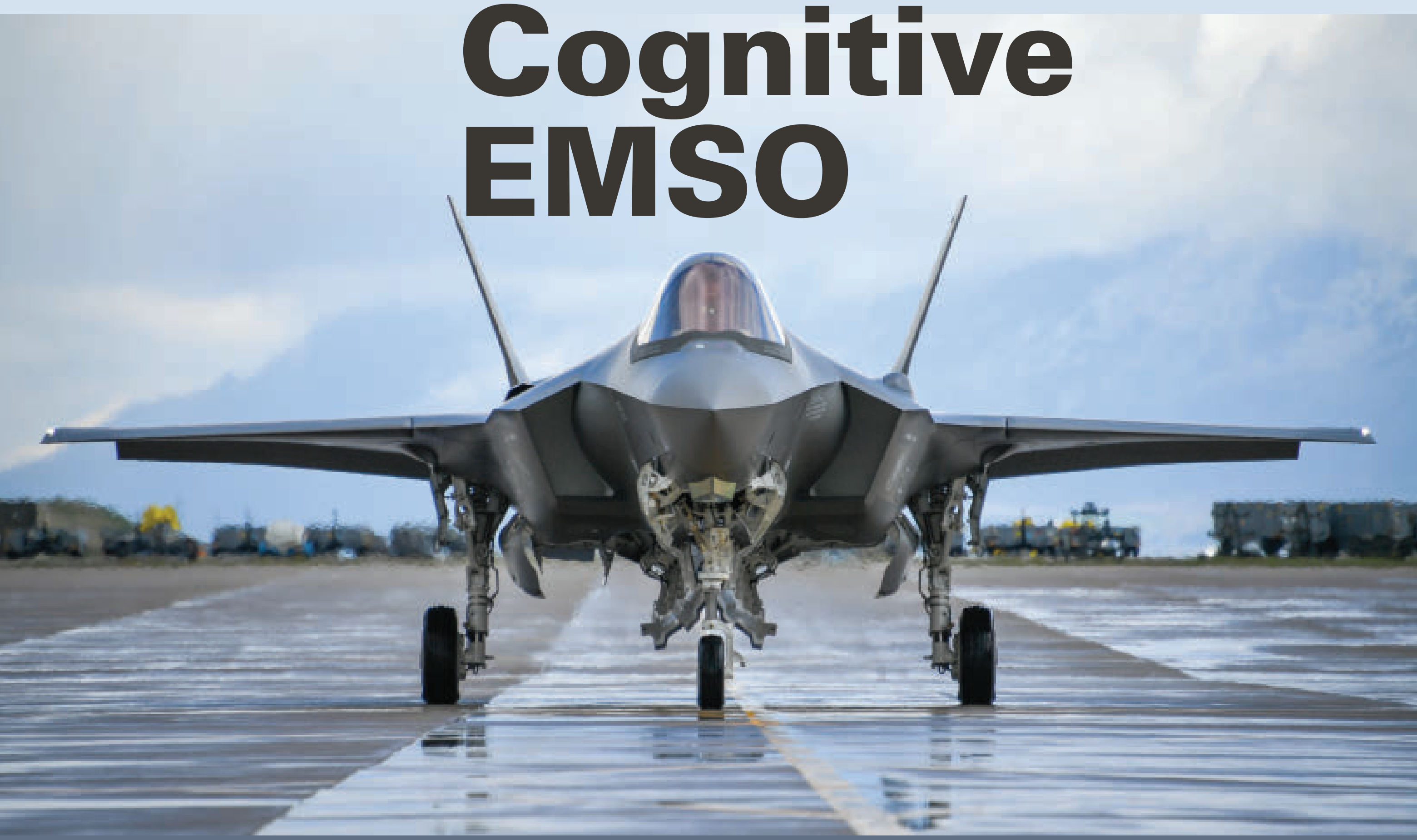
March 2023 Vol. 46, No.3

JED

Journal of Electromagnetic Dominance

Building Cognitive EMSO



Also in this Issue:

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- News: Army Seeks Industry Input for High-Altitude SIGINT and Radar Sensors

JED
Journal of Electromagnetic Dominance

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US AIR FORCE

COVER PHOTO COURTESY OF US AIR FORCE

US Navy Cryptologic Technician (Technical) 3rd Class Matthew Willman loads chaff rounds into a Mk36 decoy launcher aboard the USS Paul Hamilton (DDG 60). Paul Hamilton, part of the Nimitz Carrier Strike Group which was conducting operations in the Pacific last month. US NAVY PHOTO BY MASS COMMUNICATION SPECIALIST 2ND CLASS ELLIOT SCHAUDT

Departments

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From the *JED* Archives: Tuning in, Turning on: Russia Brings Radio-Electronic Combat to the Fore

ADVOCACY

The Pentagon is expected to release its FY2024 defense budget request sometime this month (March 9 as of this writing), and it will be followed by the familiar series of congressional hearings involving testimony from Pentagon leaders about their various concerns, challenges and budget priorities. EMS Operations (EMSO) sometimes factors into these hearings, although more often it is discussed in one or two "items of special interest" in committee reports from the House Armed Services Committee (HASC) or the Senate Armed Services Committee (SASC).

Over the past several years, the HASC and SASC have shown greater interest in EMSO policy, in part due to consistent advocacy from AOC. (It's important to note that advocacy differs from lobbying in that advocacy aims to educate and create broad understanding of an issue or mission area, like EMSO. Lobbying, on the other hand, typically focuses on requesting funding or support for specific programs or initiatives.)

Advocacy for EMSO requires constant engagement, in part because EMSO is a complex topic to explain and also because educating legislative staffs requires continuous reinforcement in a busy place like Capitol Hill, where thousands of issues compete for attention across all of the congressional policy and spending bills.

Despite this noisy legislative environment, EMSO has received steady attention from the House and the Senate. On the House side, the Electromagnetic Warfare Working Group (EWWG) has been a tremendous resource for communicating EMSO knowledge to Congress. Under the leadership of Rep. Joe Pitts (its founding member) and his successors, such as Rep. Austin Scott, Rep. Don Bacon and longtime co-chair Rep. Rick Larsen, the EWWG has helped shape EMSO policy in the House defense authorization bills. In fact, AOC is working with the Hudson Institute on a panel discussion with congressional representatives from the EWWG this spring.

Advocacy provides knowledge and understanding that can translate into action. Over the years, Congress has been a strong proponent for the DOD to identify an EW senior designated official, establish an EMSO Cross Functional Team, and to develop a Department-wide EMS Superiority Strategy. However, EMSO advocacy is not limited to Capitol Hill. Anyone can advocate for EMSO just about anywhere. EMSO advocacy can educate senior military officials and other decision makers who need to understand what EMS maneuver means for military operations. EMSO advocacy can inform industry leaders to focus their resources and business strategies on developing next-generation EMSO technologies. EMSO advocacy can even encourage students and young professionals pursue a career in EMSO.

If we change our perspective about what advocacy is – and who it is for – it can be something all EMSO professionals can practice. Just as with the aggregated effects of distributed EW, consider the aggregated effects of distributed EMSO advocacy practiced by anyone and everyone in our community. So, maybe the next time you run across someone who needs to understand EMSO just a little bit better, please take that opportunity to explain what EMSO is and why it is important. That simple act, practiced often enough, can make a big difference. – *J. Knowles*

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MARCH

AFA Air Warfare Symposium
March 6-8
Aurora, CO
www.afa.org

Satellite 2023
March 13-16
Washington, DC
www.satshow.com

Collaborative EW 2023
March 14-16
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March 15-17
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March 19-22
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AUSA Global Force Symposium and Exhibition
March 28-30
Huntsville, AL
www.ausa.org

APRIL

Navy League Sea-Air-Space
April 3-5
National Harbor, MD
www.seaairspace.org

Annual Directed Energy S&T Symposium
April 3-6
Mobile, AL
www.deps.org

LAAD Defence and Security
April 11-14
Rio de Janeiro, Brazil
www.laadexpo.com.br

Army Aviation Mission Solutions Summit
April 26-28
Nashville, TN
www.quad-a.org

SPIE Defense + Commercial Sensing
April 30 – May 4
Orlando, FL
www.spie.org

MAY

IEEE Radar Conference
May 1-5
San Antonio, TX
https://radar2023.ieee-radarconf.org

Cyber Electromagnetic Activities (CEMA) Conference
May 2-4
Aberdeen Proving Ground, MD
www.crows.org

SOF Week 2023
May 8-11
Tampa, FL
www.gsof.org

AOC Europe
May 15-17
Bonn, Germany
www.aoceurope.com

EW Capability Gaps and Enabling Technologies Conference
May 16-18
Crane, IN
www.crows.org

JUNE

Cyber/EW Convergence Conference
June 6-8
Charleston, SC
www.crows.org

International Microwave Symposium
June 11-16
San Diego, CA
https://ims-ieee.org

Paris Air Show
June 19-25
Paris, France
www.siae.fr

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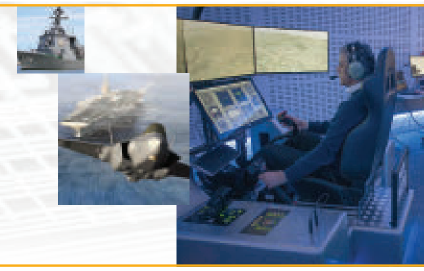

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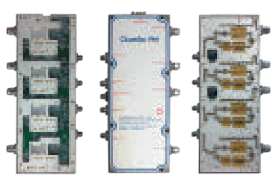

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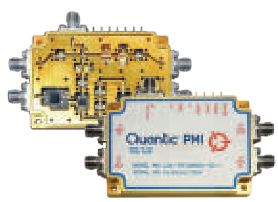

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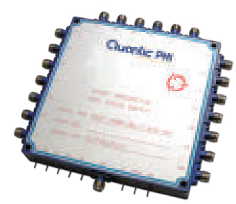

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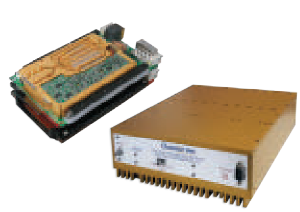

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Calendar *Courses & Seminars*

MARCH

AOC Virtual Series Webinar: Chinese Thinking on the Establishment of Information Dominance
March 2
2-3 p.m. EDT
www.crows.org

SIGINT Fundamentals
March 7-8
Denver, CO
www.pe.gatech.edu

AOC Virtual Series Webinar: Countering UAS Using EW and DEW Attack Vectors
March 9
2-3 p.m. EDT
www.crows.org

Aircraft Survivability
March 13-17
Shrivenham, UK
www.cranfield.ac.uk

AOC Virtual Series Webinar: SDR for Strategic COMINT Applications
March 23
2-3 p.m. EDT
www.crows.org

Counter-IED Capability
March 27-31
Shrivenham, UK
www.cranfield.ac.uk

Principles of Millimeter-Wave Radar EW
March 28-29
Atlanta, GA
www.pe.gatech.edu

APRIL

AOC Virtual Series Webinar: EMS as the Context of Military Operations
April 6
2-3 p.m. EDT
www.crows.org

Basic RF EW Concepts
April 11-13
Atlanta, GA
www.pe.gatech.edu

IR Countermeasures
April 11-14
Atlanta, GA
www.pe.gatech.edu

AOC Virtual Series Webinar: Coexisting or Clashing: 5G with Radar/Satellite
April 13
2-3 p.m. EDT
www.crows.org

Cyber Deception
April 24-28
Shrivenham, UK
www.cranfield.ac.uk

MAY

Threat Radar Systems
May 1-5
Atlanta, GA
www.pe.gatech.edu

AOC Virtual Series Webinar: 5G Non-Terrestrial Networks (NTN) – Technology Outlook and Evolution
May 4
2-3 p.m. EDT
www.crows.org

EW Data Analysis
May 15-18
Online
www.pe.gatech.edu

Military EW
May 15-19
Shrivenham, UK
www.cranfield.ac.uk

SIGINT Fundamentals
May 16-17
Atlanta, GA
www.pe.gatech.edu

AOC Virtual Series Webinar: Multifunctional Composite for Electromagnetic Shielding
May 18
2-3 p.m. EDT
www.crows.org

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SHORTFALLS

This month I'd like to talk about the challenges to preparing our forces to maneuver, fight and win in the electromagnetic operational environment (EMOE) and to solicit your thoughts.

To begin, I believe industry is focused correctly on developing the EW technologies and systems the warfighter needs. Large EW system manufacturers and small businesses with unique competencies are working together to produce incredible capabilities that help us keep pace with our potential adversaries. But where the rubber meets the road – in execution – our warfighters are extremely challenged to fight in this increasingly congested, contested and complex maneuver space.

Why is this? As we advocate across industry, defense, government and academia, our AOC Board members are perceiving a few common causes. First, our forces continue to be severely restricted as to when and where they can train to fight in the electromagnetic spectrum (EMS). The mantra, "train like you fight," is currently impossible in most training areas on land, in the air, or even at sea. We are also significantly behind in our capability to replicate EMOEs or conduct electronic attack (EA) missions with virtual and constructive training capabilities. (If you are working on this problem, the AOC would love to hear from you.)

Second, our Services are not organized around EW as a competitive career for our officer corps. Within the US Navy's surface warfare community, for example, EW officer billets are filled only by junior officers or mid-career enlisted – and for only transient periods. As a result, EW readiness in the surface navy is severely lacking. In naval aviation, an individual can focus their career as an EW professional through O-5 command (and a few opportunities beyond), but once selected for the potential to become a Flag officer, billets designed to take advantage of 20-plus years of EW expertise disappear. Despite the rapidly growing importance of Electromagnetic Spectrum Operations (EMSO) in every warfighting domain across the entire range of military operations, there is not a single designated Navy Flag billet to focus on EW as their primary mission responsibility. While these are Navy examples, I believe the other Services face similar challenges.

Third, and most importantly, our Services do not have a senior leader empowered with resources and held accountable for EW readiness and maneuver in any of the five warfighting domains. This has been highlighted and acknowledged as an issue for well over a decade, including in the DOD's 2009 EW Capabilities Based Assessment (CBA), but it has never been resolved. When Service budgets are built in the Pentagon each year, EW must have 3-star representation fully prepared to brief and advocate for EW priorities. Without measurable advancement in EW and EMSO leadership, career paths and realistic training, we will be relegated to continuing on the current fractured execution of EMS maneuver, risking warfighter lives, and unfortunately discovering critical EMS vulnerabilities only *after* conflicts begin.

Dissenting opinions are always welcomed. Please send your thoughts directly to me at president@crows.org. I look forward to the discourse. – *Brian "Hinks" Hinkley*

US ARMY SEEKS INDUSTRY INPUT FOR HIGH-ALTITUDE SIGINT AND RADAR SENSORS

The US Army's Project Director Sensors-Aerial Intelligence (PD SAI) has issued a Request for Information (RFI) seeking industry responses about current active and passive RF sensor capabilities for "different sized stratospheric platforms" that will serve as a sensing suite in Multi-Domain Operations (MDO).

The Army is developing new airborne sensor capabilities under its Multi-Domain Sensing System (MDSS) family of programs. This includes the High Accuracy Detection and Exploitation System (HADES) airborne ISR program, a manned aircraft that will replace the Army's fleet of RC-12 Guardrail signals intelligence (SIGINT) aircraft. Another part of MDSS is the High-Altitude Extended-Range Long-Endurance Intelligence Observation System (HELIOS), which will comprise various stratospheric platforms, such as balloons or solar-powered fixed-wing aircraft, fitted with electronic intelligence (ELINT), communications intelligence (ELINT) and radar sensors. By operating at higher altitudes than the Army's current airborne ISR systems, HADES and HELIOS will support the Army's deep sensing requirements for MDO.

As part of its HELIOS development program, PD SAI is initially conducting the High-Altitude Platform – Deep Sensing (HAP-DS) experimentation and demonstration effort. The RFI calls for information about currently available (TRL 6 and higher) ELINT, COMINT and radar sensors that can be integrated on a HAPS-DS platform and evaluated in anechoic chamber and/or flight tests in FY2025. Requested sensor information includes overall frequency range, geolocation frequency range and accuracy, signal sets covered by the sensor, pulse and signal density processed, field of view, system architecture standards and payload environmental specifications.

The contracting point of contact is Tianna Woods, 443.861.1919, e-mail tianna.woods.civ@army.mil. RFI responses are due by March 20. *– J. Knowles*

DSO'S JOINT EMBM ACQUISITION PLAN MOVES FORWARD

The Defense Spectrum Organization (DSO) has outlined the next stages of its plan to develop a Joint Electromagnetic Battle Management (EMBM-J) capability to support Electromagnetic Spectrum Operations (EMSO) at the Joint Force Commander (JFC) level, including Combatant Commands and Joint Task Force (JTF) elements.

Within the Defense Information Systems Agency (DISA), DSO is developing an EMBM-J system to help JFCs "in all activities related to organizing, understanding, planning, deciding, directing, and monitoring joint EMS operations (JEMSO)," according to a program description. Further, it states that Combatant Commands and JTF JEMSO Cells (JEMSOCs) "coordinate with Service Component EMS Operations (EMSO) staffs to enable situational understanding of the electromagnetic operational environment (EMOE), and prioritize, integrate, and deconflict Service electromagnetic spectrum operations (EMSO) plans for their assigned operational areas, across all domains, functions and technologic standards implementation. In an evolving and growing competitive environment, the traditional, manual, time- and labor-intensive methods of managing the myriad of electromagnetic emitters and apertures on the modern battlefield are no longer adequate. An EMBM system operating in command centers will allow commanders to coordinate, synchronize, and integrate EMS operations into the maneuver space across the full range of their military operations." The need for an EMBM-J system is also driven by "new spectrum dependent systems (SDSs) [that] will enable dynamic and autonomous maneuver in spectrum. Therefore, the design of this EMBM system must anticipate and account for current and unknown future EMS maneuver behaviors of SDSs. Joint Force Commanders will then achieve unity of effort resulting in EMS superiority."

The EMBM-J program is divided into four capabilities. The first increment, which focuses on Situational Awareness (EMBM-SA), has been under development by Expression Networks via a $121 million contract awarded in 2020. Hosted in the National Geospatial-Intelligence Agency (NGA) commercial cloud services (C2S) environment, the first EMBM-SA capability release is scheduled for delivery in the coming weeks.

The next EMBM-J increment, which calls for developing an EMBM Decision Support (EMBM-DS) capability, was outlined in a Request for Initial Presentation (RFIP) solicitation issued last month on behalf of DSO by Defense Information Systems Agency (DISA's) Emerging Technology Directorate. The RFIP seeks responses for an Other Transaction (OT) agreement under which a contractor will begin developing the EMBM-DS prototype that enables JFC-level JEMSOC end-users to "plan current and future EMS operations using the Joint Planning Process" and to "rapidly recommend well-informed spectrum operation decisions." As with EMBM-SA, the EMBM-DS capability will be hosted on NGA's commercial cloud services hosting environment and will be interoperable with EMBM-SA.

During the EMBM-DS selection process, DSO will task each selected bidder to conduct 30-day challenge demonstrations, after which it will select one or more companies to receive a Request for Project Proposals (RFPP) solicitation. DSO's goal is to receive a Minimum Viable Capability Release (MVCR) from the contractor within one year of initial selection and a completed prototype (MVCR plus two additional releases) six months later – a total development schedule of 18 months. After the prototype phase is completed, DSO could award a follow-on production contract to the developer. The contracting point of contact is Crag Carlton, (618) 418-6805, e-mail craig.j.carlton.civ@mail.mil. – *J. Knowles*

INDIA SHOWCASES DOMESTICALLY DEVELOPED EW SYSTEMS

The recently concluded Aero India air show, held in the Southern Indian city of Bengaluru, was witness to a growing range of domestically developed electronic warfare (EW) systems.

Among the items showcased were the Sarang electronic support measures (ESM) system developed for use on Navy Kamov Ka-31 Airborne Early Warning (AEW) helicopters and the Dhruti digital radar warning receiver (RWR) and Advanced Self Protection Jammer (ASPJ) pod developed for use on Indian Air Force (IAF) Sukhoi SU-30 MKI fighter jets.

India's Defence Research & Development Organisation (DRDO), the nation's lead defense research agency, runs its Navy EW/ESM projects under Programme Samudrika, with seven different systems in development. The airborne systems are Sarang, Sarakshi, Sarvadhari and Nikash, while the shipborne systems are Shakti, Nayan and Tushar.

The Sarang project was accorded the Acceptance of Necessity (AoN), which is the first step in the Indian procurement process, in January, this year. Work on the program had started in 2018. The ESM system intercepts, detects and identifies air/ground/shipborne radar emissions including short duration transmissions from submarines in the B-K frequency band, a DRDO official said, adding that the system had completed developmental trials, and User Evaluation Trials (UET) were now underway. The sensor information is presented on a single ruggedized laptop display.

Production versions of the Sarang heliborne ESM system will be built by state-owned defense public sector undertaking (PSU) Bharat Electronics Limited (BEL).

The Dhruti DR 118 digital RWR and ASPJ pod are under development at the Combat Aircraft Systems Development & Integration Centre (CASDIC) in Bengaluru. The new RWR is a form-fit replacement for the existing RWR on air force SU-30 MKIs. Following the completion of user trials, the IAF approved production of 129 systems. Manufacture of the digital RWRs was to have started in December 2022 by an Indian industry consortium of BEL, Data Patterns, Mistral Solutions, FLIC and Astra Microwave.

The pod-mounted ASPJ replaces a Russian-origin equivalent and will be installed as pods on the wing-tip stations of the SU-30 MKI. The official said the ASPJ pod structure had been developed and the system was presently undergoing qualification trials. The pod-mounted ASPJ features an Active Phased Array sensor, wide band digital receiver, ultra-wide band Digital Radio Frequency Memory (DRFM) and an in-built cooling system. – *A. Chandra*

IN BRIEF

The Air Force Research Lab's **Strategic Development Planning and Experimentation (SDPE) Office** has issued a Request for Information (RFI) seeking information about long-range air vehicles that can be used to deliver non-kinetic effects under its Rapid Dragon

Program. Begun in 2019, Rapid Dragon initially focused on showing how a transport aircraft, such as and C-130 or C-17, could deploy standard/legacy cruise missiles from a palletized deployment system. After successfully demonstrating the concept from an MC-130J in December 2021, "The program is broadening to include non-kinetic effects to be delivered via low cost, expendable air vehicles," according to the RFI. It also states, "SDPE is explicitly looking for a powered vehicle that will fit within the confines of an individual cell of the Rapid Dragon system, and carry a currently unspecified payload for vertical employment (downward). Range of at least 1000 nm is desired, with an open architecture that supports network and collaborative capabilities." Responses are due by March 17. The contracting point of contact is Dean Evans, e-mail dean.evans@us.af.mil.

Naval Air Systems Command has announced plans to award a sole-source contract to **L3Harris Technologies** (Clifton, NJ) to integrate the Adaptive Radar Countermeasures (ARC) Bootloader software into AN/ALQ-214A(V)4 RF Countermeasures (RFCM) systems, Full-Rate Production Lots 14-16. These will be installed on US Navy and Royal Australian Air Force F/A-18E/F Super Hornet aircraft.

The US Air Force's 350th Spectrum Warfare Wing, **513th Electronic Warfare Squadron (EWS),** is seeking alternative sources for non-personnel services to provide labor, materials, equipment, repair maintenance, and training and technical support for the Communication, Navigation, and Identification (CNI) Function Stimulator (CFS) in support of the 513^{th}'s US Reprogramming Lab for the F-35. The 513th EWS is soliciting capabilities statements from interested companies who can provide these types of support. Responses are due by March 9. The contracting point of contact is Logan Deming, e-mail logan.deming@us.af.mil.

US Army Futures Command (AFC), **Combat Capabilities Development Command (DEVCOM)** is soliciting White Papers from interested companies for its next Technology Gateway experimentation event, which is expected to begin in October 2023. Working in coordination with the Army's Rapid Capabilities and Critical Technologies Office (RCCTO), the specific areas of interest for this year's Technology Gateway are "network" and "joint contested logistics." Topics include "State-of-the-art Means to Defeat Targeting and Delivery Capabilities of Precision Munitions (Including Loitering Munitions & UAS)"; "Innovative Ways to Conduct Multi-Domain Obscuration and Maneuver in an 'Unblinking' Environment"; and "Emerging Means to Protect Forces from Threat Electromagnetic Warfare Capabilities." White Papers must be submitted by March 31. They will be reviewed separately for technical merit and for operational merit. Selected teams will participate in additional Technology Exchange Meetings (TEMs) and could be selected for live demonstrations at the Technology Gateway experimentation event. The contracting notice ID is W50RAJ23R0003.

The Air Force Research Laboratory, **Materials & Manufacturing Directorate, Nanoelectronic Materials Branch (AFRL/RXE)** (Wright-Patterson AFB, OH) has issued a Broad Agency Announcement (BAA FA8650-23-S-5012) soliciting proposals for its Materials for Integrated Nano-electronic and Opto-electronic Structures (MINOS) Program. As described in the BAA, the objective of the MINOS effort is to "develop and maintain competencies that enhance optoelectronic, photonic, and quantum materials; wide-bandgap semiconductors; ultra wide-bandgap semiconductors; magnetic, ferroic materials; digital and analog switching materials; as well as hybrid systems and electronic materials integration to enable next-generation effective and novel Intelligence, Surveillance and Reconnaissance (ISR) and Electronic Warfare (EW) systems for DAF applications." The MINOS BAA includes two initial task orders. Task Order 1 is titled "Research within the Optoelectronic Blueprint for Emergent Sensing Systems (ROBERSS)," and it covers development of quantum information and materials; non-linear structured optical systems; integrated photonics; and next generation optoelectronic sensing. Task Order 2 focuses on wide-bandgap and ultra-wide-bandgap semiconductors for power electronics; ferroic materials; digital and analog switching materials; and materials integration. The MINOS program is scheduled to run for seven years and is valued at $74.9 million. Proposals are due by March 17. The technical point of contact is Joseph Burns, Program Manager, AFRL/RXE, e-mail Joseph.burns.9@us.af.mil. The contracting point of contact is Lorie Walther, e-mail Lorie.walther.2@us.af.mil.

The Australian Government announced last month that it has awarded **CEA Technologies** (Canberra, Australia) a A$277 million (US$192.1 million) contract to upgrade portable and fixed-site threat emitters at EW training ranges. The contract will include a number of fixed and portable emitters to support training exercises and strengthen capability across the joint force. The contract represents the first award under Project AIR 5349 Phase 6 - Advanced Growler. Subsequent Phase 6 contracts will cover cooperative development of the Next-Generation Jammer weapon system with the US Navy to gradually replace the Growler's ALQ-99 Tactical Jamming System; aircraft modifications including sensor upgrades; anti-radiation missile war stocks; new longer-range and more advanced anti-radiation missiles (AARGM-ER); and facility upgrades to the Delamere Air Training Area, near Katherine in the Northern Territory and RAAF Base Amberley near Brisbaine. RAAF Base Amberley hosts No. 6 Sqn, which operates, trains and maintains the EA-18G fleet. Phase 6 has an approved budget of over A$2 billion.

NaThe US Army Research Lab's Sensors and Electron Devices Directorate (SEDD), Electronic Warfare (EW) Branch (FCDD-RLS-EW), announced plans to award a one-year sole-source contract to

Electronic Warfare Associates (Herndon, VA) for maintenance and engineering services for its Advanced Electronic Warfare Laboratory (AEWL) Radar and Target Emulator (RATE) System. According to an AEWL program description, "The overall objective of the AEWL RATE project is to develop a prototype laboratory that will allow the Government to evaluate the technical feasibility of utilizing a reconfigurable and extensible EW hardware-in-the-loop laboratory architecture as a replicable framework that may be duplicated at Government Research and Development (R&D) facilities across the nation. The AEWL is a laboratory facility containing a variety of radio frequency (RF) equipment and accompanying software configured in a manner appropriate to evaluate emerging EW subsystem and system prototypes. This particular configuration of specialized hardware and software does not currently exist anywhere else in the Government." It also states, "ARL hosted the first instantiation of the AEWL RATE and is assessing its capability to evaluate a variety of emerging EW prototypes currently under development. If the AEWL RATE proves successful in evaluating these prototypes, replication and/or improvement of the AEWL RATE concept will be possible for other Government organizations to share a common framework, language, and hardware/software configuration for testing and evaluating emerging EW subsystem and system prototypes." EWA helped develop the AEWL under a $12.4 million OTA contract awarded via the National Spectrum Consortium in 2016.

The Defense Advanced Research Project Agency (DARPA), **Microsystems Technology Office (MTO),** has issued a Broad Agency Announcement (BAA HR001123S0019) for its Miniature Integrated Thermal Management Systems for 3D Heterogeneous Integration (Minitherms3D) program. According to a DARPA program description from the BAA, "Minitherms3D program seeks to revolutionize thermal management for three-dimensional heterogeneous integration (3DHI). This program seeks to significantly reduce thermal resistances within the 3D stack and external to the stack of 3DHI systems, while increasing volumetric heat removal." The solicitation seeks, "…innovative proposals for the research and development of compact thermal management technology scalable to an arbitrarily large number of high-power tiers in a 3D Heterogeneous Integration (3DHI) chip stack. Specific program goals include: 3D stacking of five tiers with total heat dissipation > 6.8 kW (compared to 1 kW for single tier state-of-the art (SOTA) logic die today) with the heat rejection system limited to <0.006 m^3 (> 2X smaller than SOTA)." The program is organized into three phases, and program officials intend to award up to six contracts for Phase 1 (18 months) and then downselect to four contractors in Phase 2 (18 months) and then three contractors for Phase 3 (12 months). Prototypes will be delivered near the end of each phase. The anticipated program budget is $69 million over four years. Proposals are due by April 11. The technical point of contact is Dr. Yogendra Joshi, Program Manager, MTO, e-mail HR001123S0019@darpa.mil.

Speak Over the Noise: Electromagnetic Spect

By Cmdr. Michael "Quatto" Posey, USN

Learning how to optimize human-machine teaching is critical to future EMSO concepts. USAF PHOTO

The promise of employing artificial intelligence (AI), specifically machine learning (ML), to enable predictive electromagnetic warfare (EW) sounds seductive. Imagine a machine knowing how, when and where to jam before the best EW operator can even process information from her scope. However, some operators hesitate to endorse cognitive EW, picturing misguided algorithms leading to faulty, life-threatening failures, like those that lead self-driving cars to crash. To prevail in a congested electromagnetic spectrum (EMS), humans must learn to trust ML algorithms in high-stakes situations like combat. Therefore, cognitive EW, the idea of ML paired with signal processing, classification and automated responses, should be at the forefront of how the EMS community evolves.

Future contests will require agile, adaptive spectrum management and the ability to hop frequencies faster than human cognition. Cognitive EW offers the electromagnetic spectrum operations (EMSO) community a reduced operator workload in the contested, congested EMS battlespace. Further, without ML algorithms, the Joint Force risks being outmaneuvered in the EMS by adversar-

Imagine a machine knowing how, when and where to jam before the best EW operator can even process information from her scope.

The Case for Cognitive rum Operations

ies. Therefore, cognitive spectrum management against a peer threat will prove indispensable as the DOD employs Joint All-Domain Command and Control (JADC2) and Multidomain Operations (MDO) as part of the Joint Warfighting Concept. Warfighters should embrace cognitive EMSO – EW and spectrum management – as the DOD must leverage ML in all aspects of EMSO to win. The Services should prioritize cognitive EMSO because agile spectrum management is essential to realizing an AI-enabled JADC2 ability. Further, the DOD needs to act now in developing software and collecting monstrous amounts of data for cognitive EMSO, a natural computational marriage of signal processing

EW ranges will play an important role in helping to fine-tune ML algorithms. USSOCOM PHOTO and ML, to see where potential flaws may be and how to optimize the human-machine teaming. Developing the technology and human-machine trust for cognitive EMSO is essential for successful JADC2.

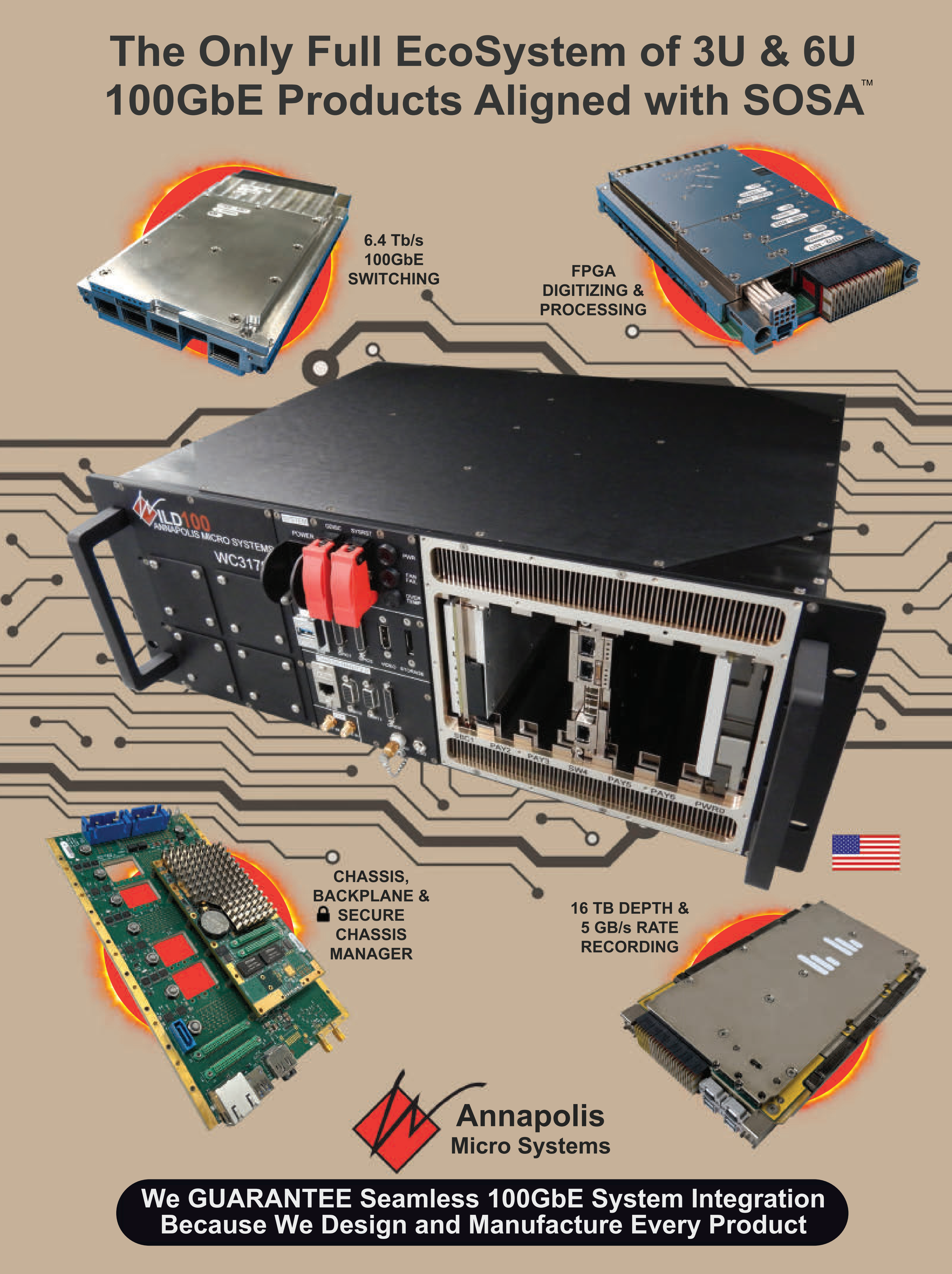
JADC2 is the DOD's concept to connect sensors from all military services – Air Force, Army, Marine Corps, Navy and Space Force – into a single network. JADC2 underpins the Joint Warfighting Concept, allowing commanders to make better decisions by leveraging AI to assist with shooter-to-target pairing and keep situational awareness of the battlespace. The EMS creates the bonds between sensors, shooters and commanders that make JADC2 perform. Further, the EMS enables crucial coordination for MDO, especially as we leverage assets in space and cyberspace. In many graphics of JADC2, artists depict the connections among all the various US and coalition assets with lines, lightning bolts or arcs. How do we ensure these all-important lines, the connective tissue of the Joint Force, remain intact?

To prevail in a congested electromagnetic spectrum (EMS), humans must learn to trust ML algorithms in high-stakes situations like combat.

Reprogramming centers, which have always been a part of EW, will continue to play a central role providing the emitter data that will help algorithms to quickly learn (and re-learn) threat behaviors. 350TH SWW PHOTO

The EMS is increasingly crowded and complex. In a contested environment, it is beyond human cognition to find available operating frequencies, especially given the speed of dynamic threat jamming systems. In conflict, the EMS will crowd with friendly and adversary active monostatic and multi-static radars, communications, passive sensors and electromagnetic attack systems, all propagating in various weather and terrain settings. The EMS picture will be far too complex for a human to make sense of during a mission. Further, a peer adversary could have electronic attack capabilities we have yet to discover and catalog. We need predictive, agile systems to combat these nascent

Without ML algorithms, the Joint Force risks being outmaneuvered in the EMS by adversaries.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Cognitive EMBM resources will utilize a combination of manned and unmanned weapons systems as sensors and effectors. US NAVY PHOTO

(or hidden) capabilities and make sense of the complex EMS environment in combat. These sorts of systems require ML. Sensors and shooters can communicate through the congested EMS by allowing machines to find available bandwidth in the spectrum and shift assets to available frequencies dynamically and faster than the adversary. ML can recommend and operate predictive frequency-hopping and jamming avoidance when required. Without the ability to predict denied EMS zones, the maneuverability of communications against a peer competitor will not exist. Adversaries will still find a way to jam some communications. Still, DOD should enable ML processing to seek available pockets of the spectrum and make it challenging for the adversary to deny our communications. Doing so will increase the number of Joint Force assets that remain connected, thereby increasing the warfighter's ability to deliver lethal and non-lethal fires upon the adversary.

As the DOD and industry develop cognitive EMSO tools, operators will become comfortable with tactical-level ML and operational-level Electromagnetic Battle Management (EMBM) systems in a dynamic environment. While the Joint Force trains and operates, their sensors can build large databases for complex predictions. Data scientists will need a significant amount of time to wrangle the vast amounts of information that friendly forces will collect. Additionally, DOD will need to

The DOD needs to act now in developing software and collecting monstrous amounts of data for cognitive EMSO, a natural computational marriage of signal processing and ML.

Commanders will rely on cognitive EMBM systems to provide a deeper picture of the battle space. Above, service members assigned to the 7th Air Support Operations Squadron, Fort Bliss, TX, and 729th Air Control Squadron, Hill Air Force Base, UT, conduct operations at the Tactical Operations Center-Light (TOC-L) during Project Convergence 22 experimentation at March Air Reserve Base, CA, in 2022. US ARMY PHOTO

model many system parameters it cannot yet mimic at ranges and input these signals manually. This time-intensive process of collecting, tagging, and conditioning signal data must begin as soon as is feasible. Cognitive EMSO's return on investment without labeled, groomed data will yield suboptimal results. Hence, the DOD and industry must partner to develop the databases now.

Building the database so that machine learning can begin will take years. Tesla, a luxury electric automobile company, took years to develop its fully self-driving feature. Tesla's ML-assisted driving ability required thousands of petabytes of data from its one-million vehicles on the road. Cognitive EMSO will likewise face a daunting challenge in collecting the data warehouses and data lakes required for ML. Once engineers, warfighters and computer scientists build signal databases, supervised learning can begin. Supervised learning uses a large sample of positive and negative examples labeled by human experts to train the system.

Surveying experts, like USN weapons and tactics instructors and USAF weapons school graduates, to wrangle and tag data fed into the supervised learning process will likewise be time intensive. Teams must test many algorithms, not just the fashionable deep-learning neural networks. In this battlespace,

Cognitive EMSO's return on investment without labeled, groomed data will yield suboptimal results. Hence, the DOD and industry must partner to develop the databases now.

being fast will often trump complete accuracy. In other words, simple computations may prove better in many circumstances. To best fine-tune ML algorithms, computer scientists must spend years with tactical experts and intelligence analysts at EW ranges and in simulations. Both computer scientists and tactical EMSO experts need time to alter and adjust scenarios, hypothesize what equipment will be on the battlefield, and develop rewards for unsupervised learning. While unsupervised learning usually takes longer, it can often produce surprising efficiencies. Data scientists and EMSO experts should work in teams in the lengthy process of collecting the necessary data, tagging and conditioning that data, and developing and refining algorithms in various scenarios. Doing so will set up the Joint Force to anticipate and overmatch adversary actions in the EMS.

Although some may be hesitant to adopt cognitive EMSO, because they note how AI fails us unexpectedly and can make humans too reliant on the machine, that is why it is imperative to adopt cognitive EMSO today. Let Joint warfighters, our closest allies, computer scientists and engineers, begin to find out where those flaws are to repair and mitigate them. Software-based capabilities like MissionWare, are an ideal proving ground for ML-assisted EMSO. David A. Mendell argues in several well-thought-out examples in "Our Robots, Ourselves" that as we create automated systems, we never pull humans out of the OODA loop. Instead, we change the workload between the operator and the machine and the relationship between humans and computers. As human-machine teams become more proficient in cognitive EMSO, we can better see a clear path forward to an AI-enabled JADC2. ML-assisted spectrum management will take time, but the outcomes will enable the C2 functional battle of the Joint Warfighting concept. The Joint Force will optimize high-demand, low-density electromagnetic resources by reducing operators' computational workload in a congested, contested, and commercial battlespace. In addition, adding ML to EMSO will enable agility and convergence in the spectrum. The Joint Force should push for material solutions that facilitate and build cognitive EMSO capability today.

About the Author

Cmdr. Michael Posey is an active-duty US Navy officer and an instructor at the US Army War College. This article is his opinion and does not represent the views of the United States Army, the United States Navy or the Department of Defense.


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JCER: Ensuring a 'JEMSO Ready' Force

By Steven "Beaker" Baxter

"In today's modern battlefield, the joint force has to achieve electromagnetic spectrum superiority. We have gotten used to a process designed for permissive environments that are intended to minimize programmatic and technical risk at the expense of operational risk. One of my big functions inside the EMSSS I-Plan is to bring the operational risk component back into the department processes," Adm. (Ret.) Charles Richard, Commander, US Strategic Command (November 2019 – December 2022) quoted in *Department Prioritizes Electromagnetic Spectrum Superiority, Implementing 2020 Strategy,* August 2021.

In the 2020 Department of Defense Electromagnetic Spectrum Superiority Strategy (EMSSS), then-Secretary of Defense Mark Esper stated: "The Nation has entered an age of warfighting wherein US dominance in air, land, sea, space, cyberspace and the electromagnetic spectrum (EMS) is challenged by peer and near peer adversaries. These challenges have exposed the cross-cutting reliance of US Forces on the EMS and are driving a change in how the DOD approaches activities in the EMS to maintain an all-domain advantage."

Embedded in that statement are implied questions: "How do elements of the Joint Force know they are adequately trained, prepared and capable of maintaining an all-domain advantage?" Furthermore, in a world where the EMS is "challenged by peer and near peer adversaries," how does a Combatant Commander know the joint forces arriving in theater to "fight tonight" are capable of fighting and winning in Joint Electromagnetic Spectrum Operations (JEMSO)? And as Admiral Richard's statement implies, what risk to mission and force is the Combatant Commander accepting if Joint Forces are not JEMSO ready?

To address those (and other) questions, the DOD EMS Superiority Strategy clearly identified objectives to attain five strategic goals. Objective 3.3 is aligned to *Goal 3: Pursue Total Force EMS Readiness* and specifically points to the question, "How will Joint Forces know they are 'JEMSO-ready?'" It states:

OBJECTIVE 3.3: EVALUATE AND TRACK EMS READINESS

"Total force readiness in the EMS will be grown, tracked, and sustained. DOD Components will be evaluated to ensure they are prepared for their missions. Achieving EMS readiness in complex EMOEs [Electromagnetic Operational Environments] requires demonstration of effective operation and integration of DOD EMS-based tools and capabilities. Periodic individual and unit-level training, joint force exercises, rehearsals and wargames must occur under, or simulate, realistic operational conditions (live, virtual and constructive modes) and must integrate all EMS capabilities and challenges, including interference and jamming scenarios."

This begs the question: Who will be the evaluator to determine when EMS readiness in complex EMOEs is achieved? *Answer: The Joint Center for Electromagnetic Readiness (JCER).*

The organization known today as JCER began as a Joint Test and Evaluation project in 2007 and was born out of a response to the 2004 COPE INDIA wake-up call; it was then known as the Joint Electronic Protection for Air Combat (JEPAC). JEPAC had a narrowly focused, air-centric charter to "improve integration of operational and tactical weapon systems with air combat aircraft to enable effective air combat operations in an advanced electromagnetic attack environment." It was DOD's answer to decisive air combat advantages of digital radio frequency memory technology versus US front-line fighter aircraft.

Results of that three-year program were so impressive the DOD made the decision to continue the organization's lifespan and expand its mission in 2010. No longer solely focused on the air domain, JEPAC changed its name (but kept the same acronym) to become "Joint Electromagnetic Preparedness for Advanced Combat." The re-imaged JEPAC mission was broadened to "conduct and support assessments and joint operational testing/evaluation of EMS-dependent capabilities to enhance combat effectiveness across the warfighting domains."

For the next 10 years, JEPAC partnered with the Services and Combatant Commands to identify JEMSO capability gaps and vulnerabilities, support development of DOTMLPF mitigation strategies, validate solutions and enhance combat capabilities across the EMS for air, ground, sea, space and cyber.

During that time (2010-2020), it became clear potential adversaries around the globe were investing heavily in capabilities utilizing the electromagnetic spectrum. Weapon system improvements designed to leverage improved capabilities inevitably led to improved tactics to challenge existing US EMS superiority. Joint Publication 3-85, written in May 2020, defines EMS

Superiority as, “That degree of control in the EMS that permits the conduct of operations at a given time and place without prohibitive interference, while affecting the threat’s ability to do the same.” That “degree of control” for Joint Forces was becoming increasingly tenuous.

The words spoken by Soviet Admiral Sergei G. Gorshkov in 1973 were heard loud and clear: “The next war will be won by the side that best exploits the electromagnetic spectrum.”

In answer to the Secretary of Defense’s October 2020 call and to signal our alignment with his intent, the organization previously known as JEPAC became the Joint Center for Electromagnetic Readiness (JCER) in January 2021.

HOW WILL WE KNOW THE JOINT FORCE IS “JEMSO-READY”?

To ensure DOD components are prepared for their missions, JCER teams will continue to participate in periodic individual and unit-level training, joint force exercises, rehearsals and wargames. Significantly, JCER participation will now *evaluate and assess readiness* of joint/operational JEMSO capabilities and identify gaps and limitations in the abilities of Joint Forces to prevail in great power conflict. To do that, our assessments will be supported by established joint criteria (Universal Joint Tasks) and must occur under realistic operational conditions, whether live, virtual and/or constructive. All EMS capabilities and challenges, including interference and jamming, should be integral with the events.

To substantiate findings, JCER will continue to deliver timely, relevant assessment results. After-action reports from JCER will enable data-driven decisions and capability investments to aggressively attack and exploit joint capability gaps and limitations using threat representative methods. Partnering with other entities, JCER will pursue and advocate for cutting-edge technology to enable robust JEMSO-focused assessments today and beyond.

Clearly, we have “entered an age of warfighting wherein US dominance in air, land, sea, space, cyberspace, and the electromagnetic spectrum (EMS) is challenged by peer and near peer adversaries.” For more than 20 years of military operations around the globe, US forces have operated with nearly unlimited freedom of action in the electromagnetic spectrum. Those days are over; Joint Forces called to respond to any threat today or tomorrow must be JEMSO-ready before they cross the line of battle. Victory, as implied by Admiral Gorshkov nearly 50 years ago, will require an unwavering focus on attaining EMS superiority in every warfighting domain. The Joint Force and Combatant Commanders must be confident they have attained the skills necessary to prevail against any adversary. The Joint Center for Electromagnetic Readiness will play a key and essential role to ensure they can.

About the Author

Steven “Beaker” Baxter is a technical advisor for the Joint Center fo Electromagnetic Readiness. During his 33-year career in the US Navy, he was an EW instructor for EA-6B air crews at VAQ-129, and later served in various positions, including Operations Director and Deputy Information Warfare Commander, and Carrier Strike Group Chief of Staff and Information Warfare Commander.

Electromagnetic Protection (Part 11)

Pulse Doppler Radars *Cont'd.*

By Dave Adamy

Picking up where we left off from last month's column, we are going to talk a little more about range jamming, more specifically range gate pull-off (RGPO). Consider Figure 1: a radar pulse reaches its target, and it is rebroadcast from a jammer on the target with gain. The stronger jamming pulse overwhelms the skin return pulse from the target. This figure shows what happens at the radar. The radar processor has an early and late gate. When the timing of those gates is adjusted to balance their received power, the transition between the two gates is taken by the radar processor to be the time of arrival of the pulse. Subsequent jammer pulses are delayed, so the two gates are delayed. The delay of the pulse is interpreted by the radar as an increase of the distance from the radar to the target. Thus, the radar assumes the target is moving farther away. Since the radar is tracking the jamming pulses rather than the radar's return pulses, the radar has lost range track on the target. A jammer using the RGPO jamming technique receives each radar pulse and generates a jamming pulse delayed by an increasing amount, as shown in the figure. The radar concludes that the range to the target is greater than it actually is.

As shown in Figure 2, the radar's resolution cell is centered on the target when there is no jamming. The resolution cell is the area in which the radar cannot resolve multiple targets. If there are two signals within this area, the radar processor averages their locations, proportionally closer to the stronger signal. The (stronger) jammer pulse captures the radar's attention, and the radar moves the resolution cell to keep the jamming signal centered in the cell. The resolution cell then remains centered on the false target generated by the jammer as the jammer signal delay is increased – until the true target is completely out of the cell. At this point, the radar does not see the real target at all. The jamming signal delay reaches a maximum and then snaps back to zero. This leaves the radar looking at empty sky, so it concludes that there is no target. Without a target, the radar returns to the search mode and does not fire a missile.

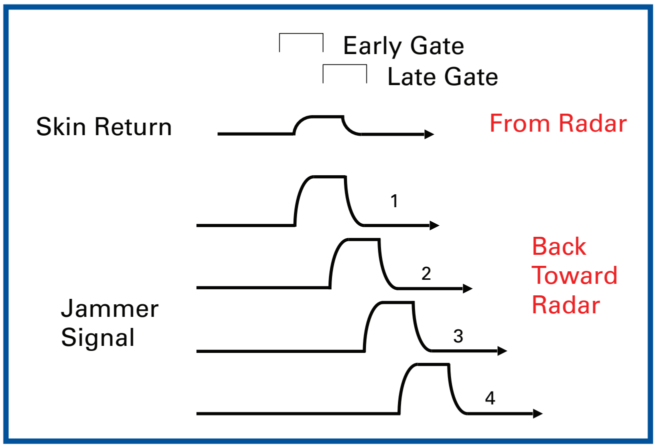


Fig. 1: *A jammer using RGPO techniques returns a pulse that is strong enough to overcome the radar skin return and delays each pulse to make the radar processor think the target is moving farther away.*

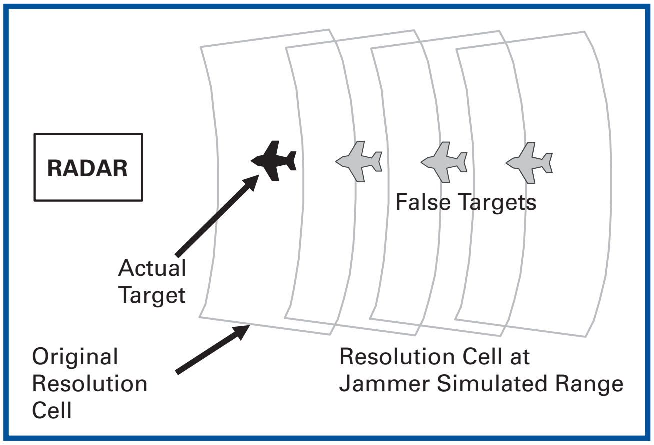


Fig. 2: *As the jammer causes the range measurement to increase, the resolution cell moves farther away from the radar and leaves the actual target location.*

As described last month and shown in Figure 3, the direct measurement of the frequency of the return signal by the pulse Doppler (PD) radar allows the radar to determine which return signal is accurate and which is the jamming signal. The actual return is qualified by the fact that the rate of change in range is consistent with the Doppler shift as shown in Figure 3.

RGPI

A different jamming technique, range gate pull-in (RGPI), makes the radar think that the target is closer than it actually is.

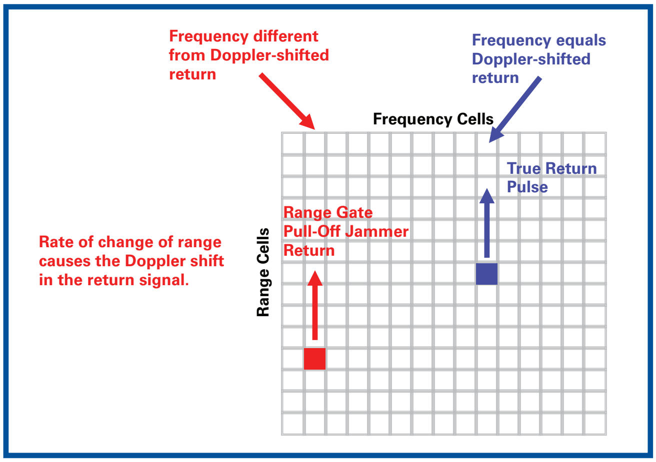


Fig. 3: *A non-pulse-Doppler radar calculates the range to a target by the time of arrival of the return pulse. The pulse Doppler radar measures the actual return frequency, which is consistent with the actual rate of change of range. Since the jammer frequency is different from the Doppler-shifted actual radar return, the pulse Doppler radar can reject the jamming signal.*

As shown in Figure 4, this technique requires that the jammer anticipate the return pulse and generate a jamming pulse by an increasing time increment. Figure 5 shows the resolution cell being moved away from the true target toward the radar. Like RGPO, the RGPI jamming technique extends the anticipation amount to a maximum and then snaps back to zero anticipation – leaving the radar looking at empty sky and preventing a missile launch. This jamming technique is also vulnerable to the separating target detection feature of the pulse Doppler radar. Again, the radar processor correlates the rate of change in range with the measured Doppler shift of each of the multiple pulses in the range vs. frequency matrix. Range tracking uses the return for which the rate of change of range is consistent with the measured Doppler shift.

This anticipation of the return pulse is generated by use of a "PRF tracker." The jammer determines when the next pulse will be generated and outputs its false pulse with the correct (increasing) anticipation. This is fairly simple when the radar has a fixed pulse repetition frequency (PRF). It can also be accomplished if the radar has a staggered PRF with a small number of pulse intervals. However, if the pulse train has a very large number of pulse-to-pulse intervals or a random staggered pulse interval, the PRF tracking task is all but impossible. This means that there is a second electromagnetic protection measure available to counter RGPI: that is to use a complex pulse modulation.

JAMMER LATENCY

A jamming system's processor has a latency that delays the jamming pulse, thus creating a minimum time between the moment a radar receives a return pulse and the moment it receives a jamming pulse. In order to capture the radar with an artificially delayed or leading jammer pulse, the initial time between the real return pulse and the jamming pulse must be fairly short; otherwise the radar will continue to track the true return. After the jamming pulse captures the attention of the radar processor, the jammer causes the radar to move its range determination far away from the true return and thus cause the radar to lose range track. If the latency is too great, the jammer will never capture the radar's signal and cannot create effective jamming.

In a later column, we will return to this subject regarding jammers that employ a digital RF memory (DRFM).

ANTI-DOPPLER PULL-OFF

Anti-Doppler pull-off is an important jamming technique that involves capturing the radar receiver and moving it away from the frequency of the return signal. This technique can be used against either continuous wave (CW) or pulsed radars. Figure 6 shows this technique used against a CW radar. A strong CW signal is transmitted to a radar and captures its receiver. In the figure, "velocity gate" means the bandwidth of the receiver and any software driven limitations to signal frequency acceptance. Then the jamming signal is moved away from the frequency of the return signal. Once the return signal is out of the "velocity gate," the radar can no longer track the target, so jamming is effective.

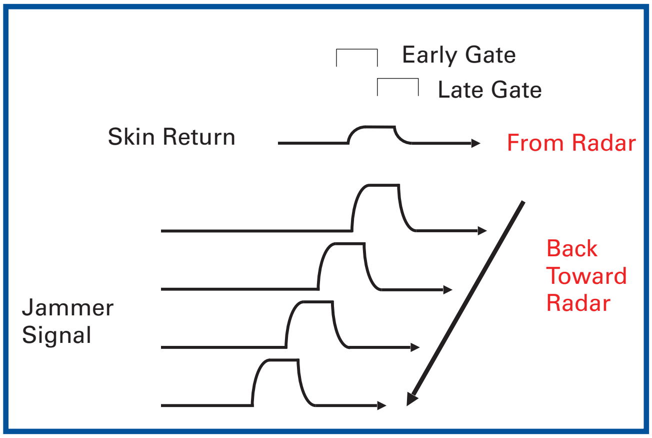


Fig. 4: *A jammer using RGPI techniques returns a pulse that is strong enough to overcome the radar skin return and anticipates each pulse to make the radar processor think the target is moving closer to the radar.*

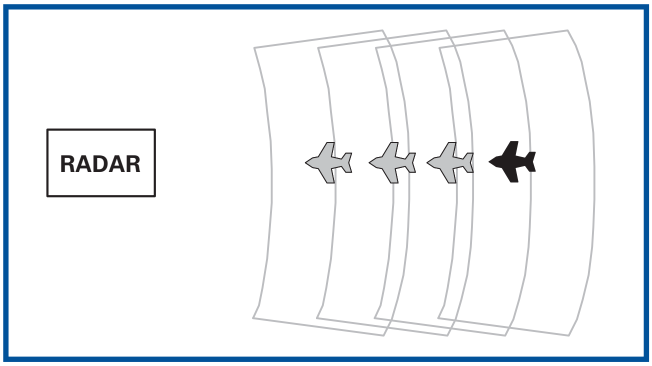


Fig. 5: *The RGPI jammer causes the radar processor to conclude that the target is closer to the radar than it actually is. As the anticipation of the true radar return pulse increases, the resolution cell moves closer to the radar and leaves the actual target location.*

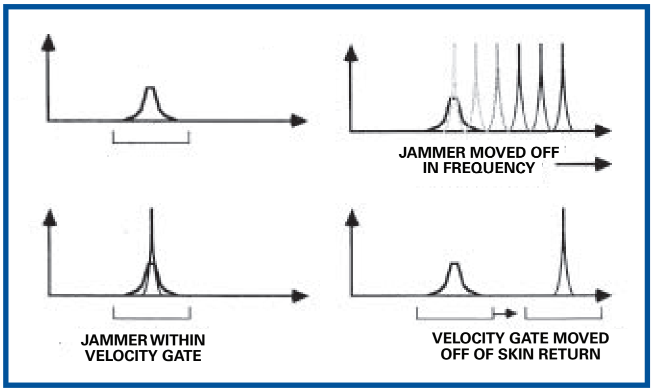


Fig. 6: *An anti-Doppler pull off or "frequency gate stealer" places a strong signal on top of the frequency of the return signal. Then, it moves the jamming signal away from the return signal frequency, which causes the radar to lose track on the target.*

Since the pulse Doppler radar can see multiple returns, it can reject the jamming signal and continue to track the true return signal.

WHAT'S NEXT

Next month, we will discuss pulse compression EP techniques. Dave Adamy can be reached at dave@lynxpub.

IMPORTANT DATES FOR AOC MEMBERS

2022 AOC AWARDS WILL OPEN MARCH 1 – APRIL 30

A central tenet of the AOC's mission is recognizing individuals, groups and military units for their outstanding performance in furthering the aims of the AOC and the Electromagnetic Warfare enterprise. The AOC has a number of awards that are available each year.

For more information, visit crows.org/awards.

AOC SCHOLARSHIP PROGRAM

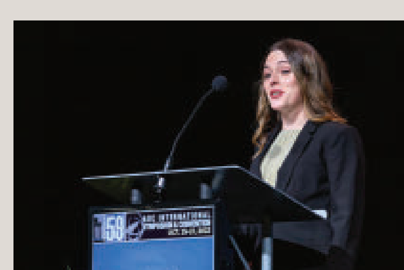
Undergraduate Scholarship for Sophomores and Juniors Dates: Feb. 15 – April 1

AOC currently provides two scholarships to students currently in their sophomore or junior year of college. Each year one male and one female student studying in engineering or engineering technology and interested in working in the aerospace and defense industry is awarded a scholarship. A generous donation from Raytheon Intelligence & Space funds these scholarships. We are seeking other industry partners to participate as well to grow our program further.

For more information, go to crows.org/scholarshipprogram.

FUTURE 5

Each year, the AOC Education Foundation recognizes five young professionals as the Future 5, showcasing those who actively innovate and strive for excellence as they build their careers in the EMS/EW/IO industry. Future 5 will elevate your professional image by being recognized as the next generation of leaders and five of the brightest and most talented young professionals in the EMSO community. Have the opportunity to connect with peers and expand your global network. 2023 Applications Open May 1 — June 30. Applicants must be 29 or younger by Dec. 31 of the year of application and be employed full-time in the EMS/EW/IO industry.



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