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September 2022 Vol. 45, No.9

JED

Journal of Electromagnetic Dominance

Defending the Fleet in the EM Environment

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- Preview: 59th AOC International Symposium and Exhibition

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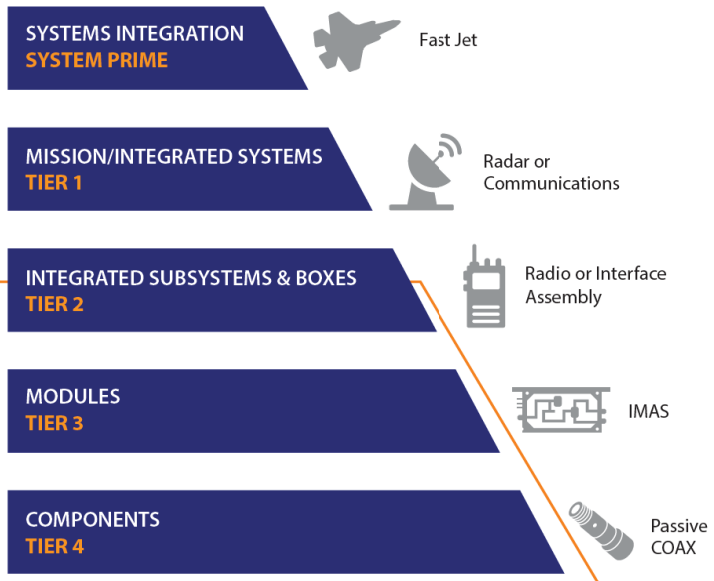

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An F-16, assigned to the 64th Aggressor Squadron and piloted by Capt Tim "REEF" Joubert, USAF, flies over North Las Vegas after participating in a Red Flag-Nellis 22-3 mission at Nellis Air Force Base, NV, in July. The F-16 performs threat simulation and jamming (note the electronic attack pod on Weapons Station 7) to maximize training in non-permissive environments. US AIR FORCE PHOTO BY SRA ZACHARY RUFUS

Departments

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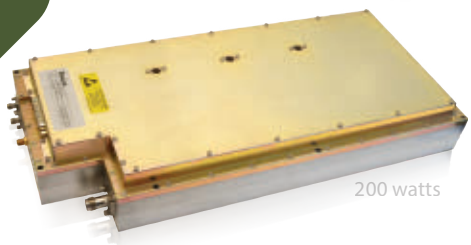

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TECHNOLOGY AND POLICY

This past summer, the US Government enacted an important piece of legislation – the CHIPS and Science Act of 2022 – which provides $52 billion to bolster semiconductor research and strengthen the semiconductor supply chain in the US. The US is a dominant player in the microelectronics market, and the CHIPS Act shores up a growing area of weakness – semiconductor fabrication – in a critical part of the supply chain. Depending on your perspective, the legislation may not be "perfect," but most would agree that strengthening the US chip manufacturing base represents good policy.

For the DOD, the CHIPS Act represents one small part of a larger discussion about technology policy. DOD technology policy takes many forms. The DOD's participation in the Small Business Innovative Research and Small Business Technology Transfer (SBIR/STTR) program is designed, as its name implies, to incentivize innovation among small businesses across a range of defense technology areas. Most SBIR contracts are for studies that help the DOD to assess whether a specific concept or technology is ready for further development. This enables the DOD to spend its R&D dollars more efficiently. Sometimes, SBIR/STTR studies can yield big results. For example, the AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) program traces its beginning back to 1995, when the US Navy awarded a $70,000 SBIR contract to Science & Applied Technology Inc. (SAT) to study the topic, "Secondary Sensor for High-Speed Anti-Radiation Missile (HARM)." The AARGM program eventually evolved from this effort and was funded for several years through congressional budget adds, until the Navy formally transitioned AARGM to a Program of Record in 2003.

Another, more recent development in DOD technology policy is the wider use of Middle Tier Acquisition (MTA) strategies to support rapid prototyping and fielding of new weapons systems and upgrades. MTA has been extremely important for EMSO-related programs because it enables faster development and fielding of EW and SIGINT systems, which helps to match the pace of new threat radars and adversary communications systems they must monitor and jam. Programs, such as the US Air Force's F-16 EW upgrade and the US Army's Terrestrial Layer System – Brigade Combat Team (TLS-BCT) system, use MTA authority.

This month, Congress is focusing its attention on both the SBIR/STTR program and MTA. The SBIR/STTR program is up for reauthorization by Sept. 30, and Congress is reviewing the program over the long-term with an eye toward making it more "efficient" with the dollars it spends. "Efficiency" sounds great in principle, but awarding these inexpensive study contracts across a wide set of small businesses helps to stimulate the technology innovation that the DOD needs from industry.

The Senate version of the FY2023 National Defense Authorization Act includes a provision that would require greater DOD oversight of programs that use MTA authority. Burdening MTA programs with additional oversight requirements will likely slow down the pace of development and fielding for some EW and SIGINT systems, and it would make them more like the sluggish conventional acquisition (i.e., ACAT) programs that MTA was designed to avoid.

Sound policy yields great results. Any technology policy reforms Congress is considering for the SBIR program and MTA authority should be careful not to undermine the original goals of these initiatives. – *J. Knowles*

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Calendar *Conferences & Trade Shows*

SEPTEMBER

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Sept. 6-8
Baku, Azerbaijan
www.adex.az

29th International Defence Industry Exhibition MSPO
Sept. 6-9
Kielce, Poland
www.targikielce.pl

AAAA Aircraft Survivability Symposium
Sept. 12-13
Lexington, KY
www.quad-a.org

SPIE Laser Damage
Sept. 18-21
Rochester, NY
www.spie.org

AFA Air, Space and Cyber Conference
Sept. 19-21
National Harbor, MD
www.afa.org

Africa Aerospace and Defense
Sept. 21-25
Air Force Base Waterkloof, Gauteng, South Africa
www.aadexpo.co.za

OCTOBER

AUSA Annual Meeting
Oct. 10-12
Washington, DC
www.ausa.org

AOC Pacific IO & EW Symposium
Oct. 18-21
Honolulu, HI
www.fbcinc.com/e/aocpacific/

EURONAVAL
Oct. 18-21
Paris, France
www.euronaval.fr

International Telemetry Conference 2022
Oct. 24-27
Glendale, AZ
www.telemetry.org

59th Annual AOC International Symposium and Convention
Oct. 25-27
Washington, DC
www.crows.org

SOFEX 2022
Oct. 31 – Nov. 3
Amman, Jordan
www.sofexjordan.com

NOVEMBER

MAST Med 2022
Nov. 2-4
Athens, Greece
www.mastconfex.com

Indo Defence Expo and Forum
Nov. 2-5
Jakarta, Indonesia
www.indodefence.com

Bahrain International Airshow 2022
Nov. 9-11
Sakhir Air Base, Bahrain
www.bahraininternationalairshow.com

2022 Directed Energy Systems Symposium
Nov. 14-18
La Jolla, CA
www.deps.org

MILCOM
Nov. 28 – Dec. 2
Rockville, MD
www.milcom.org

EXPONAVAL 2022
Nov. 29 – Dec. 2
Valparaiso, Chile
www.exponaval.cl

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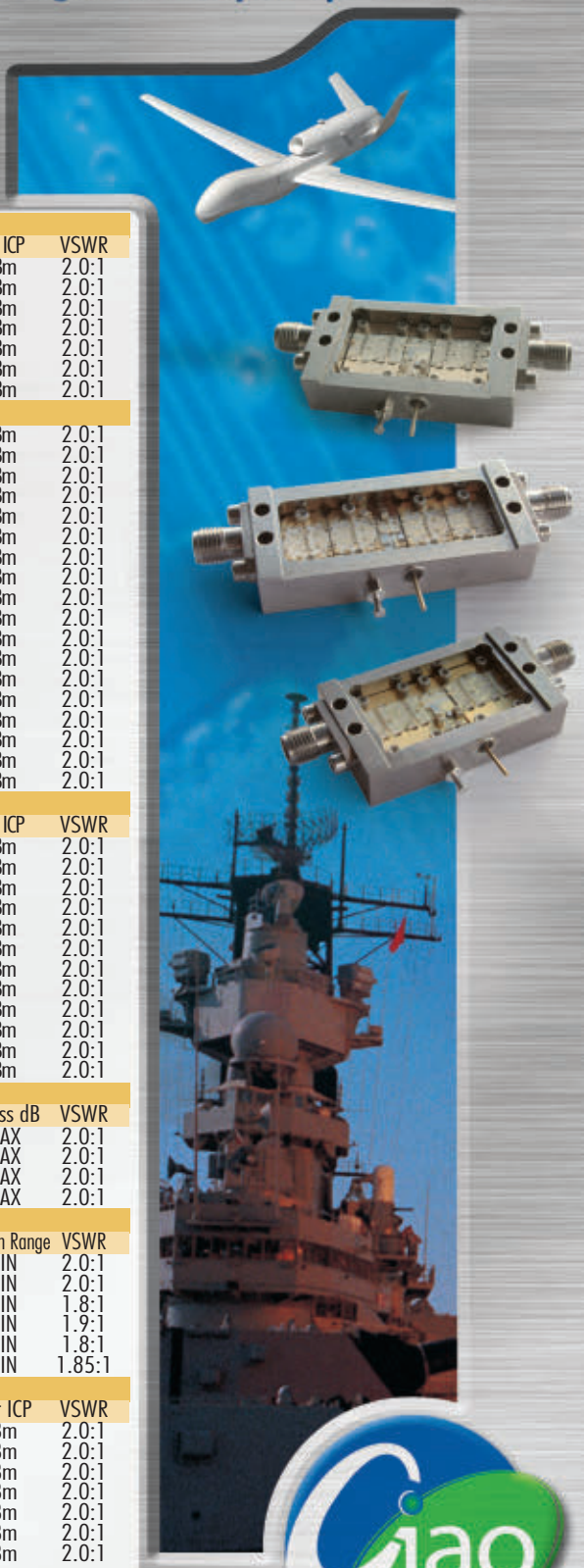

OCTAVE BAND LOW NOISE AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2110	0.5-1.0	28	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA12-2110	1.0-2.0	30	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA24-2111	2.0-4.0	29	1.1 MAX, 0.95 TYP	+10 MIN	+20 dBm	2.0:1
CA48-2111	4.0-8.0	29	1.3 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA812-3111	8.0-12.0	27	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA1218-4111	12.0-18.0	25	1.9 MAX, 1.7 TYP	+10 MIN	+20 dBm	2.0:1
CA1826-2110	18.0-26.5	32	3.0 MAX, 2.5 TYP	+10 MIN	+20 dBm	2.0:1

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2111	0.4 - 0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8 - 1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2 - 1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2 - 2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7 - 2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7 - 4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4 - 5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25 - 7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0 - 10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75 - 15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35 - 1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1 - 3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9 - 6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0 - 12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0 - 12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2 - 13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0 - 15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0 - 22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA0102-3111	0.1-2.0	28	1.6 Max, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA0106-3111	0.1-6.0	28	1.9 Max, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-3110	0.1-8.0	26	2.2 Max, 1.8 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-4112	0.1-8.0	32	3.0 MAX, 1.8 TYP	+22 MIN	+32 dBm	2.0:1
CA02-3112	0.5-2.0	36	4.5 MAX, 2.5 TYP	+30 MIN	+40 dBm	2.0:1
CA26-3110	2.0-6.0	26	2.0 MAX, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA26-4114	2.0-6.0	22	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA618-4112	6.0-18.0	25	5.0 MAX, 3.5 TYP	+23 MIN	+33 dBm	2.0:1
CA618-6114	6.0-18.0	35	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA218-4116	2.0-18.0	30	3.5 MAX, 2.8 TYP	+10 MIN	+20 dBm	2.0:1
CA218-4110	2.0-18.0	30	5.0 MAX, 3.5 TYP	+20 MIN	+30 dBm	2.0:1
CA218-4112	2.0-18.0	29	5.0 MAX, 3.5 TYP	+24 MIN	+34 dBm	2.0:1

LIMITING AMPLIFIERS

Model No.	Freq (GHz)	Input Dynamic Range	Output Power Range Psat	Power Flatness dB	VSWR
CLA24-4001	2.0 - 4.0	-28 to +10 dBm	+7 to +11 dBm	+/- 1.5 MAX	2.0:1
CLA26-8001	2.0 - 6.0	-50 to +20 dBm	+14 to +18 dBm	+/- 1.5 MAX	2.0:1
CLA712-5001	7.0 - 12.4	-21 to +10 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1
CLA618-1201	6.0 - 18.0	-50 to +20 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	Gain Attenuation Range	VSWR
CA001-2511A	0.025-0.150	21	5.0 MAX, 3.5 TYP	+12 MIN	30 dB MIN	2.0:1
CA05-3110A	0.5-5.5	23	2.5 MAX, 1.5 TYP	+18 MIN	20 dB MIN	2.0:1
CA56-3110A	5.85-6.425	28	2.5 MAX, 1.5 TYP	+16 MIN	22 dB MIN	1.8:1
CA612-4110A	6.0-12.0	24	2.5 MAX, 1.5 TYP	+12 MIN	15 dB MIN	1.9:1
CA1315-4110A	13.75-15.4	25	2.2 MAX, 1.6 TYP	+16 MIN	20 dB MIN	1.8:1
CA1518-4110A	15.0-18.0	30	3.0 MAX, 2.0 TYP	+18 MIN	20 dB MIN	1.85:1

LOW FREQUENCY AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure dB	Power-out @ P1-dB	3rd Order ICP	VSWR
CA001-2110	0.01-0.10	18	4.0 MAX, 2.2 TYP	+10 MIN	+20 dBm	2.0:1
CA001-2211	0.04-0.15	24	3.5 MAX, 2.2 TYP	+13 MIN	+23 dBm	2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 MAX, 2.8 TYP	+17 MIN	+27 dBm	2.0:1
CA002-3114	0.01-2.0	27	4.0 MAX, 2.8 TYP	+20 MIN	+30 dBm	2.0:1
CA003-3116	0.01-3.0	18	4.0 MAX, 2.8 TYP	+25 MIN	+35 dBm	2.0:1
CA004-3112	0.01-4.0	32	4.0 MAX, 2.8 TYP	+15 MIN	+25 dBm	2.0:1

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Calendar *Courses & Seminars*

SEPTEMBER

AOC Virtual Series Webinar: 8 Simple Rules for Executing Joint EW
Sept. 1
2-3 p.m. EDT
www.crows.org

AOC Virtual Series Webinar: Cognitive EW and Reinforcement Learning
Sept. 8
2-3 p.m. EDT
www.crows.org

AOC Live Course: Cognitive EW: An Artifical Intelligence Approach
Sept. 12-28
6 sessions, 1-4 p.m. EDT
www.crows.org

SIGINT Fundamentals
Sept. 13-14
Atlanta, GA
www.pe.gatech.edu

Basic Electromagnetic Warfare Modeling
Sept. 13-16
Online
www.pe.gatech.edu

AOC Virtual Series Webinar: Across the Spectrum Pond: How the US Military Can Procure Tested Solutions from Europe
Sept. 22
2-3 p.m. EDT
www.crows.org

AOC Virtual Series Webinar: EMBM Situational Awareness: Data Integration, Visualizations and Analytics
Sept. 29
2-3 p.m. EDT
www.crows.org

NOVEMBER

AOC Virtual Series Webinar: Testing Your RWR: Accuracy Matters
Nov. 3
2-3 p.m. EDT
www.crows.org

AOC Virtual Series Webinar: Electromagnetic Maneuver: Towards a Theoretical Underpinning
Nov. 10
2-3 p.m. EST
www.crows.org

RWR System Design and Analysis
Nov. 15-17
Atlanta, GA
www.pe.gatech.edu

Infrared Countermeasures
Nov. 15-18
Atlanta, GA
www.pe.gatech.edu

AOC Virtual Series Webinar: Two-Way Time-Transfer Digital Design for Distributed Array Operations
Nov. 17
2-3 p.m. EDT
www.crows.org

Survivability
Nov. 28 – Dec. 2
Shrivenham, UK
www.cranfield.ac.uk

DECEMBER

Electromagnetic Warfare Data Analysis
Dec. 6-7
Atlanta, GA
www.pe.gatech.edu

Test and Evaluation of RF Systems
Dec. 6-8
Online
www.pe.gatech.edu

AOC Virtual Series Webinar: In the Flat Field: Did Russian Army EW Underperform in Ukraine?
Dec. 15
2-3 p.m. EDT
www.crows.org

*AOC courses and webinars are noted in **red**. For more info or to register, visit crows.org.*

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From the Crows' Nest

This regularly scheduled podcast, hosted by Ken Miller, AOC's Director of Advocacy and Outreach, features interviews, analysis, and discussions covering leading issues of the day related to electromagnetic spectrum operations (EMSO).

This includes current events and news from around the world, US Congress and the annual defense budget, and military news from the US and allied countries.

crows.org/FromtheCrowsNest

SCAN ME

THE HISTORY OF CROWS

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

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SCAN ME

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Send your ideas and recommendations to Ken Miller, Director of Advocacy and Outreach, at kmiller@crows.org. We look forward to hearing from you!

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EMI IS A FACTOR FOR EVERYONE

World events continue to highlight the need to be able to use, maneuver, counter and dominate within the Electromagnetic Spectrum (EMS). As I have stated previously, Electromagnetic Spectrum Operations (EMSO) are not just for the military, but for all. The commercial and civilian sectors also do EMSO – in fact your cellphone does it every time you use it, seeking out the best frequency within its band to operate and provide you with clear phone calls, texting, internet access, streaming and gaming to mention a few.

I am a fan of NASCAR and attended the New Hampshire Motor Speedway (NHMS) Xfinity and Cup series races at the "Magic Mile" in Loudon, NH, this summer. A few days prior to the race, the speedway was struck by lightning and the electronics that ran the scoreboards at the main track and dirt track were not fully functional until Saturday, but the strike also appeared to affect the Wi-Fi and cell coverage at the track. Loudon, NH, is rural (population of 5,575), and the race can bring in as many as 76,000 people; so NHMS provides free Wi-Fi and cellphone companies add towers to handle the influx. The Wi-Fi and cellular service worked well for Saturday's smaller crowd, but appeared to be overtaxed on Sunday with the large crowd. Both my son and I could not keep a connection to the Wi-Fi nor with our cellular service, and we were not the only ones. EMSO was not happening at NHMS, even with the extra capacity that had been brought in, and I believe it was due to a few factors – the crowd was large, and I'm not sure that all the damage by the lightning strike earlier in the week had been fixed.

So, Powder, what's the point? We can plan, test and equip for situations, but there are always dynamic factors that will impact and influence our ability to operate in the Spectrum, whether civilian, commercial or military. The civilian/commercial side typically plans to meet the needs, but the military cannot just "meet the needs." It must be prepared to exceed/flex the needs within the spectrum.

The military has unique and highly capable systems, personnel and units to ensure access and freedom of maneuver in the EMS. Service labs, test ranges, maintainers, operators and planners are available resources that enable our EMSO warriors to effectively use the EMS, and one unit that celebrated its first year is the 350th Spectrum Warfare Wing (SWW). (Next month, *JED* will feature a profile of the 350th SWW.) This Wing is responsible for delivering electromagnetic spectrum capabilities global electromagnetic warfare systems, electromagnetic warfare reprogramming, modeling and simulation and assessments. Units and organizations like the 350th SWW give us the opportunity to ensure that we can sense, fight, maneuver and dominate across EMSO.

Don't forget to register for our 59th Annual International Symposium – our flagship event for the AOC – and I am hoping to see many of you in person in Washington, DC. Keep spreading the word on EMSO and be AOC ambassadors.
– *Glenn "Powder" Carlson*

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UK FORMS TEAM PELLONIA

The UK Ministry of Defence (MoD) has established a new government/industry entity, known as Team Pellonia, to deliver air platform protection to front-line air assets and maintain core sovereign intellectual and industrial capability in airborne EW.

Bringing together the Royal Air Force (RAF), Defence Equipment and Support and the Defence Science and Technology Laboratory (Dstl) with three key industry suppliers – Leonardo UK, Thales UK and Chemring Countermeasures – the new collaborative national enterprise has been established to develop integrated self-protection systems for UK armed forces' air platforms.

The announcement of the formation of Team Pellonia – named after the Roman goddess renowned for protecting people from their enemies – follows the signing of individual strategic partnering arrangements by the MoD with the three industry partners over the last 12 months. The creation of the new entity is aligned to the Next Generation Air Survivability framework being adopted by the MoD and the RAF.

According to the MoD, Team Pellonia partners "will work together to offer defence platform-level integrated self-protection systems based on Leonardo's Modular Advanced Platform Protection System architecture." It added, "Depending on the platform requirements, sensors and effectors could include Leonardo's Miysis directed infrared countermeasures system, Thales's Elix-IR infrared threat warning system, Thales's Vicon XF countermeasures dispensing system and Chemring's chaff/infrared expendable countermeasures."

Dstl will act as technical partner to the team throughout the capability development, system integration and entry into service process, providing quality assurance to ensure military advantage now and into the future. As well as working together to provide current capability to the front-line, the Team Pellonia members will work together to agree an investment plan/technology roadmap that draws on the skills of each team member in a collaborative enterprise-wide approach.

Team Pellonia will equip RAF E-7A Wedgetail airborne early warning aircraft with new defensive aids suites. Above, a Royal Australian Air Force Wedgetail. ALAN WILSON PHOTO

The industry participants within Team Pellonia are already under contract to deliver defensive aids suites the RAF's Shadow R.2 surveillance aircraft and the new E-7A Wedgetail airborne early warning aircraft, with the expectation that a number of other UK platforms will be brought within scope in the coming years. In addition, it is planned that UK partners and allies with similar requirements will also be able to access self-protection systems from Team Pellonia compliant with the latest NATO Defensive Aids System standard. – *R. Scott*

ANGRY KITTEN POD DEMONSTRATES OVERNIGHT SOFTWARE UPDATES

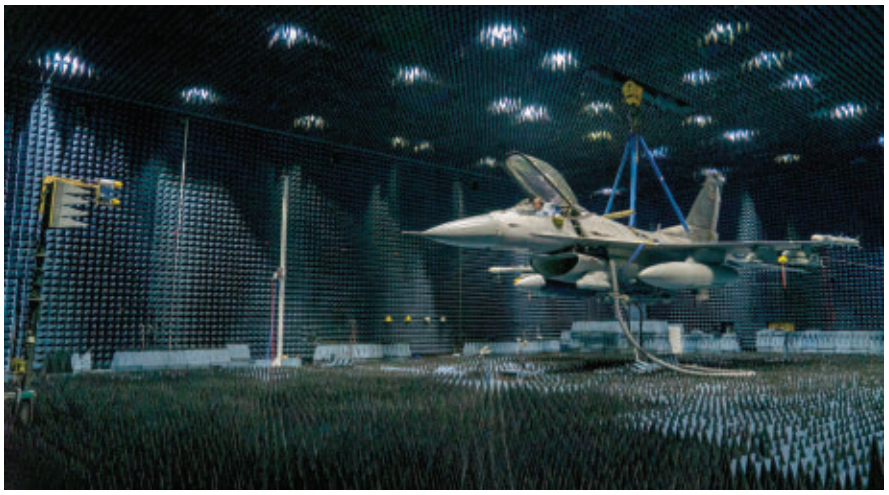
Rapid reprogramming of an Angry Kitten electronic attack (EA) pod has been demonstrated during an operational assessment as part of the App-Enabled Rapidly Reprogrammable Electronic warfare/electromagnetic Systems (AERRES) experiment campaign performed by the Air Force Research Laboratory (AFRL).

Undertaken in April this year – but only publicly briefed by AFRL in early August – the two-week test period saw the self-defense jamming pod's mission data file software updated each night to improve performance seen against threats each following day. The operational assessment has sought to identify the effectiveness and suitability of the combat pod and provide operational feedback to inform Air Combat Command on a potential future fielding decision.

AFRL's Strategic Development Planning and Experimentation Office funded the assessment as part of the AERRES campaign. AERRES is evaluating the operational utility and competitive advantages of open hardware/software architectures and standards to provide app-enabled electronic warfare/electromagnetic systems solutions for the 350th Spectrum Warfare Wing, and the electronic warfare enterprise in general. The US Air Force (USAF) is looking to employ more open architecture software to enable "agile" updates to systems.

The Angry Kitten pod, originally developed by Georgia Tech Research Institute (GTRI), is used to simulate adversary EA effects during USAF test and training missions. Given the success of the pod in training, and its demonstrated ability to be reprogrammed, Air Combat Command recommended that four pods be converted into combat pods to provide EA capabilities against enemy radio frequency (RF) threat systems, rather than simulating them.

The experiment aimed to show how the new government-owned architecture could be exploited in order that the pod



The Angry Kitten ECM training pod previously underwent testing at the 350th Spectrum Warfare Wing's Joint Preflight Integration of Munitions and Electronic Systems (J-PRIMES) test facility at Eglin AFB, FL in October and November 2021. In the image above, the pod is carried on a pylon attached to weapon station 5L (left-hand weapons station beneath the engine intake).
USAF PHOTO/TSGT JOHN MCREL

could be more quickly reprogrammed to counter new RF threats. This is an increasingly important attribute given the increasing deployment of software-defined threat radars that can quickly be updated with new RF waveforms or mode characteristics so as to reduce their vulnerability to EA effects.

Historically, EA systems have been designed with tightly coupled software and hardware which took considerable time and funding to update. The Angry Kitten architecture provides greater flexibility to update or reprogram the system – similar to a smartphone and digital app store — as the electronic warfare threat environment changes.

The mission data files use an open-source programming language, enabling programmers to design effective jamming techniques against threats with known RF signature data. This means that EA systems can be quickly updated or loaded with new software to defeat complex and constantly changing threat emitters.

Various EA techniques were evaluated over many months to improve accuracy and efficiency. Multiple organizations, including the 36th Electronic Warfare Squadron, GTRI, the Air National Guard Air Force Reserve Command Test Center and the US Air Force Air Warfare Center, worked to ensure the most current techniques were programmed.

Before the flight test events, programmers developed the specific mission data files for the system, and the team worked with the Air Force Life Cycle Management Center's Agile Combat Support Directorate to verify and validate these updates in laboratory evaluations at Robins AFB, GA. Team members created next-day data file updates at Nellis AFB, NV, during the operational assessment.

The test team completed 30 sorties and demonstrated post-flight reprogramming to improve effects seen in earlier flights. The operational assessment culminated with a final flight test event at China Lake, CA: in this case, the software was updated within hours based on the performance seen against certain threats, with those improvements then verified during flight test the following day. – *R. Scott*

LEONARDO SECURES ASPARKLE EOD ECM DEAL

The UK business of Leonardo is to supply the British Army with a new generation of Explosive Ordnance Disposal (EOD) Electronic Countermeasures (ECM) equipment to defeat remotely-triggered bomb threats/Radio-Controlled Improvised Explosive Device (RCIEDs).

Procured by the Defence Equipment and Support (DE&S) Special Projects Counter Measures and Exploitation (SPCME) delivery team, the new countermeasures suite will be used by bomb disposal teams in the UK mainland and Northern Ireland in support of the police and other civil authorities.

Leonardo is delivering the program – known by the Ministry of Defence (MoD) as Project Asparkle – under a £41 million contract. As through-life systems integrator, the company will procure, integrate, modify and provide through-life software and other techni-

The 11 EOD & Search Regiment, Royal Logistics Corps, will take delivery of the new counter-RCIED jammers in late 2024. Above, a member of the 11 EOD Regiment operates a "Wheelbarrow Mk 8a" EOD robot at Exercise Shamal Storm 16 in Jordan. MOD/CROWN COPYRIGHT

cal support to an agile, modular, flexible suite of ECM equipment. Both vehicle-mounted and portable EOD ECM modules are to be supplied.

Approximately half the Asparkle contract will be delivered by onshore small/medium-size enterprises. Companies working with Leonardo under its "Team Endure" construct include CommsAudit, Elma Electronic, Kirintec and Waymont Consulting, together with Marshall Land Systems and training specialist EWS.

Deliveries of the new ECM equipment commence in late 2024. The capability will be deployed in 2025 by 11 EOD & Search Regiment, Royal Logistics Corps, as the specialist British Army unit responsible for explosive device and munitions disposal.

The contract covers the delivery of the equipment and an initial two-year in-service support period. Contract options provide for further extensions to the support period.

According to Leonardo, the contract marks the first application of the MoD's Land Cyber and Electromagnetic Architecture (CEMA), which has been developed to specifically meet the requirements for ECM applications. Land CEMA is an underpinning element for future ECM programs and aligns with MoD policy on designing systems with open architectures to enable flexible deployment, upgrade and "evergreening" of both hardware and software capabilities over the life of the system.

Leonardo has previously provided its Guardian RCIED equipment to the UK armed forces for operations in Iraq and Afghanistan. – *R. Scott*

AUSTRALIAN DEFENCE FORCE AWARDS CONTRACT FOR LAND 555 PHASE 6 FORCE LEVEL EW PROGRAM

Raytheon Australia Pty Ltd is to deliver a new Force Level Electronic Warfare System capability to the Australian Defence Force (ADF) under Tranche 2 Project LAND 555 Phase 6

Valued at AUS$75 million, the contract will see Raytheon deliver the new force-level EW mission systems into

AUSTRALIAN... *continued on page 18*

THIRD TEST SUCCESS FOR AARGM-ER MISSILE

Northrop Grumman has completed the third live fire test of its AGM-88G Advanced Anti-Radiation Guided Missile Extended Range (AARGM-ER), the company announced on July 21.

Undertaken from a US Navy F/A-18 Super Hornet aircraft at the Point Mugu Sea Range off the coast of California in late April, the AARGM-ER missile used its emitter acquisition system to detect, identify, locate and engage a land-based air defense threat radar system.

Being integrated on US Navy F/A-18E/F Super Hornet and EA-18G Growler aircraft, as well as the F-35 Lightning II strikefighter, the AGM-88G missile marries the existing AARGM sensors, electronics and warhead with a new tail-controlled air vehicle incorporating an extended range rocket motor.

The first AARGM-ER developmental test flight was conducted in July 2021. A second flight test was executed in February 2022.

AARGM-ER achieved a Milestone C authorization for Low-Rate Initial Production (LRIP) in August 2021. LRIP Lot 1 missiles are currently in-production to support Initial Operational Capability fielding, planned for the fourth quarter of FY 2023.

LRIP Lot 2 missiles, under contract, will further augment the inventory. Full-rate production is planned for FY 2025. – *R. Scott*

US NAVY PHOTO

AUSTRALIAN... *continued from page 18*

Bushmaster protected mobility electronic platform variant vehicles. The capability is planned to be delivered from late 2025.

The force level EW mission system requirement comprises three components, an electronic attack system to be capable of jamming techniques to deny adversary use of the electromagnetic spectrum (EMS), disrupt and degrade adversary communications systems, generate misleading information to deceive, and assess the effectiveness of battle management; an electronic support system capable of detecting adversary use of the EMS, locating the source, identifying, tracking, exploiting, recording, analyzing and reporting adversary communications and electronic signatures; and a command and control mission system to be capable of networking/communicating at the tactical and operational/strategic levels, and battle management including providing situational awareness, planning, coordinating, analyzing and reporting.

Raytheon Australia, as prime contractor and systems integrator, said it will build a "sovereign electronic warfare ecosystem" that will enable the Australian Army to collaborate with joint, allied, and coalition forces to provide new levels of situational awareness and effects. The project is intended to inject more than AUS$46 million into the Australian supply chain, contributing to the strengthening of the sovereign defense industrial base, and supporting delivery of multiple Sovereign Industrial Capability Priorities. – *R. Scott*

IN BRIEF

Boeing (St Louis, MO) and **BAE Systems** (Nashua, NH) announced that the first two US Air Force F-15E Eagles that will be upgraded with the AN/ALQ-250 Eagle Passive Active Warning and Survivability System (EPAWSS) began aircraft modifications at Boeing's facility in San Antonio, TX. The Air Force plans to upgrade 43 F-15Es with the ALQ-250, as well as installing the system on its new F-15EX Eagle II aircraft. Previously, the EPAWSS suite had been evaluated on a pair of F-15EX aircraft that participated in Northern Edge exercises in May 2021, as well as exercises and flight tests in October 2021 and February 2022.

Col Melanie Olson has assumed command of the 55th Electronic Combat Group (Davis Monthan AFB, AZ). In a July 29 ceremony, she accepted the guidon from outgoing 55th ECG commander, **Col G. Michael Cundiff, Jr.** Colonel Olson has served within the 55th ECG multiple times throughout her career, including most recently as its deputy commander from February 2017 to July 2019. Colonel Cundiff moves to 12th Air Force (Air Forces Southern), where he will serve as the A3 director.

The US Navy has cancelled its $495.5 million contract with **L3Harris** to develop the Next Gen Jammer – Low Band (NGJ-LB) system and will "re-award" the contract in early 2023. The NGJ-LB development contract was contested between L3 Technologies (Salt Lake City, UT) and a **Northrop Grumman** (Bethpage, NY) and Harris Corp. (Clifton NJ) team. (L3 Technologies merged with Harris in 2019, although they did not collaborate during the NGJ-LB competition, which began in 2017.) After the NGJ-LB Engineering and Manufacturing Development (EMD) contract was awarded to the L-3 Technologies team in December 2020, Northrop Grumman protested the

NAVY RECEIVES FIRST PRODUCTION REPRESENTATIVE NGJ-MID-BAND PODS

Raytheon Intelligence and Space (McKinney, TX) shipped the first "fleet representative" AN/ALQ-249 Next Generation Jammer - Mid Band (NGJ-MB) pods to the Naval Air Warfare Center - Aircraft Division (Patuxent River, MD) on July 7. The delivery (technically, it was made to Naval Air Systems Command's Airborne Electronic Attack Systems Program Office (PMA-234)) consisted of two pods, which together comprise a single shipset of the NGJ-MB system. The pods "will be used to complete the developmental test (DT) program and commence operational test (OT) that requires the use of operationally representative hardware and software," according to a NAVAIR press release. "We will test the pods for everything we expect to encounter in the fleet," said LT Alexander Belbin, Airborne Electronic Attack project officer with NAWCAD's Air Test and Evaluation Squadron (VX) 2. "For example, the power they generate, the frequency range they operate in, and the effects we can achieve against expected targets across the spectrum." The remainder of DT will be conducted by VX-23 and VX-31 at the Naval Air Warfare Center Weapons Division, (China Lake, CA), and OT will be conducted by VX-9 at Naval Air Weapons Station China Lake, NAVAIR said. – *JED Staff*

decision with the Government Accountability Office (GAO). The GAO upheld the protest and the two teams, as well as the Navy, went to court – eventually reaching an agreement in July under which NAVAIR will re-evaluate the bids and re-award the contract.

Col Joshua Koslov has assumed command of Air Combat Command's 350th Spectrum Warfare Wing (SWW) at Eglin AFB. Stood up in July 2021 under **Col William Young,** the Wing achieved IOC in less than a year, noted **Brig Gen Curt Bass,** Air Force Warfare Center vice commander, in a change of command ceremony on July 28. Colonel Koslov comes to the 350th SWW after serving as the 609th Air Operations Center commander at Al Udeid Air Base, Qatar. Previous assignments include commander of the 755th Operations Support Squadron (Davis-Monthan AFB, AZ), Director of Operations, 43d Electronic Combat Squadron (Davis Monthan AFB, AZ) and Assistant Director of Operations - Electronic Warfare, 8th Weapons Squadron, USAF Weapons School (Nellis AFB, NV). At the ceremony, Colonel Koslov said, "Our mission is simple. We're going to dominate the spectrum and win. To do this, we'll continuously deliver relevant warfighting capability to warfighters. Our wing and the way we think is the weapons system."

The Defense Advanced Research Project Agency (DARPA) has awarded two more contracts for its Electronics for G-Band Arrays (ELGAR) program. In addition to the previously announced contract to HRL Laboratories (see *JED*, August 2022, p. 20), contracts have been awarded to **Teledyne Scientific & Imaging LLC** ($18.6 million) and **Northrop Grumman** ($17.7 million). The contractors will develop the integration technologies needed to create compact, high-performance RF electronics, including monolithic microwave/millimeter wave integrated circuits and transmit and receive array front-end test articles, to enable communication and sensing systems at G-band frequencies.

DARPA's Strategic Technology Office (STO) is soliciting proposals for Technical Area 2 (TA-2) of its Ouija program. According to the Broad Agency Announcement (HR001122S0028), "One goal of Ouija Technical Area 2 (TA-2) is to develop near-real-time assimilative ionospheric models capable of modeling ionospheric disturbances at scales of 100 kilometers and below. These models must assimilate ionospheric measurements taken with the scientific instrumentation packages to be flown on the Ouija TA-1 CubeSats in very low-Earth orbit (VLEO), in addition to standard vertical and oblique sounder data." A second focus area will concentrate on developing "…HF propagation models capable of high-fidelity prediction of ground-to-VLEO propagation. The propagation models will be validated using on-orbit measurements taken from the Ouija spacecraft HF payload, which will receive test signals from cooperative terrestrial transmitters." Proposals are due by September 8. Program officials can be contacted via e-mail at HR001122S0028@darpa.mil.

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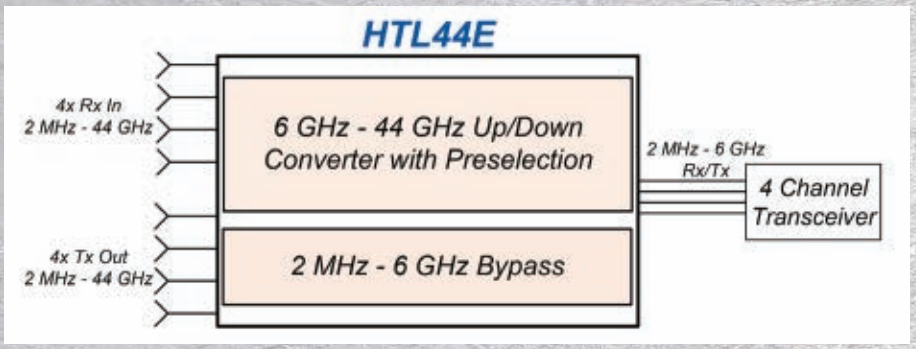

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WHO SHOULD ATTEND

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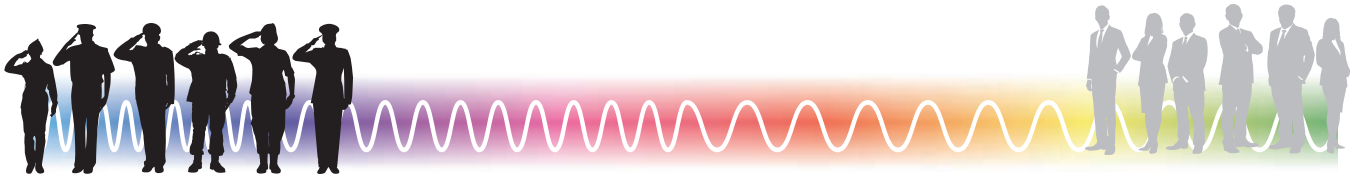

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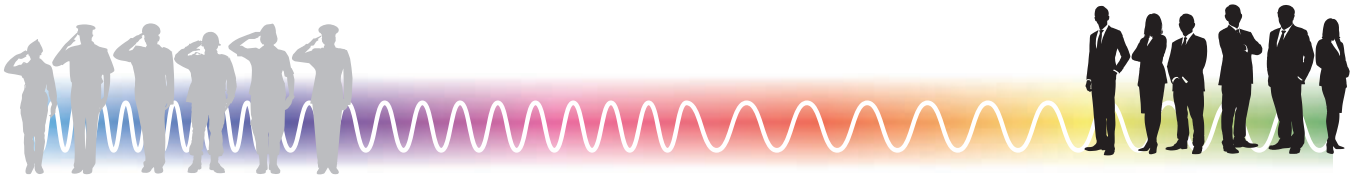

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"Given that I am new to this community, it reignited my motivation. It was fascinating to see how different people (small but determined) are making changes that will forever change how we operate on the domain."

- 2021 Attendee

"Attending allowed me to engage with the end-user community and learn what is happening across DoD as well as educate myself on the art of the possible."

- Dr. Ilya Lipkin, Technical Expert, Open Architecture

"Attending the AOC International Convention provided me with several amazing opportunities to network with government and federal CEMA professionals that enabled me to develop the connections to secure employment quickly after leaving active duty service. Additionally, the exhibit hall provided a hands-on opportunity to gain familiarity with the latest EW/Cyber equipment being developed. A one-of-a-kind experience."

- CW3 Eric Colon, CEMA Technician/USARCYBER Command

"As the director of advanced RF systems, I love and enjoy attending the AOC international symposium. It's giving me the opportunity to connect with attendees from different backgrounds, connect with them and learn from them. Listening to talks and presentations can give you a new idea, one that you had previously not thought about. Also you get the chance to learn from the best including Dave Adamy."

- Previous Attendee Working in Engineering

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SCHEDULE AT-A-GLANCE

MONDAY, OCTOBER 25

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On-site Registration Open
(Badge Pick-up and Registration)
L Street Bridge of the
Walter E. Washington Convention Center

Welcome Reception
Hosted by L3Harris

TUESDAY, OCTOBER 26

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Onsite Registration Open

Exhibit Hall & Crows' Nest Open

Morning Coffee

Opening Keynote Session

Lunch

Spotlight Session

Breakout Session – JADC2

Symposium Session – SPACE EMSO: C-CSISRT

Program Manager Briefing Series - Navy Programs

Exhibit Hall Happy Hour

As of August 10, 2022. Subject to change.
All events occur at Walter E. Washington Convention Center unless otherwise noted.

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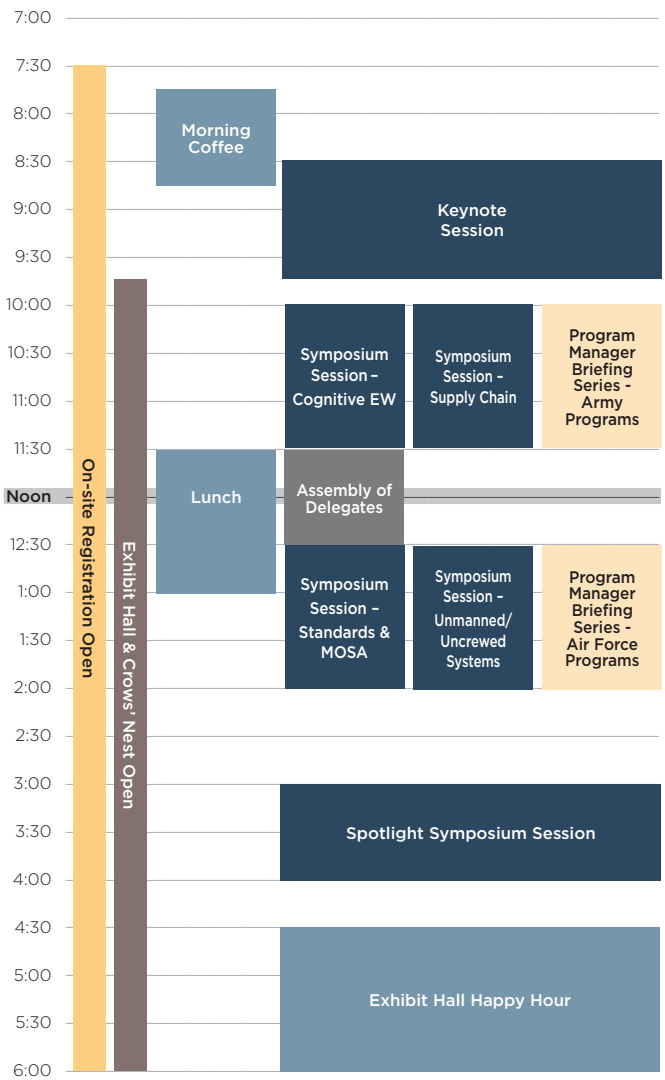
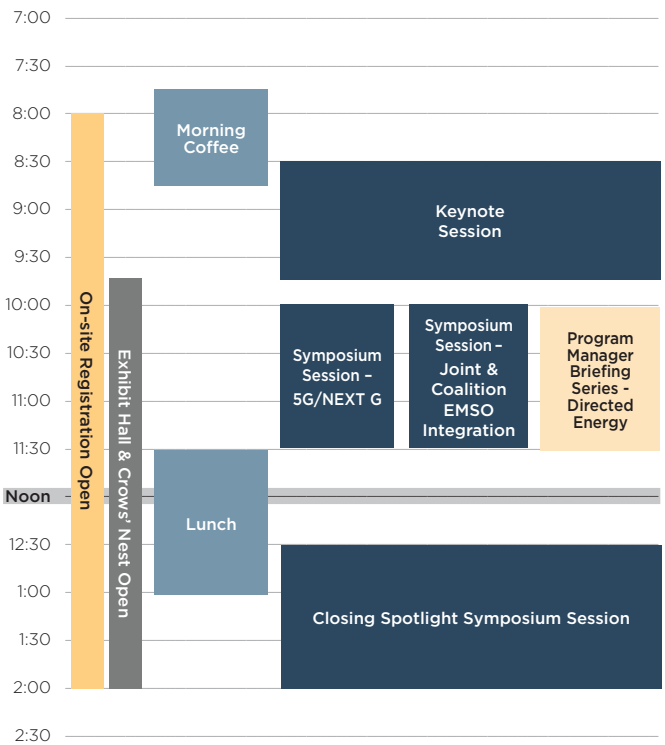
SCHEDULE AT-A-GLANCE

WEDNESDAY, OCTOBER 26



THURSDAY, OCTOBER 27



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SYMPOSIUM AGENDA

TUESDAY, OCTOBER 25

OPENING KEYNOTE SESSION | 8:30 - 10:00 AM

Session information coming soon.

SPOTLIGHT SESSION | 12:30 - 2:00 PM

SPOTLIGHT PANELISTS:

Mr. David Tremper, SES, Director Electronic Warfare (EW), Office of the Undersecretary of Defense for Acquisition and Sustainment

Maj Gen James 'Rainman' Adams, Deputy Director for Requirements and Capability Development, Joint Staff J8

Mr. Logan Harr, Principal Director Integrated Sensing and Cyber, OSD R&E

Dr. Ken Plaks, Director, Adaptive Capabilities Office (ACO), DARPA

BREAKOUT SESSIONS | 2:30 - 4:00 PM

JADC2

All Domain Operations is the critical integration of the Joint Force. While the components historically focused on a single domain, emerging concepts require a diverse group of commanders, soldiers, sailors, marines, airmen, and even guardians to collaborative provide capabilities. This panel will provide a current perspective on the rapidly evolving JADC2 ecosystem, the programs, the standards, and the interoperability required to meet our national security objectives.

SESSION MODERATOR:

Dr. Michael Zatman, Principal Director for Fully Networked Command, Control and Communications, Office of the Under Secretary of Defense for Research and Engineering

SESSION PANELISTS:

Rear Adm Susan BryerJoyner, Deputy Director, Command, Control, Communications, and Computer/ Cyber Systems, J-6, Joint Staff

Ms. Carly Jackson, Director of Science and Technology, Chief Technology Officer, Naval Information Warfare Systems Command and Head, Cyber/Science and Technology Department, Naval Information Warfare Center Pacific

Retired Brig Gen Richard S. Stapp (Ret), Vice President of Technology Development, Northrop Grumman Aerospace Systems

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SPACE EMSO: C-C5ISRT

Space offers a unique strategic sanctuary, and it also creates a unique dependency in any future military operation. While a commercial SATCOM provider was able to mitigate Russian jammers with a software update, both the ground and space-based layers have different vulnerabilities and thus require unique mitigations. USSF currently has two astronauts; the remainder of their Guardians operate ground and space systems through the EMS. Additionally, the panel will discuss how China has integrated its Space and EMSO capabilities into the Strategic Support Force as a net assessment compared to US capabilities.

SESSION MODERATOR:
Mr. Bryan Clark, Senior Fellow, Hudson Institute

SESSION PANELISTS:
Mr. Mike Dahm, Principal Analyst, Mitre Corporation

PROGRAM MANAGER BRIEFING SERIES – NAVY PROGRAMS

SESSION MODERATOR:
Dr. James Stewart, Chief Scientist, Electronic Warfare, NSWC Crane

SESSION PANELISTS:
CAPT Dave Rueter, Program Manager, NAVAIR PMA-234 (AEA)
Col Tamara Campbell, Program Manager, Naval Air Systems Command, PMA-272
CAPT Jason Hall, Major Program Manager, Above Water Sensors and Lasers Program Executive Office Integrated Warfare Systems (PEO IWS 2.0)

WEDNESDAY, OCTOBER 26

KEYNOTE SESSION | 8:30 - 9:45 AM

Dr. William A. LaPlante, Under Secretary of Defense for Acquisition and Sustainment

BREAKOUT SESSIONS | 10:00 - 11:30 AM

COGNITIVE EW

Cognitive EW is not just a future challenge, it is a TODAY challenge. Technology is racing ahead of operational issues such as security, safety, and risk management. This panel brings together thought leaders from operations, industry, and academia to explore important aspects of the practical operational issues that must begin to be addressed. The discussion generated by the expert panel in addressing these and similar questions is intended to facilitate a holistic awareness and improved understanding of how COgEW might change operations, and what prudent actions all actors must undertake now to be prepared for the future.

SESSION MODERATOR:
Col William "$" Young, Commander, 350th Spectrum Warfare Wing

SESSION PANELISTS:
Dr. David Zurn, Georgia Tech Research Institute
Dr. Karen Haigh, Expert in Cognitive Electronic Warfare; AI and ML for Physical Systems
Mr. Dylan Duplechain, 350th Spectrum Warfare Wing, Director of Engineering

SYMPOSIUM AGENDA

SUPPLY CHAIN

General Eisenhower famously stated, “Plans are worthless, planning is everything.” Nothing could be truer today than when a lack of material in the supply chain forces government and industry leaders to rebuild their plan daily. The panel will cover key domestic dependencies of the supply chain, i.e. microelectronics, and the foundational access to materials which support our EMSO systems. The U.S. has a unique lead in some of these technologies, such as GaN for DE systems, while others are global commodities. Additionally, the panel will discuss how visionary development methods such as digital engineering are flowing down to partners and suppliers, expediting the delivery of new systems.

SESSION MODERATOR:

Mr. Alan Shaffer, former Deputy Under Secretary of Defense Acquisition and Sustainment, current Board Member: Global Foundries Government Security Committee, Potomac Institutes Board of Regents, Strategic Advisory Board, Pacific Defense

SESSION PANELISTS:

Ms. Jenn Santos, Deputy Assistant Secretary of Defense for Industrial Policy (IndPol)
Ms. Leigh, Method, SES, Deputy Assistant Secretary of Defense for Logistics

PROGRAM MANAGER BRIEFING SERIES – ARMY PROGRAMS

SESSION MODERATOR:

Mr. Mike Ryan, AOC Board of Director

SESSION PANELISTS:

Mr. Kenneth Strayer, Project Manager, PM EW&C
COL Gary Brock, Army Capabilities Manager - Electronic Warfare

#AOC2022

BREAKOUT SESSIONS | 12:30 - 2:00 PM

STANDARDS & MOSA

This panel will discuss the Open Architecture ecosystem: how different standard bodies are governed, how to get involved, and how to ensure conformance with the standard to meet the ultimate expectation of improved performance, schedule, cost, modularity, upgradability, sustainability, and ultimately improved warfighting capabilities. The panel will include advanced standards that support Cognitive EW.

SESSION MODERATOR:

Mr. Ben Peddicord, Branch Chief at CERDEC/I2WD

SESSION PANELISTS:

Mr. David Tremper, SES, Director Electronic Warfare (EW), Office of the Undersecretary of Defense for Acquisition and Sustainment
Mr. Robert Normoyle, Senior Systems Engineer, Herrick Tech
Dr. Ilya Lipkin, Technical Expert for Open Architectures, Air Force Life Cycle Management Center (AFLCMC)/EN SOSA
Mr. Edward Thiel, Jr., Chief Architect, Lockheed Martin

UNMANNED/UNCREWED SYSTEMS

Uncrewed systems require different technology under the hood to make real-time decisions instead of depending on operators. What does an uncrewed system need to return from a mission to enable a "debrief?" Does reprogramming change in this new world? How does AI & ML impact the operations of the EMSO systems on these platforms?

SESSION MODERATOR:

Mr. Dan Patt, Senior Fellow, Center of Defense Concepts and Technology, Hudson Institute

SESSION PANELISTS:

Panelists to be announced

PROGRAM MANAGER BRIEFING SERIES – AIR FORCE PROGRAMS

SESSION MODERATOR:

Ms. Lisa Fruge-Cirilli, AOC Past President

SESSION PANELISTS:

Mr. Matt Bryant, Chief Engineer, Electronic Warfare & Avionics Division, AFPEO Agile Combat Support
Mr. Tom Graves, Sr. EMS Technical Advisor, USAF - AFMC - AFLCMC/WNY
Col Jesse Warren, F-15 Senior Material Leader, USAF - AFMC - AFLCMC/WNY
Col Corey Klopstein, SZY Warfighting Enterprise Acquisition Delta

SPOTLIGHT SESSION | 3:00 - 4:00 PM

STRATEGY MEETS THE HILL

SESSION MODERATOR:

Katy Nazaretova, Director, National Security and Technology Policy

SPOTLIGHT PANELISTS:

Panelists to be announced

SYMPOSIUM AGENDA

THURSDAY, OCTOBER 27

KEYNOTE SESSION | 8:30 - 9:45 AM

Session information coming soon.

BREAKOUT SESSIONS | 10:00 - 11:30 AM

5G/NEXT G

This panel will discuss how 5G supports EMSO. Beginning with the architecture, the panel will discuss how 5G building blocks can be leveraged to enable future EMS operations. 5G represents another spin-in technology from commercial to defense applications. Over time, how these spin-in technologies transform our expectations of distributed processing, testing of complex systems, and networked system-of-systems.

SESSION MODERATOR:

Dr. Tom Rondeau, Program/Manager, Strategic Technology Office, DARPA

SESSION PANELISTS:

Dr. Sheryl M Genco, Senior Advisor, Ericsson

Maj Ben Pimentel, PhD, Communications Officer and Electronics Engineer, USMC

JOINT AND COALITION EMSO INTEGRATION

EMSO must be a fully integrated and trained feature of the Joint Force that aligns with allied partners. Technical advances with commensurate training and readiness standards must be strategically, operationally, and tactically aligned to the ability for military services to meet joint requirements in cooperation with our allied partners. This includes systems operating in the RF, but also EO/IR, and DE portions of the EMS.

SESSION MODERATOR:

Mr. Tim Grayson, Special Assistant to the SecAF for Mission Centered Analysis and Operational Imperatives

SESSION PANELISTS:

Mr. Ali Serdar Kiliniç, Electronic Warfare Program Director, Aselsan

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PROGRAM MANAGER BRIEFING SERIES – DIRECTED ENERGY

SESSION MODERATOR:

Mark Niece, Executive Director of the Directed Energy Professional Society (DEPS)

SESSION PANELISTS:

Panelists to be announced

CLOSING SPOTLIGHT SESSION | 12:30 - 2:00 PM

Mr. Chris O'Donnell, DASD, Platform and Weapon Portfolio Management, OUSD, A&S

AWARD RECIPIENTS

CONGRATULATIONS 2022 AOC Award Winners!

Please join AOC in recognizing this year's award winners who will walk the stage during the Opening Keynote Session on Tuesday morning and during the Assembly of Delegates on Wednesday.

PRESTIGE AWARDS

AOC GOLD MEDAL AWARD
JON T. GRAVES

Awarded for over a half-century of contributions to electronic warfare, Mr. Graves has a breadth of technical expertise and corporate knowledge in RF/IR signature characterization/reduction and ECM systems ranging from the Vietnam era to the next generation of aerospace vehicles — most notably in key technical roles as an AC-130 Gunship engineer, F-22 Deputy Director, and USAF Airborne Electronic Attack Portfolio Manager. An encyclopedia of EW historical and technical facts, top military and DoD leaders seek his advice and counsel on EMS strategy. The sustained efforts of Mr. Graves reflect great credit upon himself and our nation.

HAL GERSHANOFF AOC SILVER MEDAL
CRAIG HARM

Awarded for over 35 years of service and dedication in continually promoting the mission and objectives of AOC, Craig Harm's involvement has been at the heart of AOC activities that continue to improve the infrastructure and governance that will improve the organization. Craig continues to be a leader in various endeavors to further the goals of AOC; He has demonstrated the true value and distinction of being a member of AOC.

ANTON D. "TONY" BREES LIFETIME SERVICE AWARD
KEITH EVERLY

Awarded for over 35 years of service and dedication in continually promoting the mission and objectives of AOC, Craig Harm's involvement has been at the heart of AOC activities that continue to improve the infrastructure and governance that will improve the organization. Craig continues to be a leader in various endeavors to further the goals of AOC; He has demonstrated the true value and distinction of being a member of AOC.

AOC TECHNOLOGY HALL OF FAME AWARD
MARK ELSON *(NOT PICTURED)*
ED MIENKO

The AOC Technology Hall of Fame recognizes individuals or groups of individuals who have been prime innovators in technology development and whose achievements have resulted in enhanced survivability of forces and equipment. Although focused on individuals, the AOC Technology Hall of Fame may recognize Government, Industry or Academic technology groups or units for specific aggregate technical achievements.

JOSEPH W. KEARNEY PIONEER AWARD
H. WAYNE WHITTEN

Awarded for pioneering contributions to the evolution of U.S. Marine Corps aviation EW over 50 years as an ECMO, requirements sponsor, test and evaluation program manager, and author/historian that materially improved the discipline of electronic warfare.

JOHN M. CLIFFORD AWARD FOR THE ADVANCEMENT OF THE ELECTROMAGNETIC DOMAIN AWARD
THE HONORABLE JIM LANGEVIN

Awarded for extraordinary leadership and advocacy of electromagnetic spectrum operations during service in the U.S. Congress.

AWARD RECIPIENTS

COMMUNITY AWARDS

PROJECT TEAM OF THE YEAR AWARD
39 EWS

39 EWS Software Development Flight, 39th Electronic Warfare Squadron, Eglin AFB, FL, distinguished itself from 1 January 2021 to 31 December 2021. The flight innovated five software algorithms, automating the Air Force's electronic warfare database and protecting the air superiority of 70 combat platforms. Additionally, the team developed novel reprogramming modules for three aircraft, supporting 1.2K sorties. The distinctive accomplishments of the Software Development Flight reflect credit upon itself and the United States Air Force.

EW PROFESSIONAL OUTSTANDING YOUNG CROW AWARD
MADELINE VAUGHN

Awarded for work at SwRI that spreads across SOSA™, DMSMS of jammers, plus the development of advanced DRFM and receivers.

PROFESSIONAL OUTSTANDING ACHIEVEMENT AWARD
GENA THORN

Awarded for leadership and contributions in developing novel cryptologic capabilities supporting special operations within the past year.

MILITARY SERVICE AWARD — AIR FORCE
MAJOR CAITLYN DEFABO, USAF

Awarded for distinguishing herself as the Director of Operations and Electronic Warfare Office, leading the Operation Reconnaissance program, analyzing worldwide radar threats, and significantly improving EW training software.

MILITARY SERVICE AWARD — NAVY
CHIEF WARRANT OFFICER ERIC NELLE, USN

Awarded for paving the way in cryptologic warfare and ensuring the next generation has the capability and tools to take on any adversary.

Find out more about AOC's award program at crows.org/awards.

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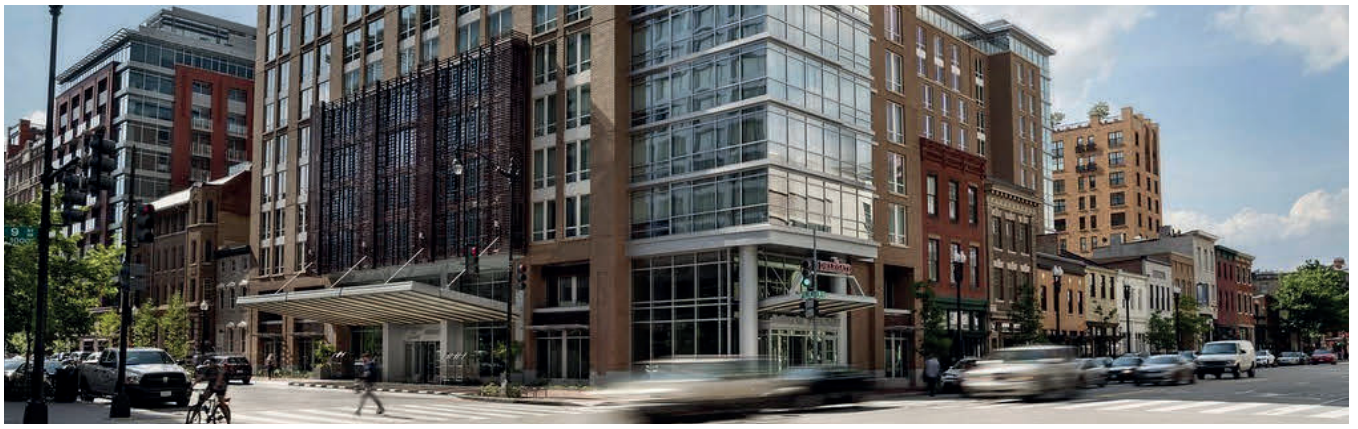

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All In

Sense and Survive: Recapitalization Se for Royal Navy EW

By Richard Scott

The UK Ministry of Defence (MoD) and Royal Navy (RN) have embarked on a major investment program intended to recapitalize the RN's ability to sense and survive in an increasingly complex electromagnetic threat environment.

Valued at approximately £500 million overall, the Maritime Electronic Warfare Programme (MEWP) is a twin-track spiral acquisition that aims to progressively update surface ship electronic surveillance, electronic warfare command and control (EWC2) and soft-kill capabilities over the next 20 years. While initially focused on self-defense at the single ship level, later increments are planned to address task group EWC2 and force-level anti-ship missile defense (ASMD).

MEWP embraces two complementary Category A procurement projects, each to be delivered in a series of staged increments. The first, known as the Maritime Electronic Warfare System Integrated Capability (MEWSIC), is being taken forward to deliver enhanced sensing and EWC2. The second effort, dubbed Electronic Warfare Counter Measures (EWCM), is intended to endow the fleet with improved soft-kill countermeasures capabilities.

According to Cdre Steve Prest, Deputy Director Navy Acquisition in Navy Headquarters and Senior Responsible Owner for the MEWP effort, the modernization of the RN's EW capabilities will deliver enhanced situational awareness, support faster operational decision-making and provide ships with more robust ASMD. "The ability to understand and exploit the increasingly complex electromagnetic environment is critical for the operational success of the Royal Navy," he explained. "This technology will deliver a generational leap in our electronic warfare capabilities to ensure we maintain the operational advantage we need well into the 21st century."

Furthermore, the investment in new technologies and techniques has afforded an opportunity to re-think the integration and operation of EW within the command chain. "It is going to give us better information to take decisions against," said Commodore Prest. "And it will enable us to increasingly automate our responses to the anti-ship missile threat."

MEWP origins

Established in 2016 through the consolidation of the earlier Maritime Electronic Warfare Surveillance System (MEWSS) and Defensive Aids Suite – Surface Ship (DAS-SS) programs, the MEWP procurement program is intended to deliver a coherent next-generation EW surveillance and soft-kill protection capability for RN *Queen Elizabeth*-class aircraft carriers, Type 45 destroyers and Type 26 and Type 31 frigates. Yet while designed to meet the needs of a 21st century fleet, many of the program's key goals can be linked back to experience hard-learned in the South Atlantic four decades ago.

Operation "Corporate" – the 1982 military campaign to liberate the Falkland Islands from Argentine occupation – taught the RN some harsh lessons with regard to the potency of the sea-skimming anti-ship missile, and the glaring weaknesses in its own ASMD capability. Air-launched AM39 Exocet missiles were responsible for the destruction of the Type 42 destroyer HMS *Sheffield*, positioned "up-threat" as a picket for the Task Force, and the container ship *Atlantic Conveyor*, which was transporting vital supplies for the forces ashore. In addition, the *County*-class destroyer HMS *Glamorgan* was fortunate to survive a strike from an MM38 Exo-

MEWP ts a New Course Capability

The RN Type 45 destroyer HMS Defender *is pictured here participating in the BALTOPS 22 exercise. All six Type 45s are in line to receive the MEWSIC Increment 1 upgrade.* US NAVY

cet fired from a jury-rigged shore battery at Eliza Cove.

EW was an essential part of the layered defense screen, providing an important means of surveillance and warning, confusing adversary targeting and offering credible soft-kill defense against anti-ship missiles. But while the EW community could point to some notable successes during the conflict, operations in the South Atlantic also highlighted shortfalls in both equipment and tactics, techniques and procedures (TTPs).

From the situational awareness perspective, the then state-of-the-art Outfit UAA(1) "Abbey Hill" radar electronic support measures (RESM) system was highly valued as a passive prime sensor for both picture compilation and ASMD threat warning. It was the first automated equipment of its kind to enter RN service, and it represented a world-first application of digital instantaneous frequency measurement technology.

Yet *Sheffield's* loss demonstrated deficiencies in both spectrum management and equipment performance: the command decision to transmit on the SCOT satellite communications (satcom) system left UAA(1) blind in the AM39 seeker threat band at the time of the attack. It subsequently emerged that the filters required to enable the system to function in the presence of consort emitters were not implemented in the original hardware baseline.

Other identified UAA(1) shortcomings included lack of frequency coverage, inadequate interfacing within the action information organization, and a limited number of warner channels. Another deficiency was the inability to rapidly update RESM threat emitter libraries on deployed ships.

There was also a mixed scorecard from "Corporate" with regard to soft-kill. Chaff Charlie (fired from a 4.5-inch gun) or Chaff Hotel (sown from helicopters) was used to effect tactical "confusion," while Corvus multi-barrel 3-inch rocket launchers could fire Chaff Delta patterns to distract a missile seeker in its search phase. In the latter case, the RN had recently begun to field a new N4 broad band chaff rocket to replace earlier narrow band N1/N2/N3 munitions.

Post-conflict analysis indicated that timely Chaff Delta deployment was successful in decoying at least two AM39 Exocet missile attacks. However, the loss of the *Atlantic Conveyor,* an unarmed and "disadvantaged" high value unit, also served to highlight the absence of effective force-level EWC2: a chaff pattern laid by the Type 21 frigate HMS

The Type 42 destroyer HMS Sheffield *burns after being hit by an AM39 Exocet missile. Four decades later, the sinking of the Russian cruiser* Moskva *highlighted the continued vulnerability of surface ships not properly equipped or prepared for ASMD.* ROYAL NAVY/CROWN COPYRIGHT

Ambuscade succeeded in decoying a pair of AM39 missiles launched at the Task Force, but having passed through or under the chaff, the Exocets then acquired and homed in on the undefended *Atlantic Conveyor*.

Another problem was the limited stock of chaff rounds available to the Task Force. The new N4 rocket was in short supply, and there was on occasions a hesitation to fire chaff lest scarce rounds be expended on false alarms.

Furthermore, RN vessels did not have a "break-lock" seduction decoy round in their soft-kill armory. This deficiency led to the hurried development of the Hampton Mayfair helicopter-borne jammer. Carried on board a handful of Lynx helicopters, this I-band home-on-jam device is widely believed to have been the world's first active offboard missile decoy.

Although ordered in the late 1970s to meet a requirement for a so-called short-term jammer, the Type 670 point defense jammer arrived in service too late for Operation "Corporate." The more capable Type 675(2) jammer – primarily designed to generate false targets to confuse reconnaissance satellites and airborne surveillance radars – did not enter service until the late 1980s.

Significant new investment was made in maritime EW in the years immediately following the Falklands conflict. Some equipment, such as the US Navy's SRBOC seduction decoy, were introduced to quickly rectify ASMD gaps exposed in the South Atlantic, while additional soft-kill enhancements were subsequently brought into service for operations in the Persian Gulf theatre. Other systems, notably the Mk 251 Active Decoy Round (ADR) and the Outfit UCB(1) Electronic Warfare Control Processor (EWCP), required more comprehensive maturation and engineering development, and so took somewhat longer to reach the front line.

THREAT ENVIRONMENT

Forty years on from the Falklands, the threat environment has changed significantly. The RN today finds itself operating in complex, diverse and congested electromagnetic environments characterized by the presence of many co-sited and consort high duty cycle emitters, an explosion in cellular communications signals across frequency bands that encroach into the traditional radar realm, and the presence of new and more complex emitter types – for example, wideband satcoms, high duty cycle multifunction radars and low probability of intercept [LPI] radars.

"The electromagnetic environment is used in a different way from even 15-20 years ago," said Commodore Prest. "Think of the explosion we've seen in mobile phones, wifi, solid-state waveform processing and software-defined radios.

"You have also got the proliferation of what were once advanced technologies and techniques into the commercial realm. For example, off-the-shelf marine navigation radars are now solid-state incorporating digital signal processing, beamforming and so on – it's a world away from the noisy, magnetron-driven systems of old.

"Viewed through the lens of a RESM system, the environment just looks different. So you need different technologies and techniques to sense – and to sense-make of – that environment. And that's before you even talk about the threat."

He continued: "We also need to reflect on proliferation. If you're looking at an operational risk approach, you could previously understand and identify the few state actors and understand broadly where they were deployed. From that, you could craft your operational design and your tactics. Now there is a much greater proliferation of these threats around the world, and in places where we're interested in operating."

From a sensing perspective, the congested RF spectrum – with its abundance of multiple and "overlapping" signals – presents a major challenge. "We're working in an exceedingly complex electromagnetic environment," Neil Clelland, senior principal anti-ship missile scientist in the Defence Science and Technology Laboratory (Dstl) and MEWP Project Technical Authority, told delegates at the AOC Europe 2022 conference in May. "It's very congested, there's other people want to play in it, and there's other people who want to deny it to us. And it's frequently degraded."

It remains the case, however, that the performance of previous-generation RESM systems using analog receivers is limited given the parameter accuracies that need to be measured in order to identify specific threats in dense electromagnetic environments. Furthermore, the overlap of time coincident signals means that high-power consort emitters may simply mask LPI threat radars.

The anti-ship missile threat has also evolved. Missiles are variously faster or more stealthy, delaying detection and so reducing the time available to respond. Radar seeker technology has advanced in parallel: the latest seekers embody a number of sophisticated electronic protection measures – examples include coherent processing, frequency agility, chaff discriminators and LPI waveforms – while the improved missile mid-course navigation techniques have enabled "late switch-on" to minimize the counter-detection window.

Another development is the emergence of seekers that operate in portions of the electromagnetic spectrum outside of the typical microwave bands. These include the millimeter-wave radar seekers associated with a new breed of shorter-ranged anti-ship missiles already proliferating into the Gulf region; advanced imaging infrared seekers able to '"recognize" and discriminate targets through their thermal signature; and electro-optical and laser guidance systems associated with short-to-medium range guided weapons that may be encountered in littoral regions. There is also a growing interest in advanced passive RF seeker technologies, and the adoption of multi-mode sensor suites combining seekers in different parts of the spectrum.

MODERNIZATION PLAN

While RN ships have benefitted from various discreet enhancements to their electronic surveillance and soft-kill systems over the past decade, there has for some time been a recognition that the changes in the threat environment demand a more structured and coherent modernization of maritime EW capability. MEWSIC Increment 1 represents the first part of that recapitalization.

MEWSIC Increment 1 will address the integration and operation of EW within the command chain, with the aim to increasingly automate the ASMD threat response.

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"MEWSIC is about sensing, locating, planning, identifying and responding," said Clelland. "That distils to three roles: shared situational awareness; ELINT [electronic intelligence]; and planning ASMD."

Improved sensing is part of the solution, but simply detecting and measuring pulse parameters is not enough by itself. Emitter data has traditionally been displayed in a format that is not intuitive or easily interpreted by non-EW specialists – and is complex to manage in the command environment. This can prevent full exploitation of available information, and/or slow down the decision-making process.

The key, according to Clelland, is to elevate EW data so that it becomes a layer of information pulled up to the command team level. "We're trying to get it more knowledge-based," he said. "Don't fight the dots on the screen – what the command team want to know is: what is it, what does it mean and what should they do? Do you shoot soft-kill? Do you shoot hard-kill? Do you run away?"

Clelland continued: "When you can tell the command that there's a specific threat at a certain range and you must action it, then you're at the knowledge level. But if you're just looking at the dots, and the frequency and the azimuth, then you're at the wrong level. [We want to] fight the battle, not the data. So MEWSIC is a completely new sensor system, and completely new C2, integrated into the combat system."

The other critical driver for MEWSIC – and indeed MEWP as a whole – is open architecture. "Built-in openness was identified as a key user requirement," said Clelland. "It's the first time we've done this. We're adopting a publish/subscribe framework with no proprietary interfaces with the goal of being able to spiral develop the system [and] adopting OMG open standards. For example, DDS for data exchange and OARIS [Open Architecture Radar Interface Standard] modified to support parametric EW data."

"MEWP has money set aside for technology insertion," Clelland explained. "Do we know what that is? No, we don't. But we've set open scenarios which define what 'change events' are. Rather than one system buy we're going to evolve it. So, we must be open so as to insert new technology – primarily software, but it may also be hardware – to match the threat as it evolves."

Open architecture brings benefits from both operational and acquisition perspectives, according to Commodore Prest. "An open system allows the rapid insertion of new techniques and protocols, and it should allow you to update algorithms and different software modules without impacting on the rest of the system," he explained. "Also, the ability to interface in a much more open way with the combat management system and other sensors. The aim is to make the software far more responsive from a through-life perspective, lower the cost of ownership and improve the agility."

MEWSIC DELIVERY

Following an industry completion, the Babcock-led BEQ team – also comprising Elbit Systems UK and QinetiQ – was in late October 2021 awarded a £103 million contract to deliver the MEWSIC Increment 1 solution. Extending over a 13-year period, the contract covers the supply of new EW suites to equip RN Type 26 and Type 31 frigates from build, for retrofit to Type 45 destroyers and the two *Queen Elizabeth*-class aircraft carriers, and for installation in trials and training establishments. The full scope of supply also includes in-service support, the provision of training solutions, installation and commissioning, technical test and integration and technical authority services.

According to Babcock, operational sovereignty and freedom of action will be assured by its industry team through "ongoing significant investment in technology and infrastructure in the UK, and throughout the life of the contract, creating new skilled jobs in manufacturing and software development." The company adds that all ship fits will be undertaken in the UK, together with all new development activity.

As part of the BEQ collaboration, Elbit Systems UK will provide both the wideband digital RESM sensor and EWC2 subsystem from its proprietary eM-e EW suite under a subcontract valued at £73 million. This solution is itself built on the pedigree of EW systems previously delivered by Elbit's Israeli parent to the Israeli Navy, the Royal Canadian Navy and the Royal New Zealand Navy.

While details are thin, information publicly released by Elbit Systems UK on its eM-e RESM solution gives an indication of a number of key performance parameters including: the use of very high sensitivity interferometric phased array antennas for direction finding; a fully digital wideband receiver architecture utilizing direct

sampling, advanced signal processing including co-pulse reception, immunity and resilience mechanisms; an automated high-sense ELINT capability; and the employment of adaptive algorithms and deep learning techniques to lower false alarm rates.

While the RN had previously attempted some level of EWC2 with the Outfit UCB(1) EWCP system, the C2 functionality to be implemented in MEWSIC Increment 1 will be substantially more advanced. "ASMD is complicated, and greater automation is recognized as critical," explained Clelland. "Exercises and scenario modelling have shown that it does not take many engagements before operators become overloaded with actions, decisions and timeliness. This will be important for mission planning and rehearsal before going into theatre. And it will provide for faster and better TTPs."

Commodore Prest amplified this latter point by explaining that ASMD threat procedures had changed relatively little since the Falklands war, and that EWC2 still relied fundamentally on members of the operations team manually executing well-rehearsed ploys. "It's a series of protocols following on from the detection of a certain threat missile," he explained. "A whistle is blown by the EW operator, and then a sequence of actions is taken. So that happens at human speed. What we now need to do is make that happen at machine speed. So instead of just producing a laminated readout for the Principal Warfare Officer and the EW operator, you actually want to encode those tactics and algorithms into your [EWC2] system."

The RN plans to field MEWSIC Increment 1 operationally from 2027. As Commodore Prest acknowledged, rolling the new system out to both new and in-service platforms brings its own challenges. "We're fitting [MEWSIC Increment 1] to four different classes, so that means four different integration solutions," he said. "And it's not a case of do one class, then the next, and the third, and the fourth. There is a lot of complexity in that.

"We have to manage that and the capacity required to do that because we've got no appetite to do this more slowly. We have to balance the new-build ships as they roll-out from vessel acceptance, with the in-service platforms.

"So we have to line up the delivery of these systems with the ships' programs, upkeep cycles and planned capability insertion periods. There are obviously multiple dependencies, and inevitable risks, which we must manage."

Two further MEWSIC increments are planned: Increment 2 will implement unspecified improvements to the Increment 1 baseline; Increment 3 represents a more substantial uplift to confer a capability for EWC2 at the Task Group level. "This is about 'plan and respond' from the most appropriate units," said Clelland. "We're building the services [in Increment 1] and putting the enablers in [for a force defense capability]. Maritime Multi-Link [Link 22] is coming in so ships can talk between themselves better. So, we're building for the next stage."

For Commodore Prest, Increment 3 is expected to tie into the broader task group air defense problem. "I suspect that won't be MEWSIC delivering something standalone, on its own. Rather, I think it's going to be a wider contribution to integrated air and missile defense in the electronic warfare domain. That will include synchronization of hard-kill and soft-kill."

NEW COUNTERMEASURES

The acquisition of a new EW decoy launch unit and offboard countermeasures under EWCM represents the second strand of MEWP. Again, it is the intention to pursue a phased procurement plan that will, over time, grow from soft-kill ASMD at single ship-level to integrated task group protection.

"We see a number of advanced technologies being adopted in missile seeker

RN ships are currently fitted with the Outfit DLH decoy launch system, which uses multiple fixed 130mm six-barrel launchers. A new trainable decoy launcher system is planned under EWCM Increment 1a. ROYAL NAVY/CROWN COPYRIGHT

EWCM Increment 1b calls for the procurement of a second-generation RF Active Decoy to replace the Mk 251 ADR (above). ROYAL NAVY/CROWN COPYRIGHT

heads," said Commodore Prest. "They are becoming more challenging to defeat, and we are also faced with a shorter time to react. So, the logic behind EWC2 [in MEWSIC Increment 1] is that we decide what we want to do against a particular threat. EWCM is then all about how we react."

EWCM Increment 1 is split into two parts: Increment 1a provides for the acquisition of a new trainable decoy launcher capable of deploying future and legacy rounds; Increment 1b calls for the procurement of a second-generation RF Active Decoy (RFAD) to replace the Mk 251 ADR.

The EWCM Increment 1a competitive phase began in mid-2022. Valued at up to £115 million over a 13-year period, the requirement calls for a new trainable launcher, at a Technology Readiness Level (TRL) of TRL 6 or above, that will be capable of deploying both future and legacy rounds. The latter stipulation conditions compatibility with the 130-mm caliber Mk 216 and Mk 217 RF distraction decoys, and the 130 mm MK 245 submunition-based IR seduction decoy.

RN ships are currently fitted with the legacy Outfit DLH decoy launch system, which uses multiple fixed 130-mm six-barrel launchers. However, fixed launchers suffer from a number of constraints – for example, they require the defended ship to perform coordinated maneuvers as part of the countermeasure ploy, and are inherently limited in terms of the accuracy of decoy placement.

Trainable launchers are necessarily larger, heavier and more complex, but their ability to traverse and elevate provides greater precision in the delivery of the soft-kill payload, enables the optimized deployment of advanced RF and IR countermeasures programmable in height and range, and minimizes the requirement for ship maneuvers.

"The point of the trainable launcher is that it enables you to put your countermeasure effect into the right place with precision, and at the time of your choosing," said Commodore Prest. "And once you've got it, you can then decide what range of countermeasure rounds you want to deploy."

EWCM Increment 1b is approximately 12 months behind Increment 1a in the procurement pipeline. RFAD studies, conducted through Dstl's Progeny maritime research framework, will be followed by a competitive acquisition phase.

The longer term EWCM Increment 2 is designed to provide a persistent offboard RF countermeasures capability for Task Group defense. Again, Dstl has already commenced work to explore possible offboard concepts, including a maritime recoverable decoy suitable for deployment on either an uncrewed aerial vehicle and/or an uncrewed surface vehicle.

ON COURSE

The challenges posed by new threats, as well as increasingly coordinated adversary tactics, mean that ASMD concepts must shift from focusing on own-ship protection to supporting collective defense. MEWP is designed to mature in this direction, and it will provide the RN with a capability that will grow as the ASM threat evolves.

AOC Webinars

AOC Webinars have been a tremendous asset providing AOC's audience with learning, advocacy, and the exchange of information. Register for an upcoming session to hear from subject-matter experts on all things EW!

Cognitive Electronic Warfare and Reinforcement Learning
Presenter: Kyle Davidson

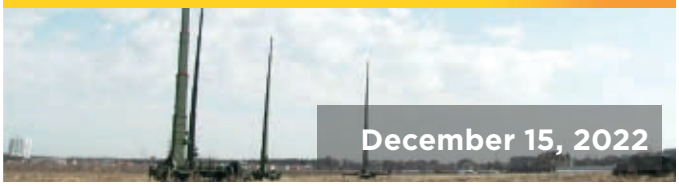
Across the Spectrum Pond: How the US Military can procure tested solutions from Europe
Presenter: Zachary George

EMBM Situational Awareness: Data Integration, Visualization, and Analytics
Presenter: Jose Perez and Josh Lindsey

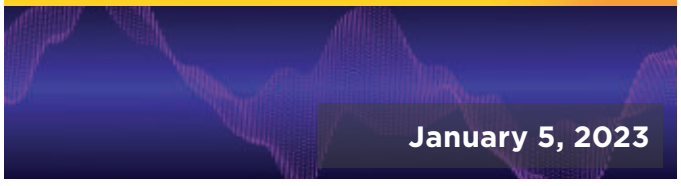
Electromagnetic Manoeuvre: Towards a Theoretical Underpinning
Presenter: Thomas Withington

Two-way Time-transfer Digital Design for Distributed Array Operations
Presenter: Jonathan D. Chisum

In the Flat Field: Did Russian Army Electronic Warfare underperform in Ukraine?
Presenter: Thomas Withington



Regaining the Spectrum Offensive
Presenter: Bryan Clark



2023 GPS Spoofing – History and Prevention
Presenter: Dana Goward

Save your seat for an upcoming webinar: **www.crows.org/webinar-schedule**

Electromagnetic Protection (Part 5)

Mono-pulse Radars

By Dave Adamy

TARGET TRACKING BY NON-MONO-PULSE RADAR

A mono-pulse radar gets angle information from each pulse it receives. As shown in **Figure 1,** a non-mono-pulse radar has a single antenna with a single feed. In order to determine the angular location of a target, that antenna must sweep. If the radar is only locating a target in one dimension (e.g., azimuth or elevation) its antenna will sweep as shown in **Figure 2.** The radar only receives return signals as the antenna beam passes a target. The antenna can sweep a full circle or (as shown in the figure) only a narrow arc. The time at which a signal is received allows the radar to determine the angle to the target.

If the radar needs to determine the angle to a target in two dimensions, the antenna must sweep in both dimensions. There are many possible sweeping patterns; **Figure 3** shows a raster scan to cover a two-dimensional area. In this same figure, the antenna's output power vs. time is shown. The smaller signals are seen when the antenna is pointed near the target location but not at the antenna's bore-sight, and larger signals are seen when the target is at the bore-sight (i.e., maximum gain direction) of the antenna pattern. The radar learns the direction to the target from the time at which it receives return signals.

To track a target in range, the radar determines the time it takes a return pulse from a target to reach the radar.

ANGLE TRACKING BY A MONO-PULSE RADAR

A mono-pulse radar antenna has multiple feed antennas, as shown in **Figure 4.** This figure shows only two feeds, but there are normally three or four to allow two-dimensional angle determination. Looking at the two feeds, **Figure 5** shows the radar's processor considering the sum and difference of the outputs from these two antennas. The radar considers the difference pattern (Δ) minus the sum (Σ) pattern. The sum pattern allows the radar to operate over a large dynamic range, and the difference pattern determines the direction and angular distance to the target from the antenna's current pointing angle. Note that the difference pattern should ideally be linear across the half-power (i.e., 3 dB) beamwidth of the sum pattern.

The difference (sum value) will determine which direction the antenna would need to be steered to place the target at the antenna bore-sight – or the angle to the target if the antenna is not steered in that direction.

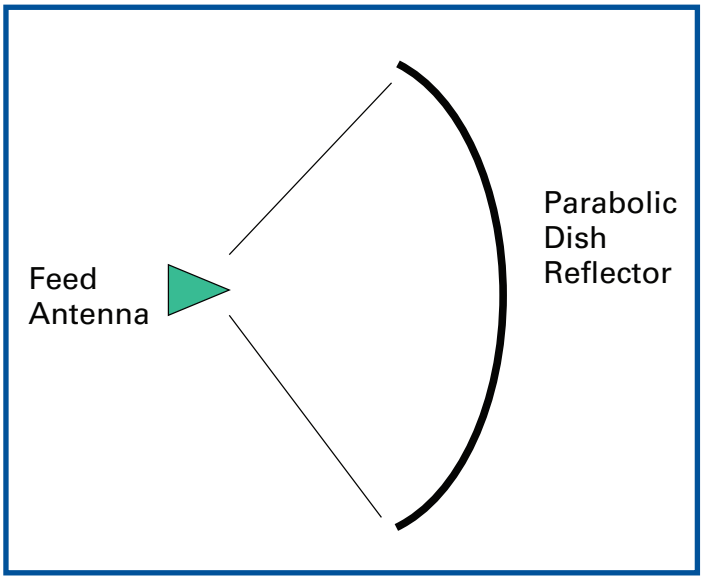


Fig. 1: *In a non-mono-pulse radar, a single antenna feed reflects into a parabolic dish reflector to transmit and also receives signals reflected by the reflector.*

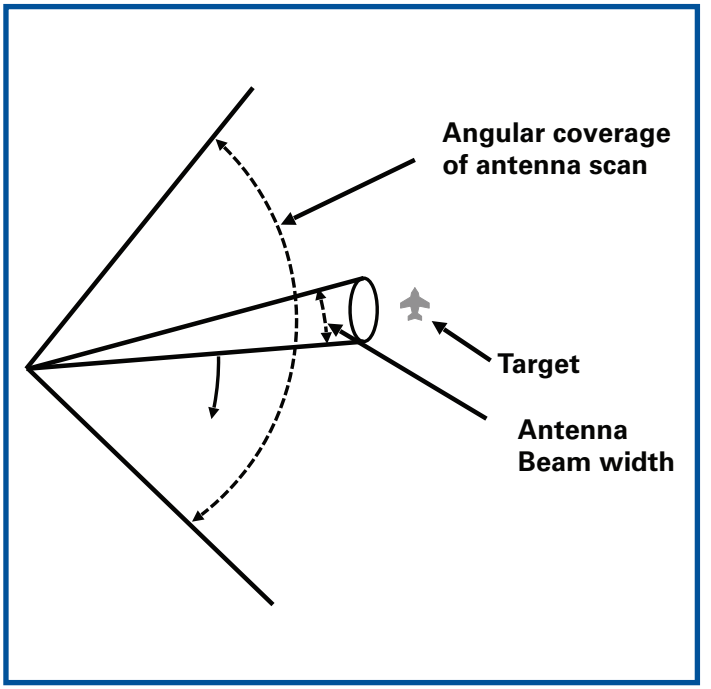


Fig. 2: *In a non-mono-pulse radar, the antenna scans all or part of 360 degrees around the location of the radar. When it encounters a target, the antenna outputs to a receiver.*

When there are more than two antennas, this analysis is performed between each pair of antennas to determine the two-dimensional angle to the target.

In terms of determining range, the mono-pulse radar tracks range in the same way as the non-mono-pulse radar.

ELECTRONIC PROTECTION FROM MONO-PULSE FEATURE

To deceptively jam the range or angle-tracking feature of a non-mono-pulse radar, the jammer places a strong signal at a different time from that of the return pulse from the target. The jamming pulse must be strong enough to capture the radar's tracking ability. Thus, the radar processor is caused to output a false angle or range determination.

The mono-pulse radar measures angle on every pulse using its multiple antenna feeds. Thus, the direction of arrival of the jamming pulse is known to be from the jammer. If the jammer is on the target (self-protection jamming) the stronger jamming pulse **enhances** the radar's tracking ability and makes the jamming ineffective. However, the jammer can still diminish the radar's range tracking ability.

Note that some jamming techniques can be used against mono-pulse radars, but the following techniques are not appropriate:

- Range-gate pull-off
- Range-gate pull-in
- Cover pulse
- Inverse gain

Different techniques must be used against mono-pulse radars. These techniques include the following:

- Formation jamming
- Formation jamming with range denial
- Blinking jamming
- Terrain-bounce jamming
- Cross-Polarization jamming
- Cross-Eye jamming

WHAT'S NEXT

Next month, we will continue our Radar Electromagnetic Protection discussion by the consideration of coherent side-lobe cancelers.

Dave Adamy can be reached at dave@lynxpub.

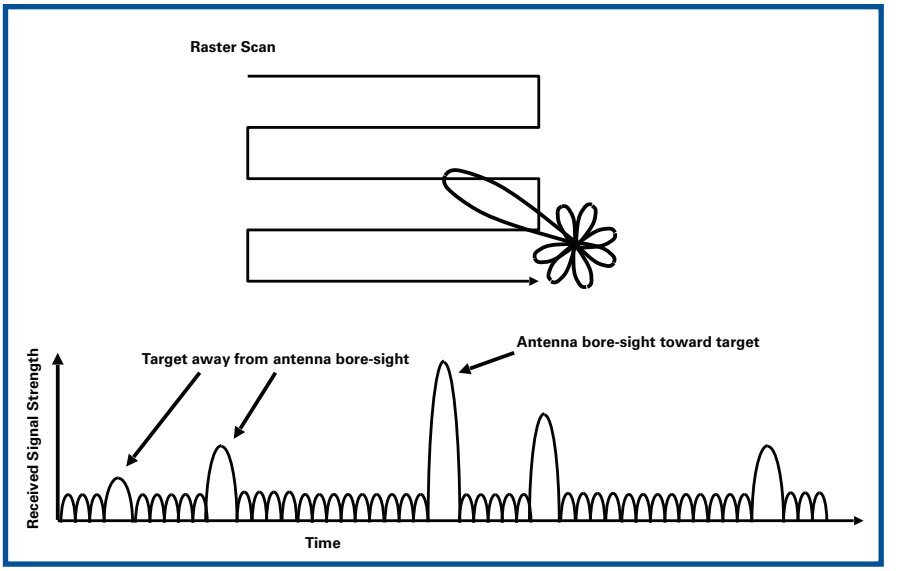


Fig. 3: *A single antenna covers two dimensions by using a two-dimensional scan pattern. This shows a raster scan. The bottom sketch shows the received signal strength by the radar as a function of time during the raster scan.*

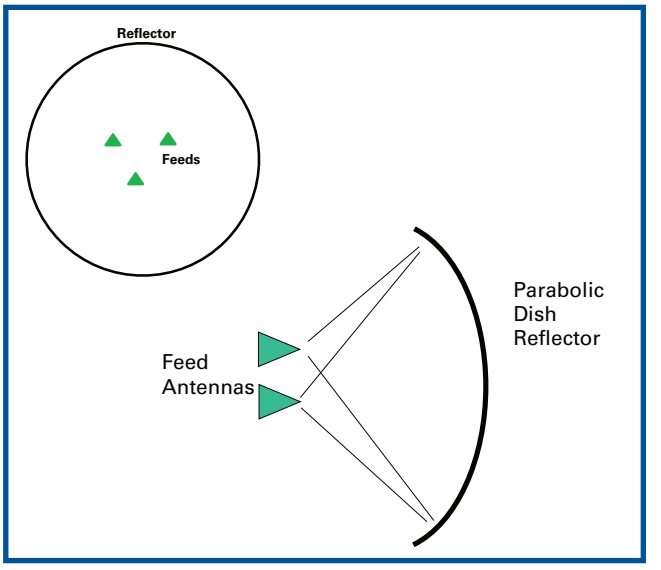


Fig. 4: *In a mono-pulse radar, there are typically three or more antenna feeds that transmit into and receive from a reflector. (Only two are shown here for clarity.) These feed locations are not co-linear.*

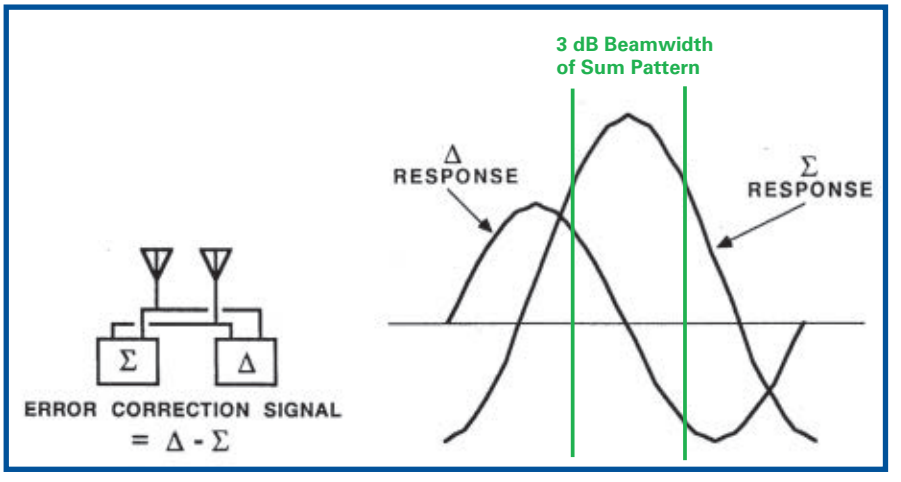


Fig. 5: *In a mono-pulse radar, the processor determines the angle to a received target by measuring the difference between two antenna outputs minus the sum of those two outputs. When there are more than two antenna feeds, this calculation is performed for each pair of antennas. Note that it is highly desirable to have the difference (Δ) response linear over the 3-dB beamwidth of the sum (Δ) response.*

AOC EDUCATIONAL FOUNDATION CRANE ROOST: 2021-22 SCHOLARSHIP AWARD WINNERS

Jessica Cruz

- Attending Ball State University pursuing a degree in Supply Chain Logistics and Computer Information Systems
- Jessica is a Pathways Student Intern at Crane working in the Maritime EW Division in the Product Based Support Branch.
- Jessica supports the AN/SLQ-32(v)6, AN/SLQ-32C(v)6, and AN/SLQ-32(v)7 systems.
- Jessica finished her Junior year in May 2022.

Sam Frauhiger

- Just graduated from Purdue University with a bachelor's in Computer Engineering.
- Sam was a SSEP Student Trainee at Crane from August 2020-21 under Dennis Jones.
- From Sam: "Through the SSEP opportunity I found my desire to work in the Electronic Warfare field. I will be continuing that career path with Booz Allen Hamilton as an Engineering Consultant in San Diego, California."

AOC JAPAN CHAPTER 11TH EW RESEARCH GROUP CONFERENCE

The AOC Japan Chapter hosted the 11th EW Research Group Conference on May 24 in person and online hybrid at Information Technology R&D Center, Mitsubishi Electric Corp., Kamakura. The event was co-sponsored by the Technical Committee on Space, Aeronautical and Navigational Electronics (SANE) of the IEICE (The Institute of Electronics, Information and Communication Engineers) Japan.

The EW Research Group of the AOC Japan Chapter holds an annual conference to promote the exchange of new ideas and information in EW and related fields.

AOC President Glenn "Powder" Carlson opened the meeting with a welcome video message. In the afternoon, AOC Japan Chapter President Shigeo Kazama welcomed the 80+ attendants from Japanese industries, academia, and government and promoted AOC membership.

The keynote talk was on Cognitive EW and AI by Dr. Karen Haigh. The discussion was pre-recorded to avoid accidental link failure; however, the Q&A discussion was held live, connecting the attendants in Japan and Dr. Haigh in France.

The technical sessions included twelve presentations on EW, radar, positioning, AI, satellite, electromagnetic, and antenna, presented by researchers, engineers, and students.

AOC Japan Chapter President Shigeo Kazama's Speech

CHAPTER FOUNDATION PHOTO

AOC President Glenn "Powder" Carlson's Welcome Remarks.

Live Q&A of Dr. Karen Haigh in France and the Attendees in Japan.

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ASSOCIATION OF OLD CROWS

2022 AOC Election Guide

Election runs Sept. 1-30

Your participation is critical. Please exercise your right to vote for your AOC 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 2022 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!

AT LARGE

Eric Colon

Eric Colon is the Director of Electronic Warfare and Cyber Strategic Solutions at Corvus LLC. In addition to his current duties, he is working as a subject matter expert on OUSD Electronic Warfare Study. Previously he was the Senior Electronic Warfare Subject Matter Expert at the Department of the Army Strategic Operation G3/5/7 Strategy Policy and Planning, where he supported the Army's warfighting transformation by integrating, prioritizing, and synchronizing multi-domain, data-enabled warfighting systems, as well as operational requirements focused on the electromagnetic spectrum and consisting of Information Dominance, Cyber Electromagnetic Activities and EMS management operations. Eric also served as a touchpoint for Joint Staff J-7 Analytic Research Program "Quantum Threats to the 2030 Joint Force," where he was responsible for advising on the optimal mix of tools to prevent adversaries' encryption and decryption of exploited data that could provide vulnerability information on weapon systems or C2.

Prior to joining Corvus, he was the Senior Technical Advisor of Electronic Warfare at Army Cyber Command, G-39, responsible for the coordination and integration of EW training strategies, managing the Army Cyber Operations Training Strategy, advising the 915th Cyber Warfare Battalion on EW Integration and the Multi Domain Task Force equipping plan. During his 31 years of service in the United States Army, he deployed to CENTCOM AOR and completed multiple deployments in support of Operation Enduring Freedom and Operation Iraqi Freedom. He has also served as an instructor at the US Army Electronic Warfare school and the Field Artillery School.

Eric is currently pursuing his doctorate in Information Technology with a concentration in Blockchain and cryptography from the University of the Cumberlands.

Eric was the AOC Oklahoma Chapter President from 2015 to 2018 and Treasurer of the Fort Sill Warrant Officer Association from 2016 to 2018. Eric currently serves on the AOC Awards committee.

Tuhin Das

Tuhin has had the privilege of getting acquainted with the AOC early in his career. Coupled with his strong appetite to learn and outgoing personality, he has served the AOC by being recently appointed to the BOD as the Memberships Committee Chair in 2020, and revitalizing the Maple Leaf chapter, while maintaining a busy full-time career as head of Global Business Development with a US focus at D-TA Systems that builds Electromagnetic Solutions. He has significant experience facilitating bi-lateral and multi-lateral R&D trade collaborations, where he successfully advised industry and academia on how to leverage Government funding opportunities for innovation and growth. Leveraging his Bachelor of International Business degree and a Project Management diploma, Tuhin works with various DoD departments, DND and FVEYs community organizations on a variety of contracts with varying complexities. He routinely travels for work to various parts of the US attending the AOC conferences at APG, Pt. Mugu, Warner Robins AFB and Annual DC Symposium to name a few. He is always reachable via email or phone and hoping to serve the Northeastern community. His immediate focus is AOC Membership Growth, enhancing communication with AOC regional directors and provide strategic insight to expand Young Crows engagement.

Mark Dotson

Mark is currently the Army Account Director at AnaVation, LLC. Prior to joining AnaVation, he served 28 years in the US Army as a leader and a planner. He led organizations of up to 1,000 Soldiers all over the world in peacetime, peacekeeping, and combat. Mark has planned from the platoon to the combatant command levels and culminated his career as the Director of the Army Capability Management Office (Electronic Warfare) at the Army's Cyber Center of Excellence in Ft. Gordon. Mark earned a Bachelor of Science from the United States Military Academy at West Point and a Master of Arts in Human Relations from the University of Oklahoma. He is married and has two children in high school – one loves acting, while the other will become a US Marine this summer.

Mark is dedicated to ensuring industry and military leaders are educated about the electromagnetic spectrum and what it takes to work within it. He is a competent speaker and can represent our organization well in public. His experience with other volunteer work could be an asset to AOC. He has put together panels (even on short notice) and is willing to do so for AOC as well. Mark is currently the Chapter President of the Green Jacket Roost.

Ken Dworkin

Ken is a retired Intelligence Community senior executive who served for 35+ years at the NSA, with joint duty tours at the DIA, NRO and CIA. He was a senior leader, systems engineer, SIGINT analyst and weapons intelligence expert. He blends experience, strategy, architecture, technology, and creativity – with a focus on promoting collaboration and mentoring the next generation.

In 1990, he analyzed radar and telemetry signals from foreign weapon systems for US Electronic Warfare database management, electronic combat systems reprogramming and Service T&E customers. He pioneered NSA digital intelligence product development. In 1995, he was the first NSA Technical Liaison to DIA/MSIC, facilitating cryptologic support for all-source weapons exploitation and intelligence production.

As a Senior Executive (2003), Ken served as Chief Engineer for the NSA Office of Weapons & Space – de facto responsible for a $1B+ modernization program – and was the first Senior Technical Director at NSA Colorado. In 2010, he became the NSA EW Executive managing strategic integration of SIGINT, EW, and Cyber missions.

At NRO, he enjoyed senior staff assignments, including Deputy Director for the Systems Engineering and Ground Enterprise Directorates and SIGINT/Cyber Advisor to the DNRO. Subsequently, he supported the NSA, CIA, and IC CIOs on a major cloud transformation program.

Ken is a member of the Board of Directors for the nascent Reginald Victor Jones Institute Center of Excellence for EMSO – and is a longstanding, active member of the AOC.

Haruko Kawahigashi

Haruko has been a chief researcher of Information Technology R&D Center of Mitsubishi Electric Corporation. She received Ph.D. in Electrical Engineering from the University of Tokyo by study of "application of neural network technology to the design of communication networks." She joined Mitsubishi Electric Corporation after graduation, where she has been engaged in research and development of commercial carrier networks, defense networks and EW. She has written more than 100 conference papers and obtained 45 patents in Japan, the US and Europe.

Haruko founded the AOC Japan Chapter's EW research group and has organized its annual conferences since 2012, cosponsored with IEICE (Institute of Electronics, Information and Communication Engineers) Japan. The annual conference has activated AOC Japan Chapter and EW R&D community in Japan. She has participated in the AOC's annual international symposium every year since 2010 and has presented technical papers in many of them. She published Japanese version of EW101, 102, 103 and 104 by Dave Adamy, co-translated with her ex-colleagues in Mitsubishi Electric. These are the only EW technical books in Japanese, with more than 13,000 copies printed. They enlightened Japanese people on EW as a defense science. She proposed effective design and evaluation methods for mission-critical wireless ad hoc networks and contributed to realizing high-reliability under severe bandwidth limitations. Her study has been highly evaluated by the military network research community and she has given a series of invited talks at MILCOM.

Haruko is currently serving as At-large Director on the AOC Board. She is on the International Advisory committee and the 2022 Awards Committee.

Chuck Quintero

Chuck is a senior RF systems engineer with the RF Seeker Group. During his 40-year career he has worked on space-based, airborne- and surface-based RF systems for remote sensing, electronic warfare, and communications at JHU-APL, Leidos, SRI International, Northrop Grumman, ITT Harris, and Lockheed Martin. He is currently pursuing a DEng from the Johns Hopkins University and has an MSEE from the University of Pennsylvania and an SB from MIT. Chuck is an avid astronomer, STEM lecturer for NASA PL and EW Certification chair for the Association of Old Crows. Chuck has published and presented papers on satellite constellation design, space surveillance, multi-channel, high-bandwidth RF Systems, and radar.

Chuck has served on the AOC Board of Governors. Currently he is a member of the Certification committee and the Educational Outreach committee. He is also active in revitalizing the Chesapeake Bay Roost Chapter.

Mick Riley

Mick has been actively involved most of his adult life supporting our chosen profession, electronic defense – protecting our warfighters and ensuring spectrum dominance. He spent 21 years on active duty, retired as EW superintendent responsible for 65 EW systems as ACC's liaison at Warner Robins ALC. He was the single point of contact for ACC to the depot. Mick worked in industry for 15 years then started his company: Test Equipment Solutions in 2010. Nearing retirement, he has more time to devote to further the cause for the AOC's goals. He will advocate for securing our country's freedom through spectrum and cyber dominance.

If elected, Mick will bring AOC corporate knowledge to the board, as well as fresh ideas to enhance our organization's mission. He is an excellent communicator who is comfortable conversing with the highest-level officers to a blue-collar hourly worker. He is recognized within DoD and industry alike for his unwavering integrity and reliability. He will work hard to engage teens, college students and enlisted EW and cyber maintainers to join and contribute to the AOC. Mick has been married for 39 years to Savien Kingwongsa (Dow) Riley. They have four adult children and seven grandchildren.

Mick has been an AOC active life member for 36 years and a BOD member for 22 years. He is an active AOC member and past board member for the Dixie Crow and Emerald Coast chapters beginning in 1986. As a member of the AOC Board, he was AOC vice president in 2008 and AOC At-Large Director for 12 years, AOC's Southern Regional director for 10 years and served on the first AOC Board of Governors. As AOC Membership Chairman for eight years, he helped achieve the AOC's largest total membership under his leadership.

Paul Vavra

Paul "Heywood" Vavra is a retired USAF officer and EW industry executive. He currently consults internationally on Electronic Warfare, Air Combat Training and LVC, unmanned systems and international business development. He enlisted in the Air Force at 16 and was commissioned at 18. His assignments included RC-135 EWO, Flight Commander, Intelligence Division Chief, Foreign Area Officer, MAJCOM Command EW, and Commander of the Pacific Reconnaissance Operations Center, where he was responsible for all DoD ISR activity in the PACOM theater. Heywood flew 261 combat, combat support and Cold War recon missions on the RC-135 and EP-3, supporting operations in Lebanon, Libya, Grenada, Desert Storm, and Bosnia to name a few. He retired in 2005 after 25 years total military service.

After retirement he served as Business Development Executive in two major defense firms, focusing on international and domestic EW and air combat training programs. Heywood has been a member of the AOC since 1984, and has served on various chapter-level committees, spoken at multiple US and international EW symposia and is currently a member of the AOC EW Certification committee. He has special interests in increasing international military cooperation and international participation in the AOC, and growing STEM programs starting at the middle school years. He has a drive to ensure the AOC stays relevant to active-duty military members. Heywood's wife, Carol, is also a retired USAFR officer, having flown RC-135, KC-135, and C-130 combat missions in Iraq, Afghanistan, and Desert Storm. They live in South Dakota.

NORTHWESTERN REGION

Mark Schallheim

Mark was first involved in AOC over 35 years ago and has over six years' experience on AOC Board of Directors and Governors. He is passionate about Electronic Warfare and specifically about supporting the evolution from traditional EW to solving Joint/Coalition EMS Warfare and Cyber Operations. His background is in Naval Airborne Electronic Attack, and he spent most of his professional career supporting the EA-6B & EA-18G. He retired as NAVAIRSYSCOM's EMS Dominance Chief Engineer in which he had a role in developing evolutionary EMSO capabilities and concepts.

Mark was an AOC Chapter President (or Past President) for 11 years and is currently the STEM Committee Chair and a member of the AOC EXCOM as well as numerous AOC Board Committees including Awards, Future Five, Membership, Scholarship, and others. He believes that AOC currently provides a growing list of benefits to membership, including self-improvement tools such as mentoring, networking, webinars, and professional development opportunities to its members and to the EMS community. In addition to supporting AOC in advocating for a decisive advantage in the electromagnetic operating environment (EMOE), he would like to specifically facilitate the Northwest Region Chapters and all AOC members to gain meaningful benefit as a member.

PACIFIC REGION

Amanda Kammier Brockermeyer

Amanda served in the US Navy as an EA-6B ECMO for nine years, served two tours in Afghanistan and worked at the Pentagon and the White House. After her military service, she transitioned to industry and has enjoyed leading various programs across all phases of the product lifecycle for the past 12 years. Amanda is currently serving as the Director of P&L leading the Embedded GPS INS Modernization and Assured Position Navigation and Timing (EGI-M/A-PNT) portfolio in Northrop Grumman's Woodland Hills facility. She previously served as a program manager and business development lead in Raytheon for eight years. During her Navy career, she served an Electronics Counter-Measures Officer (ECMO) for nine years. She was posted to the Pentagon for three years and was in a dual role at the White House for two of those years.

Amanda has previously held roles supporting the AOC community both on the Board of Governors and on the Board of Directors. She served two terms as a Director at Large. During her tenure on the Board, she helped revamp the website in coordination with the Communications Committee team. She served on the Building Committee and worked to find a new home for the AOC – both as part of the process of selling the legacy building and finding a new building that better served our staff and their needs. Amanda is a lifetime member of the AOC and looks forward to continuing to support, education and advocacy of Electronic Warfare and EMS dominance.

INTERNATIONAL REGION I

Erik Bamford

Erik has been with the Norwegian Armed Forces since 1995, where he began in the infantry. He served as Infantry Junior leader until 2000, including deployments to Bosnia and Lebanon. He was accepted into the Military Academy, class of 2000-02, and while there he changed his focus to EW and has worked in the field ever since. From 2002 to 2006, he served as troop commander Comms-EA, and Comms-ES, Comms EW-Analyst in EW Company 2IC. He had a short break from EW whilst serving as S-3(Cadre) for a reserve unit in 2007. As a forward-leaning and unafraid EW practitioner, he was ordered back to the Army as Chief for Counter-RC-IED development. From that post he was recruited by the Norwegian Navy SOF Command and served as EWO with the NORNAVSOC, including and during a deployment with NORNAVSOF to Kabul Afghanistan. From 2009 he was Branch Head for EW with the Army TRADOC and since 2013 he been the principal EW officer with the Norwegian Air Force (NAF), which includes his service as Senior EWO with the NAF.

Erik holds a master's degree in political science from the University of Bergen, where he focused on commercial counter privacy operations.

He has been a Chapter Board member of the Artic Roost since 2010 and was an Arctic Roost Chapter Board member from 2011 to 2016. Erik has also been on several AOC headquarters committees such as Awards and International Advisory committee as well as a speaker at the 53rd AOC Annual Symposium and the 17th AOC Security Cooperation's Symposium in 2017.

Erik and his wife, Metter, have two children ages 10 and 12.

Daljit Singh

Air Marshal Daljit Singh was commissioned in the Fighter stream of the Indian Air Force (IAF), in June 1976. The Air Mshl commanded a Mirage 2000 squadron, an operational fighter base and retired as the Air Officer Commanding-in-Chief of an operational Command. During his tenure of 38 in the IAF, the Air Mshl accumulated vast experience spanning 20 years in EW operations and has flown more than 3,500 hours on fighters of the Russian, European and Indian origin. The Air Mshl was instrumental in inducting and operationalizing EW systems onboard the IAF's Mirage 2000 fighter fleet, and he formulated EW doctrine, tactics, and techniques for all fleets of the IAF. He organized International EW seminars for the IAF and tenanted the post of Directing Staff at EW Range and Director EW Operations at Air Headquarters. As Director General (Air Operations), the Air Mshl formulated plans for netcentric operations and EMSO. After retiring from the IAF, the Air Mshl has been regularly conducting lectures for the serving personnel of the IAF on Electromagnetic Spectrum Operations, and he has been participating in international seminars on Cyber and EW Operations.

During his service in the IAF, Air Marshal Singh has been an associate board member of the AOC India Chapter. Since his retirement, he has been an active member of the AOC India Chapter. He has presented papers on future operational challenges in EW during the AOC India Chapter Seminars and was a keynote speaker during the AOC Asia Seminar 2020 in Singapore and distinguished speaker during the AOC Asia Seminar 2021. He volunteered to be the member of the AOC Awards Committee 2022 and continues to take lectures for the serving IAF personnel to generate EMSO awareness.

2022 Online Voting Instructions

Beginning Sept. 1, 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 Aug. 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 Sept. 1 and before Oct. 1 and be addressed to:

AOC – 2022 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.

2022 AOC Election Ballot

Paper Ballots accepted Sept. 1-30.

Name: .....

AOC Member Number: .....

E-mail Address: .....

AT LARGE (vote for 2 candidates)

- ☐ Eric Colon
- ☐ Tuhin Das
- ☐ Mark Dotson
- ☐ Ken Dworkin
- ☐ Haruko Kawahigashi
- ☐ Chuck Quintero
- ☐ Mick Riley
- ☐ Paul Vavra

NORTHWESTERN REGION

(vote for one candidate)

- ☐ Mark Schallheim

PACIFIC REGION (vote for one candidate)

- ☐ Amanda Kammier Brockermeyer

INTERNATIONAL REGION I

(vote for one candidate)

- ☐ Erik Bamford
- ☐ Daljit Singh

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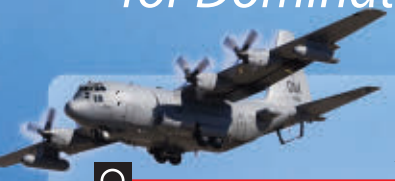

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