ASSOCIATION OF OLD CROWS
Advancing Electromagnetic Warfare TOGETHER
crows.org

August 2021 Vol. 44, No. 8

JED

Journal of Electromagnetic Dominance

Realizing the US Navy's EMW Vision

- Technology Survey: Benchtop Spectrum Analyzers
- News: German Air Force Selects SIGINT Aircraft
- EW 101: 5G Comms - Military Applications

JED
Journal of Electromagnetic Dominance

CONTENTS

August 2021 • Volume 44, Issue 8

In 2014, the US Navy introduced its Electromagnetic Maneuver Warfare (EMW) concept, which it saw as vital to achieving maritime dominance. This month, JED *discusses how far the Navy has journeyed on the path toward achieving its EMW vision.* US NAVY

COVER PHOTO COURTESY OF US NAVY

US Marine Corps LCpl Sydney Rogers, USMC, a SIGINT analyst with 3d Marine Division, collects signals with a VROD during May's Jungle Warfare Exercise (JWX) in the Northern Training Area on Okinawa, Japan. JWX pitted two reinforced infantry companies against each other, one from 2d Reconnaissance Battalion, 2d Marines, the other from 3d Reconnaissance Battalion, 3d Marines. JWX simulated a realistic fight across multiple domains in distributed jungle and littoral environments. USMC PHOTO BY LANCE CPL. UJIAN GOSUN

Departments

COLLABORATION AND INNOVATION

This year, the venerable microwave power module (MPM) is celebrating its 30th birthday. Conceived by the Naval Research Lab in 1989, a DOD Tri-Service (Army, Navy, Air Force) Science and Technology (S&T) initiative began awarding contracts to develop MPMs just two years later. This led to the further development of wideband MPMs for radar jamming applications, and today power amplifier makers are pushing their performance envelope into higher and higher frequency ranges – beyond 40 GHz.

In many ways, the MPM's success story represents why the DOD's Science and Technology (S&T) community has been so good at enabling US Forces to maintain their technological advantage for the past 80 years, especially in EW. What made the MPM effort work so well was collaboration. First, the Naval Research Lab explored the MPM concept, and then it shared this concept with the other Service labs, which were also looking for a new power amplifier technology for their Services' jamming systems. Within two years, the Service labs got together, agreed to share the MPM development costs and incubated the technology via development contracts with defense companies. Once initial MPM development was completed, the DOD transferred the MPM technology to industry, which has continuously extended its performance envelope and tailored it for various EW, radar and communications applications. The MPM program is just one example of S&T collaboration. DARPA and the Service labs have worked together on EW technology very efficiently over the past several decades – achieving tremendous innovation success for relatively modest levels of investment and keeping the US technologically ahead of its competitors.

In other ways, however, the MPM is an artifact from a simpler S&T ecosystem. When the MPM was developed, the S&T community did not have a difficult time explaining its operational value (more jamming power in a smaller SWAP package) to EW system developers and buyers. As a follow-on to traveling wave tube (TWT) technology, the MPM's advantages were easily understood, and it has been widely adopted as a result.

Today, the S&T community faces a more complex challenge, because many of the DOD's weapons system designs are so old that the follow-on solutions are not so obvious. For the user or the buyer, this can make it difficult to recognize the operational value of new "leap ahead" or "next generation" technologies. (If you have only ever driven a 1970 Chevy Impala, you may struggle to understand the utility – as well as the price tag – of a Tesla Model S.) As a result, the S&T community finds itself engaging in more collaboration with the operational community in order to better understand the operational challenges the warfighter needs to solve. DARPA and the Service labs then develop technologies to address these emerging problems and collaborate with the users to help them see some of the ways they can exploit these new technologies and develop new tactics, techniques and procedures around them. This is collaboration on a completely different scale than the days of the MPM, and we need more of it if the DOD is going to innovate at the same pace as its potential adversaries. – *J. Knowles*

JED

Journal of Electromagnetic Dominance

EDITORIAL STAFF
Editor: John Knowles
Publisher: John Bacon
Senior Editor: John Haystead
Managing Editors: Hope Swedeen & Monica Elliott
Technical Editor: Barry Manz
Threat Systems Editor: Doug Richardson
Contributing Writers:
Dave Adamy, Luca Peruzzi, Richard Scott, Dr. David Stoudt, and Andrew White
Proofreaders: Ken Janssens, Shauna Keedian
Sales Manager: Kira Krewson
Sales Adminstrator: Alexandra Lewis

PRODUCTION STAFF
Layout & Design: Barry Senyk
Advertising Art: Elaine Connell
Contact the Editor: (978) 509-1450, JEDeditor@naylor.com
Contact the Sales Manager:
(770) 810.6982 or kkrewson@naylor.com
Subscription Information:
Please contact Glorianne O'Neilin at (703) 549-1600 or e-mail oneilin@crows.org.

Journal of Electromagnetic Dominance is published for the AOC by
NAYLOR ASSOCIATION SOLUTIONS
1430 Spring Hill Road, 6th Floor
McLean, VA 22102
Tel (800) 369-6220
www.naylor.com

COVER PHOTO COURTESY OF US NAVY
PUBLISHED JULY 2021/JED-M0821/3389

Calendar *Conferences & Trade Shows*

AUGUST

Navy League Sea-Air-Space
August 1-4
National Harbor, MD
www.seaairspace.org

Technet Augusta 2021
August 16-19
Augusta, GA
www.afcea.org

36th Space Symposium
August 23-26
Colorado Springs, CO
www.spacesymposium.org

SEPTEMBER

MSPO 2019
September 7-10
Kielce, Poland
www.targikielce.pl

Satellite 2021
September 7-10
Washington, DC
www.satshow.com

AAAA Aircraft Survivability Equipment Symposium
September 13-14
Kissimmee, FL
www.quad-a.org

DSEI
September 14-17
London, UK
www.dsei.co.uk

AFA 2021 Air, Space and Cyberspace Conference
September 20-22
National Harbor, MD
www.afa.org

Modern Day Marine
September 21-23
Quantico, VA
www.marinemilitaryexpos.com

2021 EW Live
September 28-30
Tartu, Estonia
www.electronic-warfare-live.com

OCTOBER

AOC Europe
October 11-13
Liverpool, UK
www.aoceurope.org

AUSA 2021
October 11-13
Washington, DC
www.ausa.org

10th Annual AOC Pacific Conference
October 18-22
Honolulu, HI
www.fbcinc.com/e/aocpacific

AUVSI Unmanned Systems Defense Phase III – Virtual
October 19-21
www.auvsi.org

Precision Strike Technology Symposium (PSTS-21)
October 19-21
Laurel, MD
www.ndia.org

Seoul ADEX 2021
October 19-24
Seoul, ROK
www.seouladex.com

Directed Energy Systems Symposium
October 25-29
Washington, DC
www.deps.org

NOVEMBER

Defense & Security 2021
November 1-4
Bangkok, Thailand
www.asiandefense.com

2021 Aircraft Survivability Symposium
November 2-4
Monterey, CA
www.ndia.org

Dubai Airshow 2021
November 14-18
Dubai, UAE
www.dubaiairshow.aero

MILCOM 2021
November 29 – December 2
San Diego, CA
www.milcom.org

I/ITSEC
November 29 – December 3
Orlando, FL
www.iitsec.org

58th Annual AOC International Symposium & Convention
November 30 – December 2
Washington, DC
www.crows.org

Avalon 2021
November 30 – December 5
Geelong, Victoria, Australia
www.airshow.com.au

AOC conferences are noted in ***red***. *For more info or to register, visit crows.org. Items in* ***blue*** *denote AOC Chapter events.*

FEATURED LIVE COURSES

Direct Energy Weapons

Kyle Davidson

Mondays & Wednesdays
1:00 – 4:00 PM ET | August 9 – 25, 2021

This course introduces students to the fundamentals of Direct Energy Weapons (DEW) across the electromagnetic spectrum. The goal is to provide an understanding of the operation of laser and high-power microwave DEWs in military applications, including their design trade-offs, and target effects.

Aircraft Radar Cross Section Engineering

Renan Richter

Mondays, Wednesdays & Fridays
1:00 – 4:00 PM ET | September 13 – 29, 2021

This course introduces students to Radar Cross Section (RCS) engineering and its basics fundamentals inside the modern EW context. Stealth technology will be addressed by presenting current challenges and future perspectives.

Introduction to Satellite Communications (Satcom)

Dr. Patrick Ford

Mondays, Wednesdays & Fridays
1:00 – 5:00 PM ET | December 6 – 10, 2021

This course will cover the core material required for participants to understand and discuss basic Satcom theory and operations.

= Web Course, no travel required!

WASHINGTON D.C. 58TH AOC INTERNATIONAL SYMPOSIUM & CONVENTION

Space Electronic Warfare

Dave Adamy
Friday & Saturday
08:00 AM – 5:00 PM EST | December 3 – 4, 2021

Machine Learning for Electronic Warfare

Kyle Davidson
Friday & Saturday
08:00 AM – 5:00 PM EST | December 3 – 4, 2021

Calendar *Courses & Seminars*

AUGUST

AOC Professional Development Live Web Course: Direct Energy Weapons
August 2-18
www.crows.org

AOC Virtual Series Webinar: Quick Searches for Emitters in an RWR
August 5
1400-1500 EST
www.crows.orgs

AOC Virtual Series Webinar: Standards and Applications in Defense Video
August 12
1400-1500 EST
www.crows.orgs

Modern Electronic and Digital Scanned Array Antennas
August 16-20
Las Vegas, NV
www.pe.gatech.edu

Directed Infrared Countermeasures: Technology, Modeling, and Testing
August 17-19
Atlanta, GA
www.pe.gatech.edu

Radar Cross Section Reduction
August 23-25
Atlanta, GA
www.pe.gatech.edu

Electromagnetic Warfare Data Analysis – Online
August 24-27
www.pe.gatech.edu

AOC Virtual Series Webinar: Introduction to Digital Signal Processing for Electronic Warfare
August 26
1400-1500 EST
www.crows.orgs

Modeling and Simulation of Phased-Array Antennas – Online
August 31 – September 2
www.pe.gatech.edu

SEPTEMBER

AOC Virtual Series Webinar: Radar Ambiguities
September 9
1400-1500 EST
www.crows.org

Test and Evaluation of RF Systems – Online
September 14-16
www.pe.gatech.edu

AOC Virtual Series Webinar: US Loses First Global Space War to Russians
September 16
1400-1500 EST
www.crows.org

Infrared Technology and Applications – Open Access
September 21-24
Atlanta, GA
www.pe.gatech.edu

AOC Virtual Series Webinar: Bandits at Three O'Clock! The RAF's Chain Home Radar and British Strategic Success
September 23
1400-1500 EST
www.crows.org

OCTOBER

AOC Virtual Series Webinar: 5G for Critical Communications
October 7
1400-1500 EST
www.crows.org

Airborne EW System Integration
October 19-21
Atlanta, GA
www.pe.gatech.edu

Electromagnetic Materials and Measurements: RAM, Radome, and RAS
October 19-21
Atlanta, GA
www.pe.gatech.edu

AOC courses are noted in red. For more info or to register, visit crows.org. Items in blue denote AOC Chapter courses.

Upcoming AOC Webinars

AOC WEBINARS

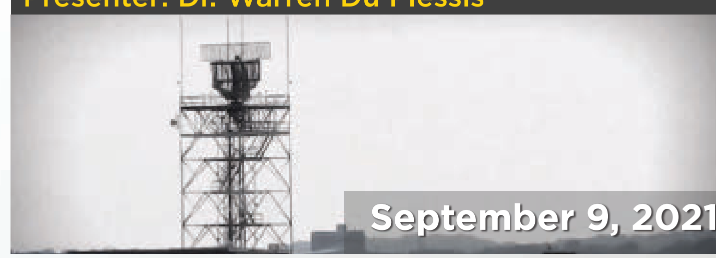
AOC Webinars are a valuable tool in providing AOC's audience with learning, advocacy, and the exchange of information. Register today to hear from subject-matter experts on all things EW!

Quick Searches for Emitters in an RWR
Presenter: Arthur Schwartz

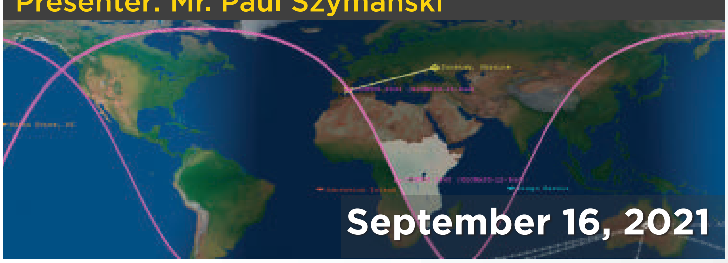
Standards and Applications in Defense Video
Presenter: Kevin Mitchell

Introduction to Digital Signal Processing for Electronic Warfare
Presenter: Dr. Clayton Stewart

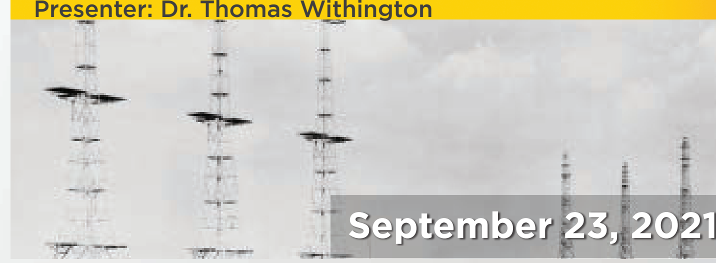
Radar Ambiguities - Knowing if a target is coming or going
Presenter: Dr. Warren Du Plessis



United States Loses First Global Space War to Russians
Presenter: Mr. Paul Szymanski

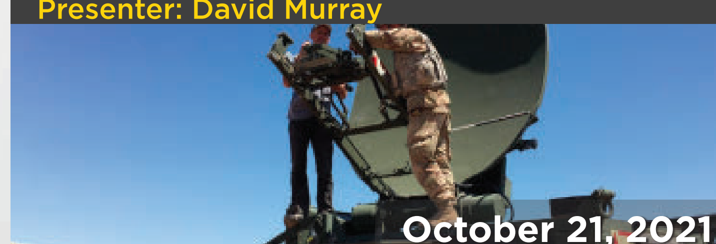


Bandits at Three O'Clock! The RAF's Chain Home Radar and British Strategic Success
Presenter: Dr. Thomas Withington



5g for Critical Communications
Presenter: Andreas Roessler

Eliminating the Pain of Transitioning EW Systems from Lab to Field
Presenter: David Murray



For more upcoming AOC Webinars, visit crows.org/Webinar_Schedule

ASSOCIATION OF OLD CROWS

President's Message

DEFINING THE ELECTROMAGNETIC SPECTRUM

Maybe it's something with months that begin with the letter "A," but I wanted to link back to my April message and address the term, electromagnetic spectrum (EMS).

Merriam-Webster defines the EMS as the entire range of wavelengths or frequencies of electromagnetic radiation extending from gamma rays to the longest radio waves and including visible light.

Wikipedia defines the EMS as the range of frequencies of electromagnetic radiation and their respective wavelengths and photon energies.

Joint Publication 3-85 defines the EMS as a maneuver space essential for facilitating control within the operational environment (OE), impacting all portions of the OE and military operations. Military operations and training are executed in an environment complicated by increasingly challenging demands and constraints on the EMS. Just as in the other physical warfighting domains, military forces maneuver and conduct operations within the EMS to achieve tactical, operational and strategic advantage. Freedom of maneuver and action within the EMS is essential to US and multinational operations.

NATO has recognized the Electromagnetic Environment (EME) as a maneuver space and defines it as " ... the totality of electromagnetic phenomena existing at a given location."

The United States Air Force activated the 350th Spectrum Warfare Wing (SWW) and the 380th Spectrum Warfare Group at Eglin AFB on June 25. Their mission is to "deliver adaptive and cutting-edge electromagnetic spectrum capabilities that provide the warfighter a tactical and strategic competitive advantage and freedom to attack, maneuver and defend."

Regardless of who you are and what you do – whether military, government, civilian, commercial or academia – we all rely on the EMS in our daily lives. We all use it to communicate, interact, work, etc., and we assume it will be available when we need it. The military and government take precautions and have tools to defend their use of the spectrum. But is it enough? What does the commercial industry do to protect themselves, their products and us to assure use of the EMS? And what do we do as civilians to assure our use of the EMS? I would bet that all of us have had some sort of spectrum disruption, whether natural or man-made. What causes cellphone calls to drop, interference on your car radio (AM, FM, satellite or even Bluetooth), your garage door opener not to work, your satellite TV to drop off, your internet connection to fail on occasion? These interruptions can be natural, power-related or caused by interference (man-made or natural). We can't prevent all disruptions and interruptions or guarantee 100% access, but we need to be aware that they can occur and to understand what we can do to regain access. It may be something as simple as recycling power or physically moving, but it also could require hardware or software updates to reduce or eliminate disruptions and/or interruptions. – *Glenn "Powder" Carlson*

PEGASUS ACQUISITION TO REGENERATE GERMAN AIRBORNE SIGINT CAPABILITY

Germany has confirmed plans to acquire a new strategic airborne signals intelligence (SIGINT) capability based on a fleet of modified Bombardier Global 6000 business jets.

Known as Pegasus (Persistent German Airborne Surveillance System), the acquisition will regenerate a SIGINT capability lapsed since the last of five Breguet BR1150 Atlantic aircraft modified under the Peace Peek program were retired in June 2010.

Hensoldt Sensors GmbH is taking the role of prime contractor and lead system integrator for Pegasus under a contract placed by the German Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw) on June 29. Lufthansa Technik, as principal subcontractor, is taking responsibility for the procurement of the three Global 6000 aircraft from Bombardier, together with their modification and installation of a sovereign SIGINT package.

The Pegasus SIGINT "collect" suite will be based on core components from Hensoldt's Kalaetron product family, with other deliverables including an analysis suite, a reference system and a training facility. Almost 30 companies from all over Germany are involved in the project as suppliers and partners.

According to the BAAINBw, the first Pegasus system is scheduled to enter service in 2026. Delivery of the full capability is planned for 2028.

Germany had previously looked to acquire a new SIGINT capability based on unmanned air vehicles (UAVs). However, the Euro Hawk program was scrapped in 2013, and a subsequent plan to acquire four SIGINT-configured Northrop Grumman MQ-4C Triton UAVs was abandoned in 2019 in favor of a manned platform solution. *– R. Scott*

US ARMY AWARDS CONTRACTS FOR COMINT/ ELINT SOLUTIONS FOR AIRBORNE ISR PROGRAM

The US Army Project Director for Sensors – Aerial Intelligence (PD SAI) (Aberdeen Proving Ground, MD), through the Consortium for Command, Control and Communications in Cyberspace (C5), has awarded L-3 Communications Integrated Systems (Waco, TX) and Raytheon Applied Signal Technology (Waltham, MA) initial contracts for "a multi-domain sensing system (MDSS) program to demonstrate, develop, build and integrate prototype electronic intelligence (ELINT) and communications intelligence (COMINT) sensors onto the High Accuracy Detection and Exploitation System (HADES) – the Army's next-generation airborne intelligence, surveillance and reconnaissance (ISR) system."

PD SAI Project Director Dennis Teefy said in a press conference, "The Army is pursuing HADES to address the demands of future multi-domain operations (MDO) against both peer and near-peer adversaries. HADES will be globally deployable and provide a multifaceted sensing capability at higher altitudes and longer ranges, and with greater endurance, than is currently available from the Army's RC-12 Guardrail, MC-12 Enhanced Medium Altitude Reconnaissance and Surveillance System (EMARSS), and EO-6C Airborne Reconnaissance Low (ARL) aircraft. The goal is to provide deep-sensing intelligence collection of indicators and warnings, electronic order of battle and patterns-of-life for target development. This will allow stand-off operations to detect, locate, identify and track critical targets for the ground commander."

The MDSS HADES program is a partnership between PD SAI and Project Manager (PM) Fixed Wing at Redstone Arsenal (AL), the Army's lead developer of fixed-wing aircraft platforms. Executed through Other Transaction Authority (OTA) agreements, the program will be conducted in three phases. Phase 1 will be a competitive effort with vendors demonstrating their sensor technology to identify system capabilities and gaps. Teefy said, "It will include demonstration of the current system being proposed against a variety of signal sets to characterize its current performance and validate its capabilities in a controlled environment that is as close to a real-world environment as we can simulate. It will also include a technical study of the system's capabilities to meet the requirements provided to the vendors in the System Specification Document (SSD) and a definition of a path forward to meet the objective requirements in the SSD, including range, sensitivity, open architecture and other key performance parameters."

In Phase 2, one or more vendors will be selected to further develop and build their prototype sensors specifically for the HADES platform. Phase 3 will then provide for a holistic COMINT/ELINT system to be flight-tested and evaluated for further production. Teefy said long-range planning is still ongoing, so they don't yet have a firm date for HADES fielding; however, he added, "we currently plan to deliver HADES to the field as a prototype for soldier evaluation in the 2024-2025 timeframe."

The value of Phase 1 of the project is expected to be $4.37 million performed over an eight-month period. The total value of the project's three phases is expected to be approximately $49 million.

The Army has long desired to replace its RC-12 and E0-6C ISR platforms. In 1996, PEO IEW&S established a PM Aerial Common Sensor (ACS) office (under then LTC Bruce Jette) to begin developing ELINT and COMINT payloads for a future ACS platform that would fly at higher altitudes and offer more endurance than its legacy ISR aircraft. (The ACS was also envisioned to replace the US Navy's EP-3E Aries II SIGINT aircraft.) Initially, PM ACS focused on development of the Joint SIGINT Avionics Family (JSAF) High-Band Subsystem and the JSAF Low-Band Subsystem, with flight demos of the HBSS beginning in 1997. In 2004, the Army awarded a contract to Lockheed Martin for the ACS aircraft, which would be based on a Gulfstream G450 business jet. However, the Army scrapped the program in 2006 due in part to ACS weight issues. – *J. Haystead* and *J. Knowles*

TROPHY APS SELECTED FOR UK'S CHALLENGER 3 MBT

Rafael Advanced Defense Systems' Trophy Active Protection System (APS) has been selected for integration on the British Army's Challenger 3 main battle tank (MBT).

The selection of Trophy follows a study completed by the UK Ministry of Defence as part of an upgrade program led by prime contractor Rheinmetall BAE Systems Land (RBSL). Rafael will now work with RBSL to perform detailed integration and system trials of the Trophy MV (Medium Vehicle) variant to fit the particular requirements of the Challenger 3 program.

Developed by Rafael as a counter to anti-armor weapons, the Trophy APS provides protection against rocket and missile threats while simultaneously locating the origin of the hostile fire for a counter response. The Trophy MV variant repackages the components of the proven HV (Heavy Vehicle) variant into a smaller and lighter form factor.

Trophy has been installed on Israel Defense Forces' Merkava tanks for over a decade and has also been installed on the Namer armored personnel carrier. Trophy has also been supplied to four US Army Abrams MBT brigades and is to be supplied to Germany for its Leopard MBTs.

RBSL was awarded an £800 million contract in May 2021 for the development and delivery of 148 Challenger 3 tanks to enter service from 2027. An upgrade of the Challenger 2 MBT designed to maintain combat effectiveness through to an out of service date of 2040, the modernization package also includes a new 120-mm L55A1 smoothbore gun, a new suite of sights for enhanced day/night targeting and a modular armor package. – *R. Scott*

DARPA SPONSORS RESEARCH IN NEW AESA FILTER TECHNOLOGY

DARPA's Microsystems Technology Office (MTO) has released a BAA for its Compact Front-end Filters at the Element-level (COFFEE) program seeking "innovative proposals in the area of microwave/millimeter wave frequency resonator and filter technology designs, with the specific aim to produce front-end RF filters that protect the elements of digital Active Electronically Scanned Arrays (AESAs) against interference in increasingly crowded RF spectrum environments," according to a program description in the BAA.

As noted in the BAA, "Over the past decade, there has been increasing interest in wideband AESA systems with digital-at-every-element architectures. Wideband AESAs are of particular interest in multi-function arrays supporting advanced radar, electronic warfare and communications capabilities."

The BAA points out that the limited dynamic range of high-bandwidth filters makes them vulnerable to jamming, with gain control typically used for element-level protection, at significant cost to receiver sensitivity. This, combined with the fact that "the area available for element-level integration decreases quadratically as frequency increases," means that today's receiver filter architectures, even those considered state of the art, can't provide the performance and protection necessary in a dense, contested EM environment. COFFEE's integrable filter technology is expected to provide the combination of size, performance and reproducibility needed to protect each individual AESA element.

The BAA requires proposed research to "enable revolutionary advances in science, materials, devices, manufacturing and systems" and specifically excludes research that offers only evolutionary improvements. The program will conclude with a demonstration of a 2-GHz to 18-GHz filter architecture to validate the scalability of the technology.

The effort is currently partitioned across two technical areas (TAs) with a third TA expected to be addressed later. TA1 will focus on design and development of a new class of compact, microwave resonators and their formation into integrable filters. The work will be conducted in three phases over 48 months. TA3 will be in two phases, conducted concurrently with TA1 over 33 months, and will extend the COFFEE effort to millimeter-wave frequencies (demonstrating performance at 50 GHz).

DARPA is expected to release a BAA for the future TA2 effort during the second half of the TA1/TA3 Phase 2 work. This will involve the validation of all the technical challenges of the current BAA by integrating the newly developed filters into a 2-GHz to 18-GHz architecture and a scalability demonstration with a filter tile consisting of 4x4 filter architectures. TA2 will be a single, 18-month effort conducted in parallel with TA1 Phase 3.

Total anticipated 6.2 funding for the effort is $30.5 million ($26 million for TA1 and $4.5 million for TA3) with multiple awards expected for each TA. The proposal due date is Sept. 10, with an estimated period of performance beginning in February 2022. The BAA reference number is HR001121S0031. The technical point of contact is MTO program manager Benjamin Griffin, email HR001121S0031@darpa.mil. – *J. Haystead*

INTREPID TIGER II EW PAYLOAD FLIES ON MV-22 OSPREY

The latest variant of the US Marine Corps' Intrepid Tiger II EW system has begun flight testing on the MV-22B Osprey tiltrotor.

Known as AN/ALQ-231(V)4, this new variant takes the form of an internal roll-on/roll-off installation. Previous versions of Intrepid Tiger II are based on an external pod.

Intrepid Tiger II is a precision, on-demand system designed to provide Marine Corps fixed- and rotary-wing aircraft with an organic, distributed and networked airborne EW capability that can be controlled from the cockpit or by a ground operator. The system's open architecture design is intended to enable rapid upgrades – utilizing both government and commercial-off-the-shelf technologies and jammer techniques – to expand frequency coverage and allow for the insertion of advanced capabilities to keep pace with new threats.

The AN/ALQ-231(V) system is designed and developed by the US Naval Air Warfare Center (NAWC) Weapons Division in conjunction with the Naval Air Systems Command's Airborne Electronic Attack Systems and EA-6B Program Office (PMA-234); Jopana Technologies (Oxnard, CA) provides support to NAWC Weapons Division through the provision of systems hardware and engineering services for Intrepid Tiger II.

The (V)1 variant of Intrepid Tiger II fielded on the AV-8B Harrier II, F/A-18 A++/C/D Hornet and KC-130J aircraft and the (V)3 version equipping the UH-1Y Huey helicopter both use a podded payload attached to an external hardpoint. However, a podded fit was not an option for the MV-22, as the aircraft does not have traditional wing stations from which to mount external payloads. Instead, the AN/ALQ-231(V)4 variant takes the form of an internal roll-on/roll-off, rack-mounted payload controlled from a laptop in the aircraft cabin.

A first flight of this latest Intrepid Tiger II system on an MV-22 was completed in mid-June. Fleet deliveries of the (V)4 variant are scheduled to begin for the MV-22B in fiscal year (FY) 2023 to achieve initial operating capability by the end of FY 2024. The Marine Corps plans to buy 42 systems.

Following successful integration on the MV-22B, the Intrepid Tiger II team plans to further expand the (V)4 design to include a counter-radar capability on the KC-130J aircraft. The intention is to leverage much of the MV-22B technology, including the in-cabin, rack-mounted payload design. – *R. Scott*

PROJECT COMBINE EXPLORES AUTOMATED PROCESSING TECHNIQUES FOR SIGINT

The UK Ministry of Defence has awarded a £108 million contract to SRC UK (Lincoln, UK) to demonstrate the application of automated processing techniques for signals intelligence (SIGINT) sorting.

The activity, known as Project COMBINE, aims to improve the efficiency of bulk data sifting in order to reduce the time taken from signal intercept to actionable intelligence without sacrificing accuracy.

Managed by the MOD's Joint Electronic Warfare Operational Support

WHAT'S HAPPENING AT AOC IN 2021!

AOC Asia
September 28, 2021

Registration Now Open!
AOCAsia.org

58th Annual AOC International Symposium & Convention
November 30 - December 2, 2021 | Washington, DC

Registration Now Open!
58.crows.org

Podcasts
AOC has two Podcasts, The History of Crows and From the Crows' Nest.

Subscribe at
crows.org/podcast

From the Crows' Nest: *Focusing on leading issues of the day related to electromagnetic spectrum operations (EMSO)*

The History of Crows: *Covering some of the most important discoveries, battles, and events that shaped what we know today as electromagnetic spectrum operations.*

Virtual Series Webinars
Bite-sized educational sessions on a myriad of technical topics in EW.

Check out the schedule at
crows.org/Webinar_schedule

Educational Courses
Professional development for the EMS workforce through world-class courses.

Start learning at
crows.org/PDC_Schedule

Collaborative EW Symposium
March 29-31, 2022
Pt. Mugu, CA

Save the date!

EW Capability Gaps & Enabling Tech Conference
May 10-12, 2022
Crane, IN

Save the date!

Check out crows.org for up-to-date information on events, resources and products.

Centre (JEWOSC), Project COMBINE seeks to improve SIGINT triage and processing capability using automation, recognizing that the growing number of emitters and signals has significantly increased the amount of radar data to sift and sort.

"By using automated systems to process simple tasks, more of the SIGINT analysts' time can be spent on complicated problems," according to program description JEWOSC. It also stated, "We foresee three main steps to achieving this: Identify then automate processing of patterns and behavior we are already aware of (known known). Identify information we are actively seeking (known unknown) for further scrutiny. Identify information we are unaware of (unknown unknown) to generate further activity. These intercepted signals will need to be matched to a stored database, create new records for new intercepted signals and be able to identify the type of signal intercept."

According to a redacted statement of work published by the MOD, SRC UK is responsible for delivering two separate work packages over a 12-week period: Work Package 1 (WP1) covers the demonstration of developed, de-interleaving software against MoD-provided synthetic data to the required standard; Work Package 2 (WP2) will demonstrate matching software against the synthetic data (scenario data and emitter database) to the required standard.

The solution will be assessed against a series of key performance indicators (KPIs). For example, in WP1 the de-interleaving software will be assessed as to its ability to identify correctly and accurately the number of waveforms in a synthetic scenario; to identify correctly and accurately classical radar parameters from any identified waveform; to highlight clearly the waveforms in a scenario that are outside of confidence threshold and require analyst attention; and to complete the entire process (ingest to completion of de-interleaving) quickly enough to process incoming intercepts in a timely manner.

KPIs will also be applied to WP2. One example is whether the solution can correctly apply the waveforms detected in WP1 and seek matches within the synthetic emitter database file: In this case, the process shall report one or more matches to the user or report that no matches can be found and prompt to create a new data entry to be added to the emitter database. On completion of matching, the solution should produce an interactive report/interrogation tool for analyst overview along with a digital document that references what has been matched/not matched. – *R. Scott*

IN BRIEF

The US Navy's ALQ-249 Next Generation Jammer (NGJ) Mid-Band (MB) program achieved Milestone C approval and has entered low-rate initial production (LRIP) under a $171.6 million contract to **Raytheon Intelligence and Space** (El Segundo, CA). Under the LRIP 1 order, the company will deliver three NGJ MB shipsets (2 pods per shipset). In FY2022, the Navy is expected to initiate another LRIP order (LRIP 2) for five shipsets. The Navy saved money by negotiating LRIP 1 and LRIP 2 together as a tandem buy, with LRIP 2 priced as an option. In the meantime, the NGJ MB development continues with chamber testing in the Air Combat Environment Test and Evaluation Facility (ACETEF) at NAS Patuxent River and with Raytheon continuing to build six System Demonstration Test Article (SDTA) Pod shipsets that are scheduled for delivery throughout FY2022.

The US Air Force's Air Combat Command formally activated the **350th Spectrum Warfare Wing** (SWW) at Eglin AFB, FL, on June 25. The new wing consolidates much of the Air Force's electromagnetic spectrum operations enterprise, and it incorporates several units that were previously part of the 53d EW Group at Eglin. Its responsibilities include EW system reprogramming, managing and disseminating EW mission data to various Air Force units, test and evaluation activities and managing the COMBAT SHIELD EW Assessment Program. Under the command of Col William "Dollar" Young, the 350th SWW comprises two sub-units: the 350th Spectrum Warfare Group and the 850th Spectrum Warfare Group. The 350th Spectrum Warfare Group includes the 16th Electronic Warfare Squadron, 36th Electronic Warfare Squadron, 68th Electronic Warfare Squadron, 513th Electronic Warfare Squadron and F-35 Partner Support Complex. The 850th Spectrum Warfare Group comprises the 39th Electronic Warfare Squadron, 87th Electronic Warfare Squadron and 453d Electronic Warfare Squadron. The 350th SWW will be temporarily located at Eglin AFB while the Air Force conducts an environmental review for its permanent location, which is expected to be announced in the spring of 2022.

The Defense Advanced Research Projects Agency (DARPA) has awarded multiple contracts for its Quantum Apertures program, which seeks to "develop a fundamentally new way of receiving radio-frequency (RF) waveforms to improve both sensitivity and frequency agility in several application areas of interest to national security including electronic warfare, radar and communications," according to a DARPA program description. The goal is to "develop portable and directional RF receivers useful for future DoD missions with greater sensitivity, bandwidth and dynamic range than any classical receiver." Contracts were awarded to **BAE Systems** of Nashua, NH ($3.3 million), **Coldquanta Inc.** of Boulder, CO ($7.4 million), **Georgia Tech Research Institute** of Atlanta, GA ($1.2 million), **Northrop Grumman** of Redondo Beach, CA ($2.9 million) and **SRI International** of Menlo Park, CA (two awards totaling $6.7 million).

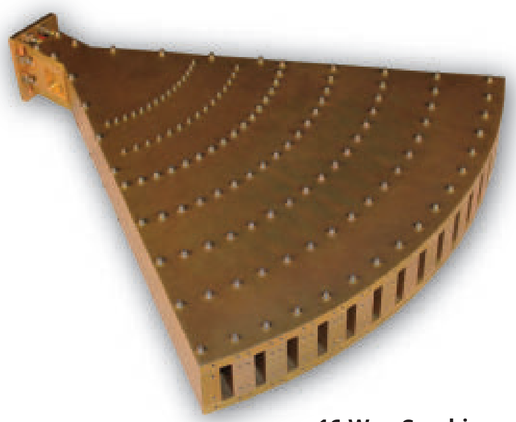
Hawkeye 360 (Herndon, VA) deployed its Cluster 3 RF monitoring satellites into orbit, and they successfully established communications with the company's satellite operations center. Cluster 3 comprises three satellites – each built on a UTIAS Space Flight Laboratory bus – that were deployed from a Spaceflight Inc. Sherpa-FX orbital transfer vehicle and launched from a Space X Falcon 9 rocket. The company plans to launch seven more satellite clusters in 2021 and 2022, with the goal of achieving signal collection revisit rates as short as 20 minutes across most parts of the earth's surface.

WERLATONE®

SOLID STATE RADAR

E-PLANE COMBINERS

HIGHER CW POWER ✦ LONG DUTY CYCLES ✦ COMPACT & LOW LOSS



16-Way Combiner
5300 - 5900 MHz
12,000 W CW, 2.5 MW Peak
WR159 Output, Half Height WR159 Inputs

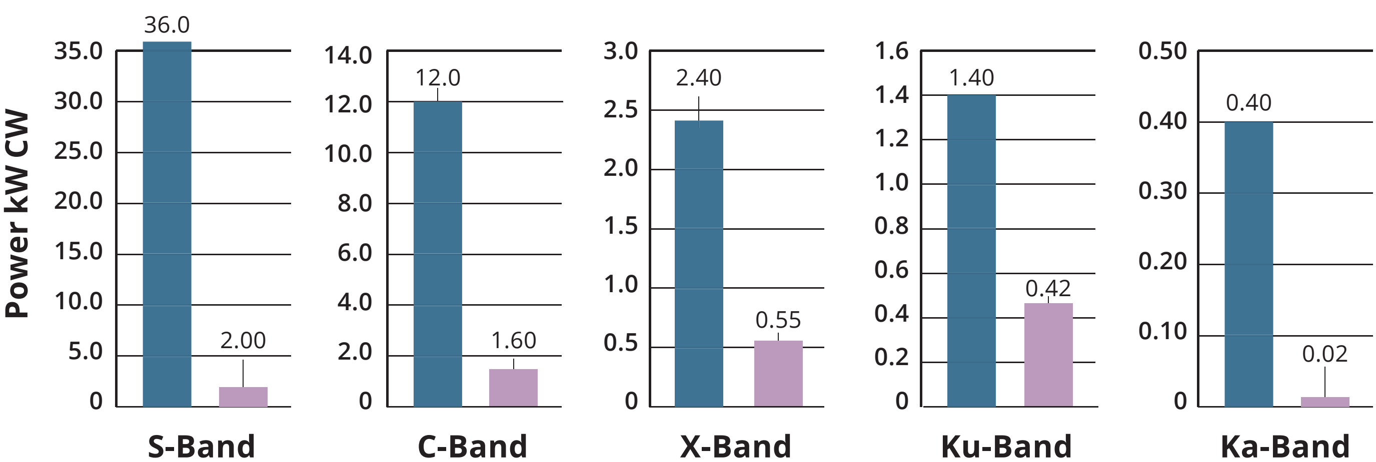
A New Class of Patented Microwave Power Combiners with Extremely High Power Handling Capability.

WERLATONE's new N-Way E-Plane Combiner architecture is ideally suited for emerging High CW Power/ High Duty Cycle Solid State Radar requirements.

Whereas an N-Way Radial Combiner design is limited in CW output power due to the diameter of the central output coaxial section (based on TEM Mode Operation), the E-Plane Combiner is limited only by the CW power rating of the respective waveguide size. This results in an N-Way Combining architecture which handles multiples higher in power at respective frequencies.

- Higher CW Power and Higher Duty Cycle
- High Power Density and Low Loss
- Space Efficient, Planar Structure
- Ideal for S, C, X, Ku, Ka Bands

CW Power ■ E-Plane Combiner vs. ■ Radial Combiner



Werlatone, Inc. 17 Jon Barrett Road Patterson, NY 12563 845-278-2220 sales@werlatone.com www.werlatone.com

Navy's EMW St
to All-Domain

By John Haystead

In diving into the subject of the US Navy's Electromagnetic Warfare Strategy (EMW), the first thing that needs to be understood is that, although the lexicon may vary somewhat by Service and DOD organization, the US military's overall understanding of the operational implementation, and the ultimate mantra of Electromagnetic Spectrum Operations (EMSO), including the Navy's EMW strategy, is that EMSO be fully integrated with operations and capabilities in all other domains – All-Domain Operations.

The best place to start this discussion is with the DOD's "Electromagnetic Spectrum Superiority Strategy" document. Published in October 2020, the strategy defines the "need to develop new capabilities, new techniques, and better integration within DOD and with its partners to enhance spectrum efficiency, maximize spectrum compatibility, and ensure EMS superiority. The shift in these activities to a sharing and maneuver focus must tightly align with efforts across the EMS enterprise to achieve military readiness, integration across warfighting domains, and increased lethality of forces."

Upfront, the document recognizes the EMS as a "critical battlespace in its own right, where DOD must conduct fires, maneuver, and communicate to achieve dominance in the presence of ever-increasing military and civilian use." Further, it defines EMS maneuver as the movement in three-dimensional positioning, time, and EMS operating parameters (e.g., frequency, power, modulation) as a means to gain an advantage over the enemy. "An EMS maneuver mindset views all actions in the EMS as a fundamental part of the commander's scheme of maneuver and is focused on creating advantage over the enemy. Inclusive within EMS maneuver is the ability to coordinate EMS fires through EMS command and control methods and means." Finally, it states that "to realize the objectives of EMS maneuver via agile EMS operations and activities, future Service and Joint warfighting systems will rely heavily on a fully integrated EMS infrastructure and a renewed focus on all-domain interoperability." Among the strategic goals outlined is the integration of the functions of Electromagnetic Spectrum Management (EMSM) and EW into Electromagnetic Spectrum Operations (EMSO).

The DOD's EMS Superiority Strategy states, "to realize the objectives of EMS maneuver via agile EMS operations and activities, future Service and Joint warfighting systems will rely heavily on a fully integrated EMS infrastructure and a renewed focus on all-domain interoperability." US NAVY

In fact, the DOD's EMS Superiority Strategy strongly reflects much of the strategy for Joint Electromagnetic Spectrum Operations (JEMSO) released in May of 2020 by the Chairman of the Joint Chiefs of Staff (CJCS) office. This document provides "official advice concerning JEMSO and provides considerations for military interaction with governmental and nongovernmental agencies, multinational forces, and other interorganizational partners."

The document goes on to describe maneuver in the EMS as similar to maneuver in other warfighting domains. For example, it states that "while maneuver in the air domain requires three-dimensional positioning and time, EMS maneuver must also consider EMS operating parameters (e.g., frequency, power, modulation) to gain an advantage over the enemy," – language also used in the DOD's EMS Superiority Strategy document.

As acknowledged in the document, each Service has a different approach to organizing for JEMSO. For the Navy it is centered on the concept of EMW, which

rategy Integral Operations

Flynn says, "The 'Advantage at Sea' strategy does a really good job of talking about how different warfare is today from the way we've been practicing for the last 20 years – transitioning from a relatively permissive to a contested environment. When you do that, all of a sudden, you went from where EMSO was an afterthought, only looked at if a problem developed, to where you now know that you have to integrate that thinking about spectrum capabilities from the get-go."

is the Service's "warfighting approach to gain decisive military advantage in the EMS and is the foundational concept that supports JEMSO. Sensing, assessing, and monitoring the Electromagnetic Operational Environment (EMOE) and all EMS-related activities provides a strategic advantage and enables freedom of action across all Navy mission areas."

Referencing the JEMSO document, first and foremost, Bill Flynn, director of Cryptologic Electronic and Cyber Warfare Division in the Office of the Deputy Chief of Naval Operations for Information Warfare/ Director of Naval Intelligence (OPNAV N2N6), emphasizes that the Navy's focus on EMW is not a separate strategy. "There's a very good triangulation or alignment between what JEMSO discusses and between what the Navy talks about specifically in its most recent strategy document – the Tri-Service Strategy for "Advantage at Sea – Prevailing With Integrated All-Domain Naval Power."

Released in December 2020 by the Secretary of the Navy, this document details the maritime strategy of the Navy, Marines and Coast Guard Service Chiefs for the next decade. The document focuses on China and Russia, "the two most significant threats to this era of global peace and prosperity," and particularly prioritizes the People's Republic of China as it "represents the most pressing, long-term strategic threat."

Says Flynn, "The 'Advantage at Sea' strategy does a really good job of talking about how different warfare is today from the way we've been practicing for the last 20 years – transitioning from a relatively permissive to a contested environment. When you do that, all of a sudden, you went from where EMSO was an afterthought, only looked at if a problem developed, to where you now know that you have to integrate that thinking about spectrum capabilities from the get-go. It becomes much more than just an offensive or defensive thing. It's your core to maneuver, and you can't separate the way you connect the force from Spectrum, because it both gives and receives, and you really have to understand it all the time."

Although the scope of the Tri-Service strategy is broad and comprehensive, one clear and consistent element is an emphasis on the need for "Integrated All-Domain Naval Power." Says Flynn, "The concepts of EMW are really pervasive in this document. Though practitioners will focus on the EMW doctrine, the rest of the Navy just folds it into Distributed Maritime Operations (DMO). This is a good thing because it shows that the Navy is thinking about this in an integrated way – not as an afterthought that you bolt on afterwards. We as a Service realize this, and it was really driven by an understanding of what we needed to achieve in DMO as those two things were developed relatively closely in time – EMW and DMO – and that they were inextricably linked to each other. We're comfortable with this, since the very way that we're going to need to execute the all-domain maritime strategy is by use of the concept of DMO, given that the ability to work everything that an EMSO strategy would look at is integral to that piece."

As per the document, "In combat, naval forces will leverage the concepts of DMO, littoral operations in a contested environment, and expeditionary advanced base operations to support Joint Force Commander objectives. Nested under the emerging Joint Warfighting Concept, our operations will mass the effects of joint, sea-based, and land-based kinetic and non-kinetic fires. Integrating and connecting our platforms, weapons, systems, and sensors improves our own battlespace awareness while complicating the enemy's scouting efforts. Distributing and maneuvering our forces across all domains allows us to exploit uncertainty and achieve surprise."

ROLE OF N2N6

Within the Navy, the two main players responsible for providing these integrated capabilities are N2N6 and the Air Warfare Division (N98). N98 is responsible for building, integrating, and defending yearly Program Objective Memorandums (POMs) for all Naval aviation programs including the EA18G Growler and EP-3E Aries II programs. N2/N6 is the Navy's primary office for resourcing capabilities in intelligence, cyber warfare, command and control, and electronic warfare, providing "end-to-end accountability for Navy information requirements, investments, capabilities and forces." Says Flynn, "As the resource sponsors, we argue for and work to set the requirement and then the resource plans for Navy capabilities. Because we own the systems side, we're responsible for both the cryptologic warfare systems, as well as more traditional self-protection systems incremented on fleet ships such as the Surface Electronic Warfare program (SEWIP). Also, in the EMSO world, spectrum management comes under our flag, so we have an element on the team that executes those responsibilities for spectrum allocation and, when questions come up, how we in the Navy will handle those issues." N2N6 and N98 also work together to identify where investments need to be made, but as noted by Flynn, "we definitely coordinate with them, but it's a different resource sponsor."

With regard to implementing specific EMW strategy goals, Flynn again emphasizes that they don't have a standalone, separate EMW focus, "because it's so directly tied to everything we're trying to do. I do think, however, that we're in a really good place in terms of making good long-term investments in some things that we believe will become very critical capabilities, including advanced SEWIP, the next major iterations in cryptologic warfare systems coming through the Spectral program, and other pieces that are core to delivering maneuver capability and decisive advantage."

INTEGRATED ALL-DOMAIN OPERATIONS

The three Services have identified "integrated all-domain naval power" as the central course to pursue in order to "expand our ability to deliver effects across the competition continuum and in all domains from the sea floor to space, and in the information environment, cyber domain, and electromagnetic spectrum," explains the Advantage at Sea strategy. Further on it says, "Closer integration allows our forces to distribute more broadly and increase our operational unpredictability across the competition continuum by varying our timing, location, domain, forces, and activities." As noted by Flynn, "When you look at the document, you see this discussion of all-domain all the time, and it specifically calls out the EMS as one of the domains (although domain is mixed in with 'information space') that the maritime force has to fully utilize and control."

As part of this doctrine, the Tri-Service document highlights a commitment to expanding information and "decision advantage," stating that, "We will sense, decide, and act more quickly and effectively than our adversaries. Maintaining decision advantage removes adversary leaders' sense of control, inducing doubt and increased caution in crisis and conflict. Emerging technologies will help us collect, analyze, and produce timely intelligence. Our networks, battle management aids, and data infrastructure will connect with other Joint networks. Combining many informational inputs into a common, actionable operational picture will enable our forces to act more quickly and effectively than our competitors."

US NAVY

DISTRIBUTED CAPABILITIES

As a key component of the path to decision advantage, the Advantage at Sea strategy recognizes that the future naval force must be designed to support distributed operating concepts with "increased scalable autonomy to distribute more broadly and accelerate decision cycles ... by incorporating leading-edge technologies more rapidly. It must be able to operate and deliver effects in contested and persistently surveilled battlespaces, in both netted and non-netted environments, to maintain decision advantage and be logistically sustainable."

As part of its efforts to achieve these objectives, the Navy plans to accelerate delivery of the next-generation Naval Operational Architecture, composed of the Naval Tactical Grid, battle management aids, data structures and infrastructure that underpin distributed operations. According to the Advantage at Sea strategy, "This network will be fully interoperable with Joint All-Domain Command and Control systems and will combine inputs into an actionable common operational picture, leveraging artificial intelligence and machine learning, to give our warfighters enhanced situational awareness and facilitate decision making at tactically relevant speeds."

The Service also plans to expand its maritime ISR framework that coordinates both inter-Service and inter-department collection strategies and priorities to "better use national imagery and intelligence capabilities to deliver shared battlespace awareness ... and enhance a maritime kill web that fuses data across domains from a variety of intelligence sources, sensors, and platforms," explains the strategy.

According to Flynn, one of the big decisions that put the Navy on this footing was its shift a number of years ago to the addition of an Information Warfare Commander at Sea, emphasizing that this is not just an auxiliary staff function. "This O6 officer is at the battle group level, and is at the center of attention as somebody who's constantly in the middle of all this activity, and the person responsible for delivering this capability to the battle group commander," he explains. "As such, you have to have a complete understanding of everything that's going on in the spectrum – the networks and links, to the readiness of EW systems."

Flynn says they're also starting to see a translation of that understanding at all levels. "Navy leaders see it's not only important in terms of an EMSO strategy; it's strategic warfare, where they have to look at not just the tactical, but the operational level of warfare. How we are staffed to man and organize at the fleet level to execute this is critical, because of the huge impact that the information warfare commanders have on the ability of force commanders to see and understand everything that is going on and how all these things link together. They're seeing they need this kind of focus at the next level as well. You put those people together to do that. It's the expertise and the understanding which are exactly the things being seen at the JEMSO level."

EDUCATION AND CONTINUITY AT ALL LEVELS

To further advance the Navy's understanding of and the importance of its EMSO/EMW strategy objectives, and ultimately to ensure that it all works together, Flynn says the Navy recognizes that it will need to better provide continuity and continual training throughout and across the Services, "because planning at the Combatant Command (COCOM) level needs to be coherent with the way the force is going to employ capabilities and then feed data all the way up and down from the maritime component commanders to the overall commanders. Everyone has to be on the same sheet of music talking about these capabilities."

In fact, specifically for this reason, in September of 2020, the Navy's Chief Information Officer issued a memo that established a new board to "oversee the implementation of a strategy, doctrine and policy for electromagnetic warfare." The Electromagnetic Battle Space Governance Board (EMBS GB) will serve as an adviser to Navy senior leadership, including the Navy secretary, on how to address enterprisewide EMBS issues and ultimately shape how the Navy pursues its EMBS enterprise, noting that "EMSO will consist of information, doctrine, training, military supplies, governance, facilities and other requirements necessary to build an EMBS enterprise."

The board will be composed of senior officials from the Navy and Marine Corps as well as secretariat-level stakeholders. Principal membership includes the DON Chief Information Officer serving as Chair and Executive Secretary; Deputy Chief of Naval Operations for Information Warfare/Director of Naval Intelligence (N2N6)/DON Chief Information Officer; Deputy Commandant of the Marine Corps for Information/DON Deputy Chief Information Officer; and Assistant Secretary of the Navy (Energy, Installations and Environment)

According to the organization's charter, "When execution authority exists with Principal member organizations of the board, the EMBS GB will function as an executive-level decision body that will review and direct modification to, or approval or disapproval of, applicable Navy EMS enterprise initiatives. In instances where statutory responsibility exists outside of the Principal membership of the board, or elsewhere in the Department (e.g., Service Forums, DoD initiatives), the EMBS GB will function as an executive level advisory body, providing recommendations to the responsible individuals and/or organizations."

US NAVY

From his point of view, Flynn says, that "the Governance Board is at a much more strategic level, as opposed to our level of focus, which is strictly on providing capabilities into the fleet." However, he does observe that "this is part of our challenge in staying aligned with what is going on at senior DOD levels, while very much understanding what we're trying to do as a Service in the maritime environment. In that regard, however, what we see is a pretty good linkage between things that the fleet commanders are telling us as to their requirements and how that fits into the larger pieces that the Navy is working."

It's currently too early in the process for the EMBS to give any useful insight into its progress or current initiatives, as it is awaiting the release of the follow-on Implementation plan for the DOD's EMS Superiority Strategy to really begin its mission. As explained by Thomas Kidd, director of Strategic Spectrum Policy for the Navy, they have not yet been given a timeline on when that will happen. However, "once the implementation plan is signed, there will be an additional 60-days for the POCs to determine implementation resources required and then additional time while the cost of implementation is evaluated. All of this is important. The DOD EMS Superiority Strategy is visionary, but in the interim, it might be a while before we're able to get things rolling again on the Board."

MOVING FORWARD

Flynn also acknowledges that "there will be a lot of pieces to coordinate and direct as the DOD's implementation plan is developed." But, once again, he stresses that the Navy is already thinking about maneuver in all the dimensions. "It's not a separate EMW focus. Everything is already organically tied into it as the way that modern maritime warfare is envisioned," he says.

In his "Navigation Plan 2021," released in January, Chief of Naval Operations ADM Mike Gilday also reinforced this point, noting once again the critical importance of all-domain operations. "Winning in contested seas also means fielding and equipping teams that are masters of all-domain fleet operations. Future fights against near-peer competitors require us to integrate the all-domain power of the fleet with the Joint Force and our allies and partners. Our fleet staffs are already fully integrating information warfare, space, cyber and special operators, both active and reserve, into their teams to leverage the full power of our Navy. We will continue to experiment through fleet battle problems, wargames and exercises — like Large Scale Exercise 2021 — to refine our concepts and capabilities."

TECHNOLOGY SURVEY
A SAMPLING OF BENCHTOP SPECTRUM ANALYZERS

By Barry Manz

The software-defined radio (SDR) and the general digitization of previously analog functions have not only transformed the spectrum analyzer market but have also redefined what can be achieved at an incredibly low cost. So, does this portend the end for the venerable benchtop spectrum analyzer, the staple of every test bench? The answer is a resounding "no" for several reasons. But first, it helps to understand the market itself.

It's been possible for some time to buy a spectrum analyzer on Amazon or eBay for less than $100, for which the customer gets basic functionality and the ability to combine it with a laptop that provides analysis capabilities. A decade ago, that would not have been possible, but with the emergence of SDR technology (that itself is available on Amazon in a thumb drive for $28), the spectrum analyzer landscape has dramatically changed.

What has not changed is the reason for using benchtop spectrum analyzers, and they are only getting more impressive with time, with features once found only in "high-end" instruments (such as real-time spectrum analyzers) now available in less costly ones, as well. The benchtop's unassailable advantage is that, as it is inherently larger, it can be "optioned out" to include a bewildering array of capabilities that range from the analysis of noise figure and phase noise to vector modulation, pulse and vector signal analysis, and many others.

Their measurement frequency range can also be extended to the far-flung regions of the spectrum using frequency extenders in segments, in some cases up to 1 THz. And with the addition of mass storage and advanced analysis software, it can become a spectrum recorder for signals intelligence (SIGINT) and other applications. The result is more than a spectrum analyzer, a multipurpose instrument that can potentially eliminate other test equipment on the bench.

Three key metrics most often requested today are increased measurement bandwidth, extended frequency range and the ability to analyze virtually any kind of signal. The current internal analysis bandwidth state of the art in commercial spectrum analyzers is about 8 GHz, which allows the instrument to scan the entire spectrum from near DC through the most densely populated part of the spectrum at incredibly high speed.

While only a few years ago, an analyzer that reached 40 GHz was considered impressive, today instruments with this ability are common, while others span up to 90 GHz or higher – without the need for frequency extenders. As for modulation analysis, benchtop instruments can be upgraded to accommodate any kind of signal, even those not encountered before. Even lower-end instruments can perform signal analysis, and when combined with increasingly affordable solid-state storage and software running on a PC, a high-end analyzer can quickly become a very comprehensive signal recorder.

Defense applications are still a formidable market for benchtop spectrum analyzers and drive manufacturers to achieve higher performance at higher frequencies. However, the commercial market is far larger, so test equipment manufacturers are focusing intently on serving the needs of the wireless industry. In a single 5G leap, this industry has entered the rarefied domain of millimeter wavelengths and their extremely complex signal environments that mandate massive MIMO and active phased array antennas, among other challenges. The "commercialization of space" is yet another market force, as SpaceX and other companies are, or soon will be, deploying enormous constellations of satellites, many operating at L-band but others at Ka-band.

The result is a demand for spectrum analyzers (and almost everything else) that must be affordable and technically superior and versatile than their predecessors. The benefit for defense system manufacturers is that while their requirements were once unique and required more costly instruments, they will also benefit from the accelerated development spurred by the commercial market.

In short, no one should fear that benchtop spectrum analyzers will soon be replaced by smaller instruments, as all their benefits make them essential for the same tasks for which they have always reigned supreme. That is, they are and will remain the workhorses of the test bench, with the ability to handle measurement challenges that are beyond the reach of their smaller, although admittedly very impressive, counterparts.

THE SURVEY

In our survey table, the first few columns focus on the model, the type of technology the spectrum analyzer uses and its operating frequency range. Some analyzers include frequency extension options, which may also be mentioned in the "features" column. The next columns indicate the unit's center frequency and span options, as well as its resolution bandwidth. The "minimum event duration" column defines the smallest amount of time in which an event can be detected, and the next column indicates the operational dynamic range from the lowest power signal detected to the highest power signal, which can be a function of the bandwidth selected. "Trigger types" define options for starting a measurement of a specific signal.

Our next technology survey will focus on radar ESM and ELINT receivers and will appear in the November *JED*.

BENCHTOP SPECTRUM ANALYZERS

MODEL	SPECTRUM ANALYZER TYPE	OPERATING FREQ. RANGE	CENTER FREQ. AND SPAN OPTIONS	RESOLUTION BANDWIDTH	DETECTOR	MIN. EVENT DURATION	SFDR
Anritsu Company; Allen, TX, USA; +1 800-267-4878; www.anritsu.com							
MS2850A	Hybrid	9 kHz - 44.5 GHz	CF: 9 kHz - 44.5 GHz; span 0 Hz, 300 Hz - 44.5 GHz (model dependent)	1 Hz - 3 MHz in 1-3 sequence	Postive and negative, +peak, sample, negative peak, RMS	*	-70 dBc at 1 GHz Analysis Bandwidth
MS2830A	Hybrid	9 kHz - 43 GHz	CF: 9 kHz - 43 GHz; span 0 Hz, 300 Hz - 43 GHz (model dependent)	30 Hz-3 MHz in 1-3 sequence. 1 Hz, 50 kHz, 5 MHz, 10 MHz, 20 MHz, 31.25 MHz	Positive and negative, +peak, sample, negative peak, RMS	*	168 dB
MS269xA	Hybrid	50 Hz - 26.5 GHz	CF: 50 Hz - 6 GHz; span 0 Hz, 300 Hz - 26.5 GHz (model dependent)	30 Hz-3 MHz in 1-3 sequence. 1 Hz, 50 kHz, 5 MHz, 10 MHz, 20 MHz, 31.25 MHz	Positive and negative, +peak, sample, negative peak, RMS	*	177 dB
Keysight Technologies; Santa Rosa, CA, USA; +1 800-829-4444; www.keysight.com/find/sa							
N9042B UXA Signal Analyzer	Swept-tuned and FFT	2 Hz - 50 GHz	CF adjustable over the full frequency range of the instrument.	1 Hz - 8 MHz standard; analysis bandwidth up to 11 GHz	Normal, peak, sample, negative peak, log power avg., RMS avg., voltage avg., and quasi-peak	*	-80 dBc
N9032B PXA Signal Analyzer	Swept-tuned and FFT	2 Hz - 26.5 GHz	CF adjustable over the full frequency range of the instrument.	1 Hz - 8 MHz standard; analysis bandwidth up to 2 GHz	Normal, peak, sample, negative peak, log power avg., RMS avg., voltage avg., and quasi-peak	*	-80 dBc
N9021B MXA Signal Analyzer	Swept-tuned, FFT, and Real-time	10 Hz - 50 GHz	CF adjustable over the full frequency range of the instrument.	1 Hz - 8 MHz standard; up to 212 MHz in zero span opt.; analysis bandwidth up to 510 MHz	Normal, peak, sample, negative peak, log power avg., RMS avg., voltage avg., and quasi-peak	3.51 µsec	-80 dBc
Narda Safety Test Solutions GmbH; Pfullingen, Germany; +49 7121 97320; www.narda-sts.com							
Narda Remote Analyzer NRA-3000 RX	Hybrid	9 kHz - 3 GHz	Set with CF and span or with start and stop; CF: 9.5 kHz-3 GHz; span: 1 kHz-3 GHz	10Hz - 20 MHz; zero span 100Hz - 32 MHz	Act, max, avg., min, +peak, RMS, -peak	TPOI≤64 nsec @ zero span CBW=32 MHz	60 dB
Narda Remote Analyzer NRA-6000 RX	Hybrid	9 kHz - 6 GHz	Set with CF and span or with start and stop; CF: 9.5 kHz-6 GHz; span: 1 kHz-6 GHz	10Hz - 20 MHz; zero span 100Hz - 32 MHz	Act, max, avg., min, +peak, RMS, -peak	TPOI≤64 nsec @ zero span CBW=32 MHz	60 dB

TRIGGER TYPES	APPLICATIONS	FORM FACTOR	SIZE	WEIGHT	FEATURES
Free run, video, wide IF video, external, frame	Tx and Rx signal characterization for R&D and manufacturing for custom/propietary digital modulation schemes and analog modulation.	Bench	426 x 177 x 390 (mm)	<21 kg	Mixers extend frequency coverage to 325 GHz; built-in signal generator; 1 GHz analysis bandwidth
Free run, external, manual	Tx and Rx signal characterization during manufacturing.	Benchtop	426 mm x 177 mm x 390 mm	≤ 13.5 kg	Mixers extend frequency coverage to 325 GHz
Free run, external, manual	Tx and Rx signal characterization.	Benchtop	340 mm x 200 mm x 350 mm	≤ 13.5 kg	Built-in vector signal generator; built-in AWGN generator
Level, level with time qualified (TQT), line, external, RF burst, frame, frequency mask (FMT), FMT with TQT.	RF, microwave and millimeter wave signal analysis	Box instrument	281 x 459 x 575 mm; 11 x 18 x 22.6 in.	38.6 kg; 85.1 lb	2 Hz - 110 GHz with V3050A frequency extender; external mixers to 1.1 THz; optional applications available for general purpose and vector signal analysis
Level, level with time qualified (TQT), line, external, RF burst, frame, frequency mask (FMT), FMT with TQT.	RF and microwave signal analysis	Box instrument	177 x 426 556 mm; 7 x 16.8 x 21.9 in.	27 kg; 59 lb	External mixers to 1.1 THz; optional applications available for general purpose and vector signal analysis
Level, level with time qualified (TQT), line, external, RF burst, frame, frequency mask (FMT), FMT with TQT.	RF, microwave and millimeter wave signal analysis	Box instrument	177 x 426 556 mm; 7 x 16.8 x 21.9 in.	25.5 kg; 56 lb	External mixers to 1.1 THz; optional applications available for general purpose and vector signal analysis, pulse measurements, and real-time I/Q data streaming
Free run, single, multiple, time controlled	L-Band analyzer for satellite pointing and tracking, antenna peaking, and carrier monitoring; troubleshooting and wideband monitoring of TV / radio / telemetry carriers; managing wireless transmission systems, from radio to cellular (GSM / UMTS / LTE) and WiMAX	Rack mountable (1U)	482 x 45 x 362 mm; 19 x 1.75 x 14.3 in.	< 5 kg; 11 lb	Designed for radio reconnaissance and radio surveillance, signal demodulation and decoding, signal analysis and classification, COMINT and ELINT
Free run, single, multiple, time controlled	See above	Rack mountable (1U)	483 x 45 x 362 mm; 19 x 1.75 x 14.3 in.	< 5 kg; 11 lb	Remote control of NRA into measurement environment via Ethernet; high speed measurement; fan-less design for silent, continuous operation

BENCHTOP SPECTRUM ANALYZERS

MODEL	SPECTRUM ANALYZER TYPE	OPERATING FREQ. RANGE	CENTER FREQ. AND SPAN OPTIONS	RESOLUTION BANDWIDTH	DETECTOR	MIN. EVENT DURATION	SFDR
Rohde & Schwarz GmbH & Co. KG, Munich, Germany, Tel. +49 89 4129-12345, www.rohde-schwarz.com							
R&S FSV3000	Hybrid	10 Hz - 44 GHz	CF: operating freq. range; center frequency > 10 MHz, span = 0 Hz	1 Hz - 40 MHz, demodulation bandwidth up to 200 MHz	Sample, peak, RMS, avg., quasi-peak, RMS, CISPR avg. (opt.)	*	-80 dBc
R&S FSVA3000	Hybrid	2 Hz - 44 GHz	CF: operating freq. range; center frequency > 10 MHz, span = 0 Hz	1 Hz - 40 MHz, demodulation bandwidth up to 1 GHz	Sample, peak, RMS, avg., quasi-peak, RMS, CISPR avg. (opt.)	*	-80 dBc
R&S FSW	Hybrid	2 Hz - 90 GHz	CF: Operating freq. Range; span 0 Hz, 10 Hz to full span	1 Hz -10 MHz, 20/50/80 MHz opt. RBW/VBW, demodulation bandwidth up to 8.3 GHz, realtime analysis bandwidth 800 MHz	max. peak, min. peak, auto peak (normal), sample, RMS, avg., quasi-peak, CISPR avg. (opt.)	0.46 µsec	100 dBc
S2 Corporation; Bozeman, MT, USA; +1 406-922-0334; www.s2corporation.com							
S2 Spec-An, Extreme Bandwidth Analyzer and Correlator (EBAC)	Optical FFT, Hybrid	30 MHz - 110 GHz	User configurable, up to 35 GHz IBW per channel, over any frequency (30 MHz – 110 GHz)	10 kHz - 50 MHz	Power spectrum, peak detection, avg. detection, max hold	No limit if energy is above the noisefloor at < -126 dBm/10 kHz	> 62 dB SFDR, third-order intermodulation limited
Signal Hound; Battle Ground, WA, USA; +1 (360) 313-7997; www.signalhound.com							
SM200A	FFT	100 kHz - 20 GHz	Any span	0.1 Hz (≤200kHz span) to 3 MHz (any span) using 40 MHz IBW; 30 kHz to 10 MHz using 160 MHz IBW	Min, max, avg.	12 µsec @ 300 kHz RBW	118 dB @ 1 Hz RBW
SM200B	FFT	100 kHz - 20 GHz	Any span	0.1 Hz (≤200kHz span) to 3 MHz (any span) using 40 MHz IBW; 30 kHz to 10 MHz using 160 MHz IBW	Min, max, avg.	12 µsec @ 300 kHz RBW	118 dB @ 1 Hz RBW
SM200C	FFT	100 kHz - 20 GHz	Any span	0.1 Hz (≤200kHz span) to 3 MHz (any span) using 40 MHz IBW; 30 kHz to 10 MHz using 160 MHz IBW	Min, max, avg.	12 µsec @ 300 kHz RBW	118 dB @ 1 Hz RBW
Tektronix; Beaverton, Oregon, USA; +1 800-438-8165, www.tek.com							
RSA5126B	Real Time	1 Hz - 26.5 GHz	Real time Bandwidth 165 MHz	0.1 Hz - 5 MHz	Peak, –peak, avg. (VRMS), ±peak, sample, CISPR (avg., peak, quasi-peak avg. (of logs))	2.7 µsec at 165 MHz BW	>75 dBc (25/40 MHz)

TRIGGER TYPES	APPLICATIONS	FORM FACTOR	SIZE	WEIGHT	FEATURES
External, IF power, RF power, video	AM/FM/PM modulation analysis, Vector signal analysis of single-carrier digitally modulated signals	Benchtop	18.15 × 7.76 × 16.42 in.	12.2-14.6 kg	SCPI recorder, event-based actions dialog, autoset, smart signal generator control, toolbar, 10.1-in. high-resolution multitouch display
External, IF power, RF power, video	AM/FM/PM modulation analysis, Vector signal analysis of single-carrier digitally modulated signals	Benchtop	18.15 × 7.76 × 16.42 in.	12.2-14.6 kg	SCPI recorder, event-based actions dialog, autoset, smart signal generator control, toolbar, 10.1-in. high-resolution multitouch display
External, IF power, RF power, video, frequency mask trigger (with realtime option)	1 GHz wide streaming of IQ data, Analysis of 5G signals, Narrowband IoT (NB-IoT), Wireless connectivity, radar signal analysis, pulse compression radar measurements	Benchtop	18.15 × 9.44 × 24.01 in.	18.6-26.6 kg	1GHz wide IQ streaming, toolbar, SCPI recorder, 12.1-in. high-resolution, multitouch display, R&S MultiView and R&S Sequencer, overview settings, noise source control, 3 USB 2.0 ports, smart port
Continuous operation with active reporting	EW, EMS awareness, geolocation, radar processing, covert communications	Rack-mount	25 U rack, 14 U compressor	500 lb + HD storage and UPS	Geolocation via time-difference of arrival (TDoA) or direction finding (DF), event reporting, tipping/cueing, radar processing, covert communications
Video, external	Remote monitoring, EW, automated test, general benchtop analysis	Benchtop	10.2 x 7.2 x 2.15 in.	7.77 lb	20 MHz - 20 GHz sub-octave preselector, headless analyzer – connected to PC for spectrum display, open and flexible API, 1 THz/s sweep speed@30k RBW, 40 MHz streaming I/Q
Video, external, frequency mask trigger	Remote monitoring, EW, automated test, general benchtop analysis	Benchtop	10.2 x 7.2 x 2.15 in.	7.77 lb	SM200A + 2 GB DDR capture @ 160 MHz IBW
Video, external, frequency mask trigger	Remote monitoring, EW, automated test, general benchtop analysis	Benchtop	10.2 x 7.2 x 2.15 in.	7.77 lb	Replaces USB interface with 10 GbE SFP+, 160 MHz streaming I/Q
Power, frequency mask, frequency edge, DPX density, runt, time qualified	Advanced radar/EW design evaluation; environment evaluation, monitoring, and recording; wideband communications design; spectrum management	Benchtop/ rack-mount	282 x 473 x 531 mm; 11.1 x 18.6 x 20.9 in.	29 kg; 64.7 lb	Functionality of a spectrum analyzer, wideband vector signal analyzer, and trigger-capture-analyze capability of a real-time spectrum analyzer in a single package

BENCHTOP SPECTRUM ANALYZERS

MODEL	SPECTRUM ANALYZER TYPE	OPERATING FREQ. RANGE	CENTER FREQ. AND SPAN OPTIONS	RESOLUTION BANDWIDTH	DETECTOR	MIN. EVENT DURATION	SFDR
Tektronix; Beaverton, Oregon, USA; +1 800-438-8165, www.tek.com ***cont'd.***							
RSA7100B	Real Time	16 kHz - 26.5 GHz	Real time Bandwidth 800 MHz	0.1 Hz - 10 MHz	+Peak, -peak, avg. (VRMS), sample, CISPR avg., CISPR Pk, CISPR QPK, avg. (of logs), CISPR avg. (of logs)	232 nsec	<-80 dBc to 3.6 GHz <-65 dBc to 26.5 GHz
Textron Systems - 124 Industry Lane, Hunt Valley, MD USA - (410) 628-3618 - www.textronsystems.com/							
SASI 240	Dual-channel FFT (Single channel variants also available)	AC coupled range 10 MHz - 40 GHz; DC coupled range DC - 20 MHz	Anywhere in range with up to 40 GHz span	1Hz - 10MHz	Peak and avg. detection	50 nsec	80 dB
SASI EW	Dual-channel FFT (Single channel variants also available)	AC coupled range 10 MHz - 40 GHz; DC coupled range DC - 20 MHz	Anywhere in range with up to 40 GHz span	1Hz - 10MHz	Peak and avg. detection	50 nsec	80 dB

SURVEY KEY – BENCHTOP SPECTRUM ANALYZERS

MODEL
Product name or model number

SPECTRUM ANALYZER TYPE
- FFT = fast Fourier transform

OPERATING FREQUENCY RANGE
Operating frequency or center frequency

CENTER FREQUENCY AND SPAN OPTIONS
The center frequency and span of the spectrum analyzer unit
- CF = center frequency

RESOLUTION BANDWIDTH (RBW)
Bandwidth of the filter (swept or digital) used for signal processing

DETECTOR
The technique used to determine the signal amplitude
- avg. = average
- CISPR = International Special Committee on Radio Interference
- EMI = electromagnetic interference
- RMS = root mean square (power averaging)
- VRMS = root mean square voltage

MIN. EVENT DURATION
Minimum event duration for 100% probability of intercept
- IBW = instantaneous bandwidth
- POI = probability of intercept

SFDR
Spurious Free Dynamic Range (SFDR)

TRIGGER TYPES
Options for starting measurement of a specific signal

TRIGGER TYPES	APPLICATIONS	FORM FACTOR	SIZE	WEIGHT	FEATURES
Power, frequency mask, DPX density, time qualified	Wideband radar and pulsed RF signals; frequency agile communications; broadband satellite and microwave backhaul links; EMC/EMI pre-compliance and troubleshooting	Benchtop/ rack-mount	445.5 x 177.1 x 577.9 mm; 17.54 x 6.79 x 22.75 in.	24.2 kg; 53.2 lb	Real time analysis, streaming
2 TTL trigger inputs 50Ω impedance BNC connector; 8-channel MLVDS wire interface trigger bus conforms to TIA/EIA-899 Molex 83614-9016 connector; provisions for two programmable internal trigger sources	Multi-purpose combined spectrum analyzer, vector network analyzer, downconverter and oscilloscope for EW, radar, coms, SATCOM and Automated Test Equipment	Benchtop/ rack-mount	Height: 3U (5") Width: 19" Standard Rack-Mount Configuration Depth: 25"	37.5 lb	Compatible LXI RF sources also available for comprehensive test capability. Two LXI RF sources and one SASI 240 provide combined capability of: 2 signal generators, dual downconverters, dual-channel spectrum analyzers, VNA, dual-channel oscilloscope
2 TTL trigger inputs 50Ω impedance BNC connector; 8-channel MLVDS wire interface trigger bus conforms to TIA/EIA-899 Molex 83614-9016 connector; provisions for two programmable internal trigger sources	Multi-purpose combined spectrum analyzer, vector network analyzer, downconverter and oscilloscope for EW test and simulation applications, including ELINT, COMINT, and SIGINT	Benchtop/ rack-mount	Height: 3U (5") Width: 19" Standard Rack-Mount Configuration Depth: 25"	37.5 lb	Compatible with Textron Systems A2PATS Family of Multi-Spectral Electromagnetic Environment Simulators.

APPLICATIONS

Uses of the spectrum analyzer

- DF = direction finding
- EW = electronic warfare
- Rx = receiver
- SATCOM = satellite communications
- TSCM = technical surveillance countermeasures
- Tx = transmitter

FORM FACTOR

Suitable operating environments (lab or field) for the spectrum analyzer

SIZE

Length, width and depth in inches or millimeters.

WEIGHT

Unit weight in pounds or kilograms

OTHER ABBREVIATIONS

- BW = bandwidth
- freq. = frequency
- IF = intermediate frequency

** Indicates answer is classified, not releasable or no answer was given.*

NOVEMBER 2021 TECHNOLOGY SURVEY: ESM/ELINT RECEIVERS

In the November *JED,* our technology survey will cover RF receivers for radar electronic support measures (ESM) and electronic intelligence (ELINT) applications. If you would like to participate, please email JEDEditor@naylor.com to request a survey questionnaire.

WHO SHOULD ATTEND

AOC 2021, the Association of Old Crow's Annual Symposium & Convention, brings together the *full spectrum of people* working in electromagnetic spectrum operations.

ACTIVE DUTY TO VETERAN

No matter what your mission, you need an advantage in the spectrum. A better understanding of the invaluable role of spectrum in military operations is imperative for success.

JUNIOR ENGINEER TO PRINCIPAL ENGINEER

You are the technology makers, the rapidly evolving designers. Through research and development, you are solving the problems and providing the solutions to the war fighters.

CASUAL TO PRO

The spectrum is part of your world and touches everything you do. You need to join our mission in order to gain the knowledge you need to drive decisions in your organization.

SUPPORT OUR MISSION • INFLUENCE OUR MISSION • LEARN OUR MISSION

SPEAKER SPOTLIGHT

Dr. Victoria Coleman
Chief Scientist
United States Air Force

Ms. Michèle Flournoy
Co-Founder and Managing Partner
WestExec Advisors

SYMPOSIUM AGENDA

All-Domain Operations - Integrating Effects Across the Spectrum

Symposium Sessions

- [5G Networks] Critical Enabler or Vulnerability?
- [Air Force Spectrum Warfare Wing] Vision, Initial Efforts, Integration Across the Joint Force
- [EMSO] Implementing EMSO for the Future Fight
- [JADC2] The Criticality of EMS Interoperability/ Compatibility
- [MBSE Digital Environment and Engineering] Enabling to Rapid Development and Fielding
- [Project Convergence 21] Linking Land, Air, Sea, Space, and Cyberspace
- [Government and Industry Perspectives] Strategic Opportunities and Emerging Technologies
- [Talent Challenges] How Space Force Is Developing Guardians To Build High-Performance Teams
- [AI and Autonomy] The Speed of Data and Decisions in the Next Fight *(brought to you by Young Crows)*

Learn more about our theme and session details at **58.crows.org**

**As of July 8, 2021 – Subject to Change*

REGISTRATION INFORMATION

Registration and housing is now open!

Discounted pricing ends 8/31!

Master Pass

The 'Master Pass' includes access to keynote sessions, access to all symposium sessions Tuesday–Thursday, access to the Welcome Reception; access to the exhibit hall, lunches and happy hours, First-Time Attendee Orientation, and access to all recorded keynote sessions and all briefings as released by the speakers. *Registration does not include access to the Program Manager Briefing Series or post-convention courses.*

	By 8/31	9/1-11/5	11/6-On-Site
Industry (Member)	$695	$795	$895
Industry (Non-Member)	$895	$995	$1095
Academia*	$445	$545	$645
Young Crows (35 and younger)*	$445	$545	$645
Government Civilian*	FREE	FREE	FREE
Military in Uniform**	FREE	FREE	FREE

*Must present proper ID for discounted price:

- Academia - faculty/staff/student ID.
- Young Crows (35 years old and younger) - photo ID with DOB.
- Government Civilian - government ID or civilian CAC card.

**Duty uniform must be worn each day. If not, a fee of $100 will be assessed.

Exhibition Only Pass

This complimentary registration type provides access to the Welcome Reception, keynote sessions and the exhibit hall. *It does not allow access to all other symposium sessions, Program Manager Briefing Series or post-convention courses.*

Exhibition Only	FREE	FREE	FREE

POST-CONVENTION COURSES

Extend your convention experience by signing up for a post-convention AOC professional development course. These courses are taught by our subject matter experts.

Space Electronic Warfare

December 3-4, 2021

Presented by Dave Adamy

Machine Learning for EW

December 3-4, 2021

Presented by Kyle Davidson

Get more information online at crows.org/2021Courses

Seperate registration required.

PROGRAM MANAGER BRIEFING SERIES

AOC is thrilled to announce the return of our Program Manager (PM) Briefing Series to this year's International Symposium and Convention. The PM Briefing Series will offer a technology interchange in a series of 45-minute sessions comprised of presentations from PM offices across the military services and audience Q&A.

PROGRAM MANAGER BRIEFING SERIES
WHERE GOVERNMENT & INDUSTRY MEET

During this program, exhibitors will hear directly from their government customers on the status of key programs and activities under their leadership, opportunities and milestones on the horizon, and how government and industry can strengthen collaboration.

This program is only open to 2021 exhibiting companies.

OPTIMIZE YOUR EXPOSURE

The best of the best in the world of electromagnetic warfare attend AOC's Annual Symposium & Convention. Have your organization stand out and make an impact. Custom sponsoring opportunities are available, no matter what the size and budget of your organization. Learn more about sponsoring and exhibiting at the show: go to 58.crows.org or contact **Sean Fitzgerald** at **fitzgerald@crows.org**.

Booth space is selling quickly! Book now! *Special opportunities for Small Businesses are available.*

5G Communications – Part 5

Military Applications of 5G

By Dave Adamy

The implementation of 5G technology in the civilian telecommunications market has some very severe cost consequences. The most serious of these has to do with use of the 5G high-band frequencies because the towers must be spaced much closer than the low-band towers, and this translates into a lot more infrastructure. Military programs must also consider these costs, but they also take on significantly more costly challenges in order to meet serious threats.

The areas of interest for military applications discussed in much 5G literature include:

- Intelligence, surveillance and reconnaissance
- Remote control of weapons, platforms and systems
- Telemedicine
- Training and mission rehearsal
- Logistics

We will consider each of these applications from a technical point of view.

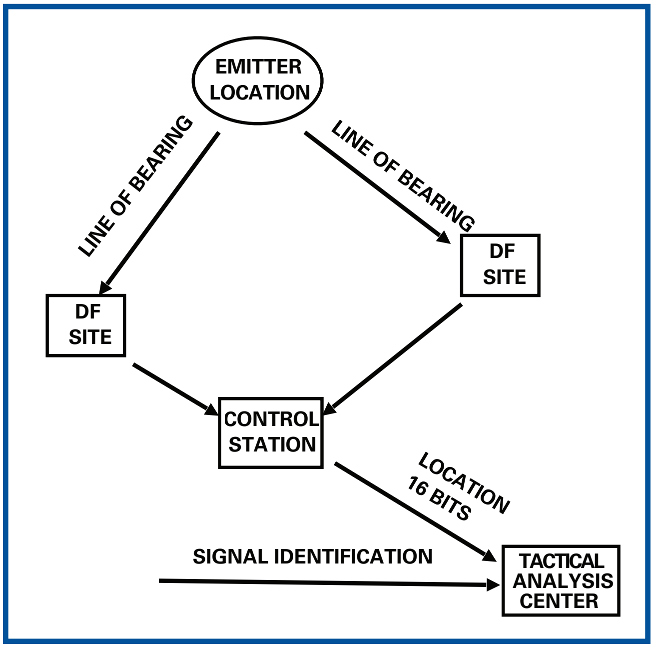


Fig. 1: *The location of each hostile emitter is combined with other information and transmitted to a location where an electronic order of battle can be generated.*

ISR

Intelligence, surveillance and reconnaissance (ISR) involves the collection and analysis of information about an enemy's capabilities and activities. ISR systems typically utilize many sensors (land, sea, air or space) to gather the necessary information over large geographical areas. This information must then be moved to locations where the necessary analysis can be performed to convert very large amounts of data to actionable intelligence. **Table 1** shows the typical amount of data required to capture various types of information. Sometimes data compression can be employed at the initial sensor to reduce the necessary data transfer rate, but there are typically large numbers of target signals that require significant total data rates.

Table 1: *Bits required to send various types of signals*

Type of signal	Bits required
One voice signal	64 kbits per second
Parameters of one hostile radar	400 bits for each signal
One 19-inch computer screen frame	31.5 Mbits, 24 times per second
Thermal image from infrared line scanner	8 bits per frame x 2.6 M frames per sec
Emitter location to 10 meters in 100 km2	16 bits

The key feature of 5G that enhances ISR performance is accommodation of increased data rates. As described in the April 2021 EW 101, mid-band 5G transmission can transport 100 Mbps to 900 Mbps (and is typically operated at 225 Mbps, which is six to seven times faster than 4G transmission). High-band transmission will be significantly higher – approximately 1 Gbps to 3 Gbps. This higher data rate means that more enemy signals can be intercepted and processed in a given amount of time.

Because there are so many types of signals, it is useful to consider a few examples to show the impact of 5G on ISR performance.

VOICE SIGNALS

An audio signal, like a typical channel of a multichannel system or a single tactical radio transmission, requires 64 kbits per second. This means that a mid-band 5G signal could carry over 3,500 voice-grade signals (versus about 500 for 4G). In the future, the number of signals will most likely increase, and along with associated data, such as emitter location, this ISR data will be a likely candidate for high-band transmission.

For example, consider the location of each VHF emitter to 10 meters in a 100 km² tactical area of interest. This requires 16 bits per emitter location. Over a brief period (a few microseconds) 10% of tactical 25-kHz channels could be expected to be occupied. If 10% of the VHF channels between 30 MHz and 88 MHz are occupied, there will be 232 signals present. To locate these 232 emitters in one second requires a data rate of 3712 bits per second. Precision location to 1 meter will require another order of magnitude of resolution (i.e., another 4 bits per signal). If each channel is observed for a period of a second or more, the occupancy factor is probably more than 100%. If every intercepted signal is captured, the data rate would be 37,120 bits per second.

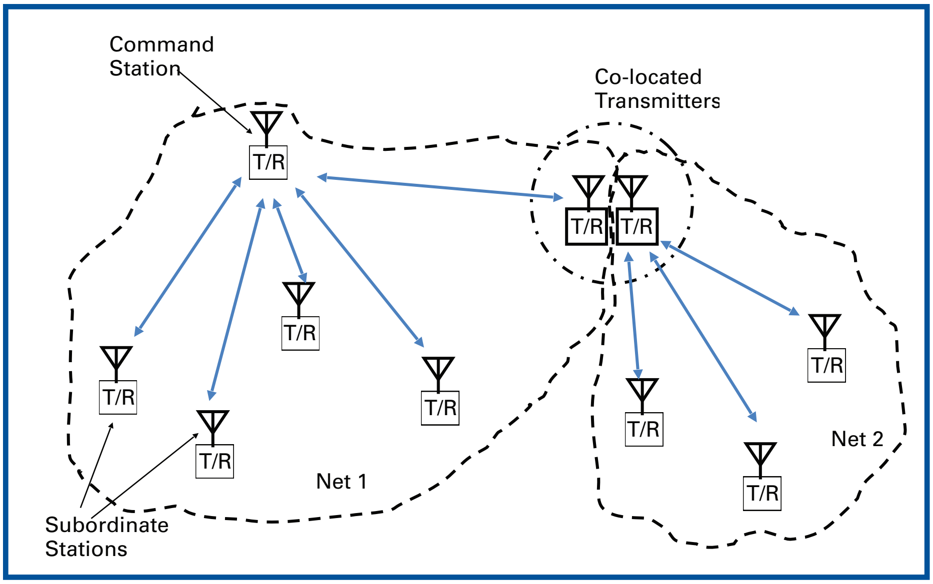


Fig. 2: The electronic order of battle (EOB) shows the organization and location of an enemy force and allows analysis of key communication nodes. A tactical communication net has several transceivers in the same geographical area. Interlocking nets show how military forces are organized.

Figure 1 shows the capture and transmission of a single emitter location by a tactical emitter location system. This shows only two directions of arrival sites; there can be significantly more. If the individual direction-finding (DF) sensors are mobile (perhaps on UAVs or satellites), the data rate on links to the control station will be significantly increased by the attachment of each site location for each measurement.

If precision emitter location (time of arrival or frequency difference) is used, very high data rates will be required to get enough data to the control station to support sufficient location accuracy.

ELECTRONIC ORDER OF BATTLE

An electronic order of battle (EOB) is a complete list of enemy emitters along with the location and characterization of each. **Figure 2** shows a very simple EOB with only two interlocking nets. The command stations are identified by traffic analysis. The types of units present can be determined from the frequencies, modulations and types of encryptors they use. The colocation of sites allows the analysis of the enemy's organization of its forces; this requires precision location information. The makeup of the enemy forces along with the location and movement of the emitters in each enemy organization allows for analysis of the enemy's intentions.

Figure 2 shows the electronic order of battle only for communication nets. When data links and radars are added to this mix, the identification of types of units becomes more accurate. Timely sharing of the EOB requires very high bandwidth, which will make good use of 5G.

IMAGERY

There are obvious advantages to sharing imagery information among military units and across different levels of command. As shown in **Figure 3**, the amount of data from an imagery sensor depends on the number of pixels and the intercept geometry. At any number of pixels, there is a tradeoff between the area of coverage and the resolution. The number of pixels controls the proportion of the full image in each resolution increment. Consider sending a single 19-inch computer terminal screen. A full-color 1280 by 1024 pixel computer screen has 31.5 Mbits of digital data. Sending a video picture over a 225 Mbps 5G link would allow seven screens per second to be sent. While this is less than full motion, it would be adequate for many ISR data collection tasks. Note that a 4G link could only carry one screen per second. With high-band 5G transmission, full motion is possible.

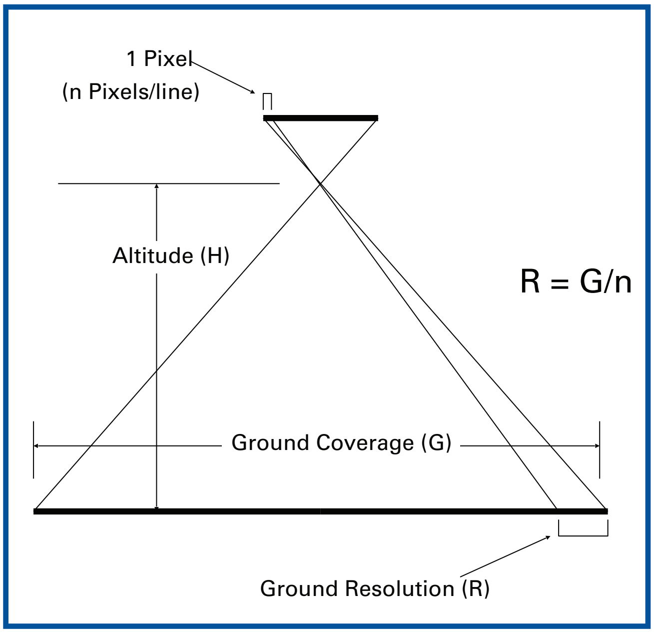


Fig. 3: The coverage and resolution in a captured image depends on the number of pixels in the sensor and the distance between the sensor and the target (in this case, the ground).

IRLS

Consider an infrared line scanner (IRLS) that is locating mines in the ground. The IRLS makes a thermal scan of the ground after sunset to identify and locate buried mines that cool down at a different rate than the surrounding ground. One study used 3 in. as the required resolution to differentiate a mine from a rock. As shown in **Figure 4,** assume that an IRLS on a UAV flying at 90 knots 1000 feet above the ground is scanning a 60-degree-wide path with a thermal sensor 0.25 miliradians wide. (The sensor would cover a 3-in. circle on the ground from 1000 feet.) At 100 knots, the sensor would have to be moved cross the UAV's ground trace at a rate of 608 sweeps per second to make one sweep every 3 in. and would need to sample 4286 times during each sweep to cover 60 degrees with a 0.25-miliradian sensor. If the thermal data needs to have 8 bits per sample to capture a fine enough temperature resolution (about ½ degree Fahrenheit), the total data rate is just over 23 Mbps. Even allowing for significant overhead (such as location and timing data), this is well within the capability of a mid-band 5G link.

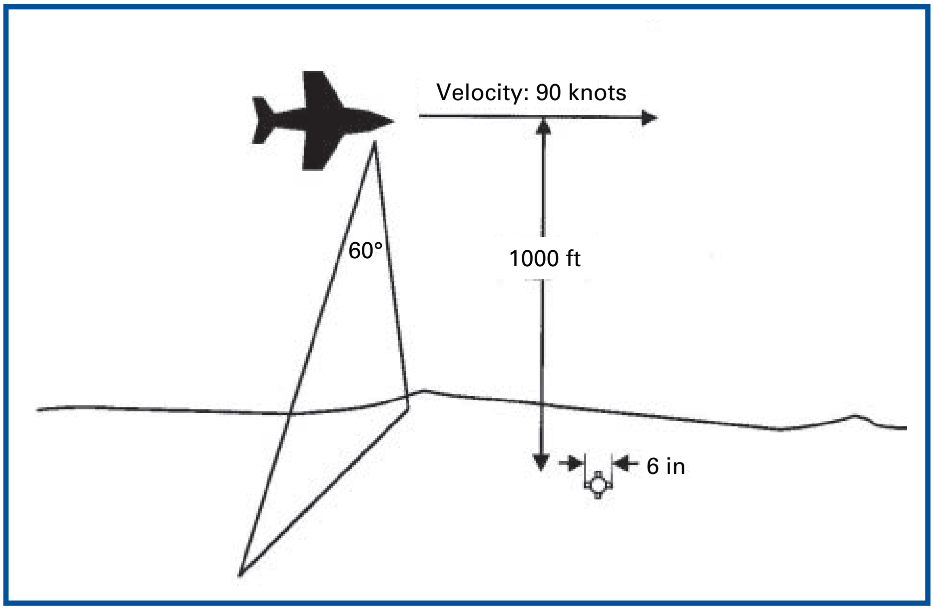


Fig. 4: *If a UAV flies at 1000 feet at 90 knots and scans an IRLS across 60 degrees, it can capture thermal images with enough resolution to locate mines in the ground. With a 0.25-milliradian wide sensor, it can measure the ground temperature every 3 square inches.*

WHAT'S NEXT

Next month, we will continue our discussion of intelligence, surveillance and reconnaissance (ISR) applications of 5G technology. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

ASSOCIATION OF OLD CROWS

2021 AOC Election Guide

Election runs October 1-31, 2021

Your participation is critical. Please exercise your right to vote for your AOC President and Board of Directors representatives. You can familiarize yourself with the candidates with this election guide. This information describes the candidates' backgrounds, leadership styles and contributions to the AOC. The 2021 Nominating Committee carefully considered the impressive nominations it received before recommending this year's candidates. The slate of candidates was subsequently approved by the AOC Board of Directors. We are grateful to all of those who participated in this process and applaud those willing to submit their names for consideration.

Thank you for your continued support of AOC. Let your voice be heard by casting your vote for the new leaders of your association!

PRESIDENT

Brian Hinkley

Brian "Hinks" Hinkley currently serves as a vice president for Amentum Inc. With more than 40 years of industry and operational experience, he is responsible for business development, capture and program management of opportunities within Electronic Warfare, Electromagnetic Spectrum Operations, Command and Control and Cyber Operations.

Prior to joining the civilian sector in 2010, Hinks served 27 years as an electronic countermeasures officer in naval aviation electronic attack. He accumulated over 2700 flight hours and 600 traps while deploying aboard several aircraft carriers and participating in multiple combat operations. Other career highlights include his tour as Commanding Officer of the VAQ-135 Black Ravens for Operations ENDURING FREEDOM and IRAQI FREEDOM and his selection as the first operational Commander of Joint CREW Composite Squadron ONE (JCCS-1) in 2006 at Camp Victory in Baghdad, Iraq. Hinks led Navy efforts to improve EW capabilities within the US Army and US Marine Corps, which resulted in significantly reducing casualties from Radio-Controlled Improvised Explosive Devices. His Navy career culminated in developing the Navy's first Fleet Electronic Warfare Center, integrating the Navy Marine Corps Spectrum Center to focus on enhancing Fleet EW readiness and highlighting the criticality of being able to maneuver forces within the battlespace of the Electromagnetic Operating Environment.

Hinks says that being a Crow is ingrained in his identity. He became a Crow as a junior officer in the VAQ community and has been a member now for over 26 years. Since 2014, he has served on the AOC Board of Directors as an at-large elected director or as an appointed director. In this time, he has been chairman for the Audit and Inspections Committee (2014-2015), the Awards Committee (2015-2016) and the Membership Committee (2016-2018), served as a member of the Board of Governors, and he has chaired the STEM and AOC Scholarship Committees (2019).

He currently serves as Vice President to the AOC President, which gives him the leadership responsibility to work closely with the AOC staff, Board of Governors, Board of Directors, Executive Committee and AOC Chapters to lead development of the AOC's Five-Year Strategic Plan. This timely insight has inspired him to run for the office of President to provide an important combination of sustained continuity and energized innovation. If elected, he will work for our members to clarify our vision and strategy, grow industry sponsorship, strengthen our international presence, and increase our advocacy with military and industry leadership. In Hinks' words, "The strength of AOC resides truly in the energy of its members. While we must constantly evolve to keep pace with emerging technologies and demographics, AOC should always prioritize a vigilant focus on listening to and responding to the needs of its members."

Sharon Lyczak

Sharon has been a contributing member and active board member of the AOC's Windy City Chapter since the mid 1980s – acting as golf co-chair for most of those years and as vice president from 2004 through 2015, then president from 2015 through 2020. She has been a Northrop Grumman employee since 1985, having served in various departments throughout the site, and she has a good overall grasp of the businesses. She is a strong supporter of our EW industry and the AOC scholarship program. Sharon won the AOC chapter support award in the early 1990s and again in 2013.

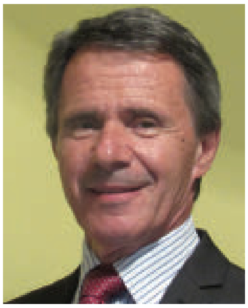
Sharon has a bachelor's degree from Judson University and her PMI certification from University of California, Irvine. She is also a member of various NGC-ERGs (employee resource groups). She has been the chairman of the Northrop Grumman WINS (Women's Initiatives for Networking and Success) Community Outreach Organization from 2007 to 2013, and the president of the Northrop Grumman Scrapbooking Club. She has served several "tours" as the secretary of the Northrop Rec Club Bowling League, the State/National Rep, president for her Mothers of Multiples (Twins & Triplets) Club and been involved in many other ERGs and clubs both internal to NGC and in the local community.

"If elected, I'd like to be able to work with the Board to expand our teamwork with our international partners. In this new global environment we live in, it's so easy now to engage our international teammates. And having worked on the N&E Committee, I've experienced firsthand the breadth of knowledge they bring to the table and the open communications we've been able to share. Also, over the years, the Board has been working hard to share the mission with the younger generations. I'd like to continue to be a member of that team and find more ways of educating our early career Crows – across the globe – about the importance of everything AOC brings to the table."

AT-LARGE

Nino Amoroso

In his over 36 years of involvement with AOC, Nino has chaired various activities and committees, including symposia at the chapter, national and international levels. His recent activities have included acting as moderator/interviewer for AOC's first virtual Executive Session, which featured Gen John Hyten, USAF, Vice Chairman, Joint Chiefs of Staff, and the position of moderator/interviewer for a Chapter International Session featuring Europe, Western Asia, Africa and the Middle East. The session focused on the newly established Praetorian Chapter in Italy, which Nino helped establish, and the EMSOPEDIA. Nino has over 44 years of both operational and procurement government and industry experience within the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), information operations and electronic warfare communities, where he has spearheaded new initiatives and directed the procurement of Air Force, Joint systems, special operations capabilities, counter-narcotics centers, coalition, command and control networks, aerial ground surveillance systems and the rapid acquisition of critical technologies. He has had government and corporate responsibility for the planning, identification and execution of programs within the C4ISR area and has held government leadership positions up to the System Program Office and Division level. Nino has also represented corporate organizations to senior government and industry across many focus areas, including the US Air Force, the US Intelligence Community, Battle Management, Aerial Ground Surveillance Systems, Battle Control Systems, International C4ISR programs and Homeland Security (HLS). Nino holds a B.A. degree from the Catholic University of America and an M.S. degree from the University of Southern California. He is also a graduate of the Air War College, Federal Executive Institute, and programs within the Defense Intelligence College and Defense Acquisition University. In addition to military and civil service awards, he has received several AOC awards, including the Hal Gershanoff Silver Medal, Anton D. "Tony" Brees Lifetime Service Award, Distinguished Service Award and the Clark G. Fiester Command and Control Warfare Award.



Bob Andrews

Bob has extensive experience on the AOC Board of Directors and Board of Governors, and he brings both past knowledge and new ideas based on that experience to the Board. Bob is very hard-working and fully committed to the goals and objectives of AOC, and he is continually improving the organization. Being an AOC member from the UK, he is able to provide knowledge and insight to the requirements and expectations of the international AOC membership. The growth of AOC membership will be in the international arena, and his experience and commitment to achieving this has been demonstrated by his representation on the Board and on various Board committees over the past decade.

Bob believes that one of AOC's most important roles is to provide educational and professional development courses to its members and to the EW community. He is excited by the introduction of the AOC EW Certification Program, which has been a long time in its preparation but will be a great asset to AOC in its mission of EW advocacy and which he wholeheartedly supports.

Col Steven Oatman, USA (Ret.)

Steve is running for the AOC Board of Directors following a 31-year career in the US Army, in which he served as an enlisted military police officer, an officer in the Field Artillery and as an electronic warfare officer, and where he began his career as a private/E-1 and retired as a colonel/O-6. His extensive experience and background during peacetime and combat will enable him to assist AOC with its efforts to expand the membership, especially across all of the Services. Having been one of the senior electronic warfare officers in the US Army, Steve is continuously focused on increasing the personnel, readiness and material capability within the US Army operational and tactical formations.

As a member of the AOC Board of Directors, he will bring that same determination and focus on increasing the visibility and importance of EW across the Services drawing on real-world combat and peacetime experience to assist in achieving AOC's overarching goals regarding all of the services EW capabilities. Simultaneously, based on his background and experience, Steve would add a crucial element to the AOC Board overall with regard to the US Army and ground electronic warfare that, while not missing on the board, is clearly underrepresented.

Pedro Vasquez Jr.

Col Pedro "PJ" Vasquez Jr., USAF (Ret.) is CEO of Peter T. J. Strategic Solutions, which provides consulting services and solutions for private sector companies and nonprofit organizations working in a complex and competitive environment. PJ has 40-plus years of experience in Department of Defense, private industry and nonprofit organizations. He has worked in key leadership and staff positions with the United States Air Force, Joint Chiefs of Staff, Pentagon, Lockheed Martin, Imperatis, (formerly Jorge Scientific Corp.) and Loui Consulting Group. PJ's background includes business development, program management, strategic/operational logistics, field and depot aircraft maintenance, electronic warfare, common avionics, training, acquisition and sustainment, strategic planning and special operations. He holds graduate degrees in public administration, international relations from Troy University and national resource strategy from Eisenhower School for National Security and Resource Strategy.

His most pronounced strength is developing business networks in aerospace defense industry, government, academia and community. He's currently consulting with industry on EW/avionics programs at Robins Air Force Base, GA. As a member of the Dixie Crow Chapter at Warner Robins, PJ actively supported their educational programs. He is the president of Central Georgia National Defense Chapter, which stood up in November 2020. As a member of the AOC Board of Directors, PJ would like to focus on three areas: First, train and educate industry and government for 21st century EW and EMS operations. Second, organize our EW enterprise to ensure EW superiority. Third, increase our partnership with industry, academia, legislative and allied partners.

REGIONAL

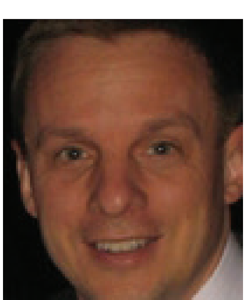
Michael Gardner (Central)

Michael started his career in electronic warfare in 2000, where he supported programs in multiple electronic warfare domains (RF, EO/IR, space). In 2009, he transferred to a leadership position within Northrop Grumman, where he has had the opportunity to lead multiple domestic and international EW programs. Michael's leadership and expertise have enabled him to work on programs in each stage of their life cycle, from early concept development through EMD to upgrades and program sustainment. He has worked to bridge the gap between development and fielding of next-generation technologies and has been a passionate advocate for electronic warfare and its importance to the warfighter. Michael has been a member of the AOC Windy City Chapter Board of Directors and currently serves as the Windy City Board elections chair.

Michael has also devoted his time toward cultivating a culture of growing the next generation EW leaders by acting as a mentor to high school students interested in EW careers, as well as to new EW professionals. Michael received his bachelor's degree in nuclear engineering from the University of Illinois at Urbana-Champaign, his master's degree in mechanical engineering from the University of Illinois at Chicago and his master's in product development from Northwestern.

James Utt (Central)

Jim's first encounter with AOC occurred in the mid-1980s, when he was a college intern at a software company working on a simulator for the EW system in the B-52. Many of his colleagues were Crows, and they nominated him for a much-needed scholarship. He went on to pursue a career in defense-related research and development of EO/IR/RF sensors and countermeasure technologies with emphasis on the high-performance computing components needed to make them practical. He eventually served as vice president of engineering for a successful small defense business, where he was honored to receive the AOC Executive Management Award in 2004. He went on to found Defense Engineering Corp. (DEC) in 2007. DEC specializes in advanced sensor and processing technologies for intelligence, surveillance and reconnaissance (ISR) and electronic warfare applications. DEC is a proud corporate sponsor of the Kittyhawk AOC Chapter, where Jim is an active participant. He has served on the Kittyhawk Board of Directors for the past eight years, including roles as vice president and the maximum two terms as president. During his tenure as president, the chapter substantially expanded the corporate sponsorship program. The chapter also instituted regular social events, which increased new membership in a younger demographic – especially monthly social events held in a pub outside Wright Patterson AFB and annual "Best Brew" competitions to see who can brew the best beer. The chapter made annual STEM scholarship awards and hosted annual classified conferences. Jim has also served on STEM, awards and nominations & elections committees at the International AOC level.

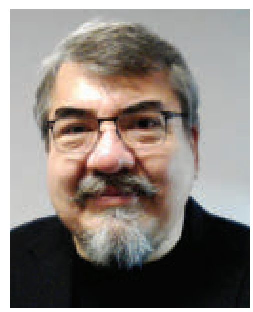


Dennis Monahan (Mid-Atlantic)

Dennis "Mancub" Monahan serves as president of the Dahlgren Roost in King George, VA, and has been a contributing member of the AOC since 2005. Dennis' priorities are focused on increasing AOC brand awareness and expanding surface warfare community representation in the AOC community. These efforts have been largely successful, despite COVID-19, by maintaining a constant offering of virtual engagement opportunities on EMS and STEM-related topics.

Dennis has engaged in operationalizing the electromagnetic spectrum (EMS) over the past 28 years, most recently through his work at Booz Allen Hamilton supporting directed energy programs at Naval Surface Warfare Center Dahlgren Division. His influencing experiences include planning, leading and conducting airborne electronic attack globally for 100 combat missions; a year on the ground in Iraq as current operations officer helping to stand up Joint CREW Composite Squadron-ONE (JCCS-1) to reduce the impact of radio-controlled improvised explosive devices (RCIEDs); and a short assignment deployed as electronic warfare (EW) liaison to a numbered task force conducting counter-insurgent operations. Since retiring from the Navy in 2007, Dennis has also worked as a senior electronic warfare (EW) analyst and project lead providing EW subject matter expertise to the Joint Chiefs of Staff (JCS) J6B IED-Defeat and the JCS J-39 Deputy Director for Global Operations.

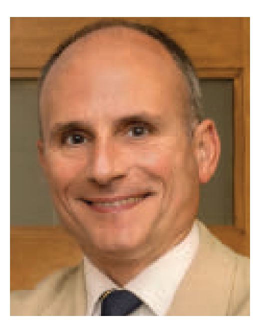
Dennis has a B.S. degree from Embry Riddle Aeronautical University, as well as an MBA from the University of Virginia (UVA) Darden School of Business. He is currently enrolled in the accelerated master's program in systems engineering at UVA.



Charles "Chuck" Quintero (Mid-Atlantic)

Chuck feels fortunate to have started his 40-year career at great schools like MIT and UPenn. That education gave him tremendous opportunities to continue his EW work at premier contractors like Lockheed Martin, L3-Harris, Northrop Grumman, SRI International and now the Johns Hopkins University Applied Physics Lab, where he is working on his Ph.D.

JHU-APL has really kindled his desire to do more to educate young engineers in signal processing aspects of EW and ELINT and to expand the representation of Hispanics in AOC leadership. He wants to help provide outreach to underrepresented groups and help guide people into the great engineering field of EW. Chuck is helping AOC develop certifications for its membership that Crows can use to publicize their talents, and he is involved in the AOC Board of Governors educational outreach work.



Wayne Shaw (Mountain West)

Wayne Shaw is a retired US Air Force Electronic Warfare Officer (EWO) with nearly 3000 hours in the B-52, B-1B, EF-111A and EA-6B. In 2009, he retired from the USAF and was employed by Booz Allen Hamilton until 2020 during which time he supported 24th Air Force (24 AF)/Air Force Cyber (AFCYBER) for eight years. Since July 2020, Wayne has worked for Alion Science & Technology as their site lead at the Joint Electromagnetic Warfare Center (JEWC) and as the contractor program manager for the Joint EMS Information, Analysis and Fusion (JEMSIAF) effort.

Wayne's military decorations include multiple Air Medals for combat time over Iraq and Bosnia and two Bronze Stars for his time in Baghdad (including going on patrol with his airmen). He led the US Central Command EW Coordination Center in the Middle East during a one-year remote assignment followed by his last military assignment at the JEWC, where he led the EA Working Group as part of the Vice Chairman of the Joint Chiefs of Staff EW CBA/FSA/ICD effort. Wayne's cyber credentials include Security+, Agile fundamentals and SAFe 5.0 Agilist certifications. He was the AOC 2017 Silver Medal recipient and is a past president of AOC (2013-2014).

2021 Online Voting Instructions

Beginning October 1, 2021, AOC members can visit the AOC homepage, www.crows.org, where they will see election information and a link to Elections On-Line, the independent vendor conducting this year's online election. You will receive an email with login instructions shortly before the elections start. The website will direct you to your ballot, where you can make your selections. **Your AOC dues must be current as of September 20 in order to vote.** As with past AOC elections, your ballot is secret.

Elections On-Line will hold all completed ballots, tabulate them and send the results to the AOC when the election is complete. Once you have cast your online vote, Elections On-Line will send you an email confirming that they have received your completed ballot.

Paper Ballots

For those AOC members who cannot vote online, the AOC has provided a paper ballot below. Members may cut out the paper ballot, mark it – including your member number (available on the front label of your *JED*) and your name and contact information – and mail it back to the AOC. Paper ballots must be postmarked after October 1, 2021, and before October 20, 2021, and be addressed to:

AOC – 2021 Ballot
1001 N. Fairfax St, Suite 300
Alexandria, VA 22314

Campaign Rules

Please remember: Other than the AOC-level "Get out the vote" campaign efforts, campaigning or electioneering on behalf of any individual candidate for AOC office, with or without their knowledge or consent, is prohibited.

2021 AOC Election Ballot

Paper ballots accepted October 1-20, 2021.

Name ....

AOC Member Number..

Email address ....

AOC PRESIDENT (vote for 1 candidate)

- ☐ Brian Hinkley
- ☐ Sharon Lyczak

AT LARGE (vote for 2 candidates)

- ☐ Nino Amoroso
- ☐ Bob Andrews
- ☐ Steve Oatman
- ☐ Pedro Vasquez, Jr.

CENTRAL (vote for 1 candidate)

- ☐ Michael Gardner
- ☐ James Utt

MID-ATLANTIC (vote for 1 candidate)

- ☐ Dennis Monahan
- ☐ Chuck Quintero

MOUNTAIN WEST

- ☐ Wayne Shaw

ASSOCIATION OF OLD CROWS

DIXIE CROW CHAPTER PROMOTES RECRUITMENT AND RETENTION

The Dixie Crow Chapter hosted a recruitment/retention event on June 23 at the Mellow Mushroom in Warner Robins, GA with 65 to 70 people in attendance. Several new membership applications and renewals were gathered while eating pizza, wings and enjoying great conversation.

A wonderful time was had by all. We received numerous compliments on the venue choice, food, etc., and we look forward to our next event! Thank you to Jon Gates for organizing this great event!

Winners of the $25 gift cards were Riley Nelson and Bill Clements

10TH ANNUAL PACIFIC INFORMATION OPERATIONS & ELECTROMAGNETIC WARFARE SYMPOSIUM

18-22 OCTOBER | JOINT BASE PEARL HARBOR HICKAM AND CAMP SMITH, HAWAII

Information Operations in Great Power Competition

This event will be delivered both in-person and online via the Federal Business Council (FBC) Online Events platform from 18-20 OCT for the UNCLASSIFIED plenary, and secure video teleconference for the CLASSIFIED plenary 21 and 22 OCT.

The UNCLASSIFIED plenary will offer three days of presentations, panels, and key note speakers. The in-person component will be held 19 & 20 OCT at the Trade Winds Club on Hickam Field, Joint Base Pearl Harbor-Hickam. The audience for the UNCLAS plenary includes U.S., Ally, and Partner military and government professionals, academia from military and civilian colleges and universities, and industry.

Classified presentations follow on October 21 and 22 at Camp H.M. Smith and attendance in these sessions requires both a SECRET clearance and submission of a visit request submitted via the Defense Information Security System (DISS, formerly JPAS). For the classified sessions, participating military commands, DOD PME institutions, academia, Industry, Allies and partners will coordinate with the symposium chair for instructions on how to be connected to the Towers Conference Room for October 21 and 22 over DOD networks on SIPRNET.

Individual registration is required to participate in any of the in-person or online presentations of the Symposium. After registering on-line participants can then choose the plenary sessions and distinct presentations they wish to attend. Registration and event information can be found at the link below.

Anyone interested in presenting at either the UNCLAS or CLASSIFIED plenary should review the call for papers on the symposium web page, and contact the Symposium Chair Dr. Arthur Tulak, COL USA, Ret., via e-mail at Arthur.N.Tulak.ctr@pacom.mil for more information.

VISIT **FBCINC.COM/AOCPACIFIC** FOR MORE INFORMATION

FEATURED SPEAKERS

ADM John Aquilino,
Commander,
USINDOPACOM
(Invited)

Lt. Gen Matthew Glavy,
USMC Deputy Commandant
for Information|
(Invited)

Ms. Bay Fang,
Executive Director,
Radio Free Asia

Prof. Austin Branch
Univ. of MD, Applied Research
Lab for Intelligence & Security
and Technology

Mr. Doug Jordan
Course Director (SOF-SC)
Joint Special
Operations University

SENIOR LEADER EMS SUPERIORITY ROUNDTABLE

Mr. Ken Dworkin,
(SES, Ret),
Executive Advisor, Booz Allen Hamilton, (Former) EW Executive (EWX), National Security Agency (NSA)

U.S. INDO-PACIFIC COMMAND

DIAMOND HEAD CHAPTER
ASSOCIATION OF OLD CROWS

AOC Members

SUSTAINING
BAE Systems
Bharat Electronics Ltd
CACI International Inc.
Chemring Group PLC
Electronic Warfare Associates, Inc.
General Atomics Aeronautical Systems, Inc.
General Dynamics
Keysight Technologies
L-3 Harris
Leonardo
Perspecta
Raytheon Intelligence & Space
Rohde & Schwarz USA
Saab Sensor Systems Germany GmbH
SRC, Inc.

MILITARY UNITS
30 Cdo IX Gp RM
547 IS
57 IS/DOD
Air Command Denmark
Detachment-A 743d
Helicopter Wing 53
IWTG Norfolk
Japan Air Self-Defense Force
NASIC/AC
NIWTG SD
Zentrum Elektronischer Kampf Fliegende Waffensysteme

INSTITUTES/ UNIVERSITIES
Georgia Tech Research Institute (GTRI)
Mercer Engineering Research Center (MERC)
Riverside Research Institute
RVJ Institute

GOVERNMENT GROUPS
Australia Department of Defence DIO
DE&S
Defence Science & Technology Agency (DSTA)
DOD
Los Alamos National Lab
New Zealand Defence Technology Agency
NGA – National Geospatial-Intelligence Agency
NLR – Royal Netherlands Aerospace Centre
Swedish Defence Materiel Administration T&E Directorate (FMV T&E)

GROUPS
35 Technologies Group, Inc.
3dB Labs Inc.
3SDL Ltd.
Abaco Systems
ACE Consulting Group
Advanced Test Equipment Rentals
ALARIS Antennas
Alion Science and Technology
Allen-Vanguard
Ampex Data Systems
Analog Devices
API Technologies
ApisSys SAS
Apogee Engineering
Applied Systems Engineering, Inc.
Armtec Defense Technologies
Aselsan A.S.
Atkinson Aeronautics & Technology, Inc.
Atlanta Micro, Inc.
Avix
Babcock International Group
Base2 Engineering LLC
Battelle Memorial Institute
Beca Applied Technologies Ltd.
Black Horse Solutions, Inc.
Blue Ridge Envisioneering, Inc.
Booz Allen Hamilton, Inc.
Boyd Corporation
Cablex PTY Ltd.
CEA Technologies, Incorporated
Centauri
Centerline Technologies LLC
Clearbox Systems
Cobham Advanced Electronic Solutions
Communication Power Corporation
Communications & Power Industries LLC
Comsec LLC
Comtech PST Corporation
Crescend Technologies, LLC, Defense Solutions
CRFS Inc.
CRFS Limited
CSIR DPSS
Cubic Defense
D-TA Systems, Inc.
Daqscribe
Darkblade Systems
Dayton Development Coalition
dB Control
Decodio AG
Defense Research Associates Inc.
DEFTEC Corporation
DEWC Group
Dreamlab Technologies AG
DRONESHIELD
DRT, Inc.
Eagle Sales Corp.
ELBIT Systems of America
Elbit Systems of EW & SIGINT Elisra
ELDES S.r.l.
Elettronica S.p.A
Empower RF Systems
Epiq Solutions
ESROE Limited
Evans Capacitor Company
Galleon Embedded Computing
GFD GmbH
Gigatronics Incorporated
Hammer Defense Technologies LLC
HASCO
HawkEye360
Hegarty Research LLC
Hensoldt Sensors GmbH
Hermetic Solutions
Herrick Technology Laboratories, Inc.
Hughes
IDS International Government Services
Indra
Intelligent RF Solutions
Interface Concept
ITA International, LLC
IW Microwave Products Division
JT4, LLC
Kihomac, Inc.
Kirintec
Kranze Technology Solutions, Inc. (KTS)
Kratos General Microwave Corporation
L3Harris TRL Technology
LCR Embedded Systems
Leonardo DRS
Leonardo Electronics-US
Liteye Systems, Inc.
MarServices GmbH
Mass Consultants Ltd.
MBDA France
MC Countermeasures, Inc.
MDA
MDSI
MegaPhase LLC
Meggitt Baltimore
Meggitt Defense Systems
Meta Mission Data Ltd.
Microwave Products Group
Milpower Source, Inc.
Milso AB
Mission Microwave Technologies
The MITRE Corporation
Molex
Motorola Solutions
MRC Gigacomp
MTSI
My-Konsult
MyDefence System Integration
N-Ask Incorporated
Nagravision S.A.
NEL Frequency Controls, Inc.
Northeast Information Discovery Inc.
Northrop Grumman Defense Systems – Advanced Weapons
Novator Solutions AB
OCS America, Inc.
Parsons
Pentek
Penten
Persistent Systems, LLC
Perspecta
Phasor Innovation
Photonis Defense Inc.
Physical Optics Corporation
Plath GmbH
PredaSAR
PROCITEC GmbH
QinetiQ Target Systems
Qnion Co., Ltd.
QuantiTech
RADA Technologies LLC
RAFAEL Advanced Defense Systems Ltd.
Research Associates of Syracuse, Inc.
Rincon Research Corporation
Rohde & Schwarz GmbH & Co. KG
Rohde & Schwarz Norge AS
Roschi Rohde & Schwarz AG
Rotating Precision Mechanisms
Rowden Technologies
S2 Corporation
School of Information Operations (SOIO)
SciEngines GmbH
Scientific Research Corp.
SEA Corp.
Serpikom
Sierra Nevada Corporation
Signal Hound
Silver Palm Technologies
SimVentions
SMAG Mobile Antenna Masts GmbH
Smiths Interconnect
Spectranetix, Inc.
Spherea GmbH
Spirent Communications
SR Technologies
STEATITE
Swisscom Broadcast AG
Systems & Processes Engineering Corp. (SPEC)
Tabor Electronics
TCI International, Inc.
Tech Resources, Inc.
Teledyne Technologies, Inc.
Telemus Inc.
Teleplan Globe Defence
TERMA
Tevet LLC
Textron Systems
Textron Systems Electronic Systems UK Ltd.
ThinkRF
Tinex AS
TMC Design
TMD Technologies Ltd.
Transformational Security LLC
Transhield Inc.
Trenton Systems
Trideum
TUALCOM, Inc.
Ultra Electronics - EWST
Ultra Electronics Avalon Systems
unival group GmbH
Valiant Integrated Services
Valkyrie Enterprises LLC
Verus Research
VIAVI Solutions
Vic Myers Associates
Vigilant Drone Defense Inc.
VITEC
W.L. Gore and Associates
Warrior Support Solutions LLC
WGS Systems, Inc.
X-COM Systems
ZARGES, Inc
Zentrum Elektronischer Kampf Fliegende Waffensysteme

ASSOCIATION OF OLD CROWS

JED, Journal of Electromagnetic Dominance (ISSN 0192-429X), is published monthly by Naylor, LLC, for the Association of Old Crows, 1001 N. Fairfax St., Suite 300, Alexandria, VA 22314.

Periodicals postage paid at Alexandria, VA, and additional mailing offices. Subscriptions: *JED, Journal of Electromagnetic Dominance,* is sent to AOC members and subscribers only. Subscription rates for paid subscribers are $160 per year in the US, $240 per year elsewhere; single copies and back issues (if available) $12 each in the US; $25 elsewhere.

POSTMASTER:
Send address changes to
JED, Journal of Electromagnetic Dominance
c/o Association of Old Crows
1001 N. Fairfax St., Suite 300
Alexandria, VA 22314

Subscription Information:
Glorianne O'Neilin
(703) 549-1600
oneilin@crows.org

JED Sales Offices

NAYLOR
ASSOCIATION SOLUTIONS
1430 Spring Hill Road, 6th Floor
McLean, VA 22102
Tel (800) 369-6220
www.naylor.com

Project Manager:
Kira Krewson
Direct: +1 (770) 810-6982
kkrewson@naylor.com

Project Coordinator:
Alexandra Lewis
Direct: +1 (352) 333-3409
alewis@naylor.com

Advertising Sales Representatives:
Shaun Greyling
Direct: +1 (352) 333-3385
sgreyling@naylor.com

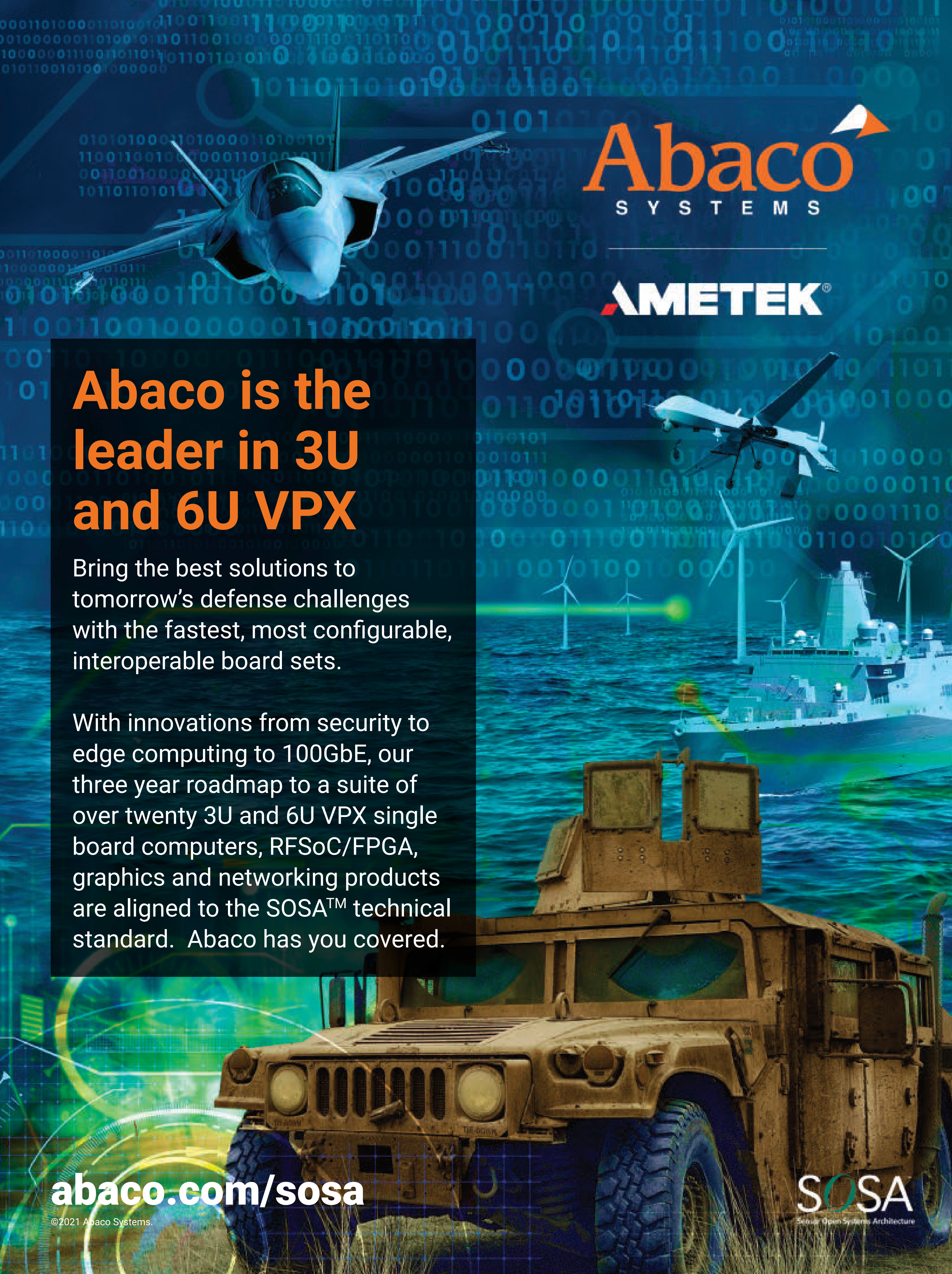
Robert Shafer
Direct: +1 (770) 810-6986
rshafer@naylor.com

Chris Zabel
Direct: +1 (352) 333-3420
czabel@naylor.com

NAYLOR (Canada) Inc.
200 – 1200 Portage Ave.
Winnipeg, MB R3G OT5 Canada
Toll Free (US): (800) 665-2456
Fax: +1 (204) 947-2047

Index of Advertisers

JED QuickLook


Abaco
SYSTEMS
AMETEK®
Abaco is the leader in 3U and 6U VPX
Bring the best solutions to tomorrow's defense challenges with the fastest, most configurable, interoperable board sets.
With innovations from security to edge computing to 100GbE, our three year roadmap to a suite of over twenty 3U and 6U VPX single board computers, RFSoC/FPGA, graphics and networking products are aligned to the SOSA™ technical standard. Abaco has you covered.
abaco.com/sosa
©2021 Abaco Systems.
SOSA
Sensor Open Systems Architecture