November 2023 Vol. 46, No.11

JED

Journal of Electromagnetic Dominance

ASSOCIATION OF OLD CROWS
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CONTENTS

November 2023 • Volume 46, Issue 11

SAAB

Departments

COVER PHOTO ISTOCK.COM/ROMANBABAKIN

US Marine Corps Cpl Jason Feasal, an EW operator with the 24th Marine Expeditionary Unit, reviews data during a direction finding exercise on Camp Lejeune, NC, in late September.

USMC PHOTO BY LCPL RYAN RAMSAMMY

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Fallen Crow: Former AOC President Stephanie McClernan-Krech Passes

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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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PARALLELS

One of the lessons I learned early in my JED career was the importance of trying to see the whole picture. In the EW discipline, it's very easy to fall into the trap of viewing EW through a "soda straw" and focusing too much on one technology or one mission area or simply seeing EW only in the context of EW. This myopic view of leads to the perception that EW is wholly unique, with unique technology requirements and unique personnel needs and unique mission areas. That's a false notion.

In order to avoid this mind trap, I spend a lot of time trying to balance my urge to see the unique aspects of EW against my need to view EW in a broader context. The EMS connects to every other major warfighting domain, and the EW mission, writ large, is part of this connection. Sometimes these connections are built on technologies or missions, and other times these connections are based on warfighting concepts. At the operational concept level, one of the most interesting parallels is between EW and undersea warfare. Acoustics are not part of the Electromagnetic Spectrum, and undersea warfare is not part of EMSO. However, as Bryan Clark and Timothy Walton of the Hudson Institute discussed in a June report, "Fighting into the Bastions: Getting Noisier to Sustain the US Undersea Advantage," many of the challenges and emerging concepts of undersea warfare parallel EW in some interesting ways.

For decades, US submarines were able to rely on superior designs to avoid detection from adversary sensors (active and passive sonar). The authors point out that this type of advantage also existed for allied bombers in the early part of World War II. However, that advantage eroded quickly as the Germans learned how to combine interceptor fighters, radar-guided artillery and EW to inflict heavy losses the high-flying bombers. Allied forces, in turn, developed new operational concepts that relied on escort fighters, radar jammers and decoys, to restore the bombers' advantage.

Undersea warfare is undergoing a similar transformation, as Russia and China develop new undersea sensor networks that are eroding the stealth design advantages of US submarines. In order to restore the US advantage in undersea warfare, more capabilities will be brought into this arena, including swarms of unmanned undersea vehicles (UUVs) that can create noisier environments near adversary acoustic arrays on the sea floor, as well as other UUVs that can take on some of the tasks, such as deploying mines and sensing the environment, that would normally be performed by SSNs. Another aspect of this concept is to improve the self-defense capabilities of the SSN by developing new attack munitions that fit into decoy dispensers rather than taking up a torpedo tube. "This imperative will fundamentally shift the paradigm for US submarine operations from 'alone and unafraid' to 'it's all about team,'" the authors write.

The EW community shares a lot of parallels with the undersea warfare community, and both could learn a lot from each other. EW doesn't exist in a bubble. Sometimes our strength is realized by looking beyond EW and seeing it in the context of other missions and concepts. – *J. Knowles*

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Calendar *Conferences & Trade Shows*

NOVEMBER

Dubai Airshow
Nov. 12-16
Dubai, UAE
www.dubaiairshow.aero

NATO Sub-Group 2 (SG/2) Meeting on EW Protection Measures for Joint Services Airborne Assets
November 13-17
Shrivenham, UK
www.cranfield.ac.uk

MILIPOL Paris
Nov. 14-17
Paris, France
www.milipol.com

Expodefensa
Nov. 27-29
Bogota, Colombia
www.expodefensa.com.co

Interservice/Industry Training, Simulation and Education Conference (I/ITSEC
Nov. 27 – Dec. 1
Orlando, FL
www.iitsec.org

Electronic Warfare Symposium
Nov. 28-29
Shrivenham, UK
www.cranfield.ac.uk

DECEMBER

40th International T&E Symposium
Dec. 5-7
Destin, FL
www.itea.org

AOC 2023
Dec. 11-13
Washington, DC
www.crows.org

FEBRUARY

Singapore Airshow
February 20-25
Singapore
www.singaporeairshow.com

Electromagnetic Warfare Symposium
February 27-28
Shrivenham, UK
www.cranfield.ac.uk

MARCH

Collaborative EW Symposium
March 12-14
Point Mugu, CA
www.crows.org

Dixie Crow Symposium 48
March 24-27
Warner Robins, GA
www.dixiecrowsymposium.org

APRIL

AOC CEMA Conference
April 30 – May 2
Aberdeen Proving Ground, MD
www.crows.org

MAY

Defense Services Asia (DSA)
May 6-9
Kuala Lumpur, Malaysia
www.dsaexhibition.com

EW Capability Gaps and Enabling Technologies
May 7-9
Crane, IN
www.crows.org

AOC Europe
May 13-15
Oslo, Norway
www.crows.org

JUNE

Cyber/EW Convergence Conference
June 4-6
Charleston, SC
www.crows.org

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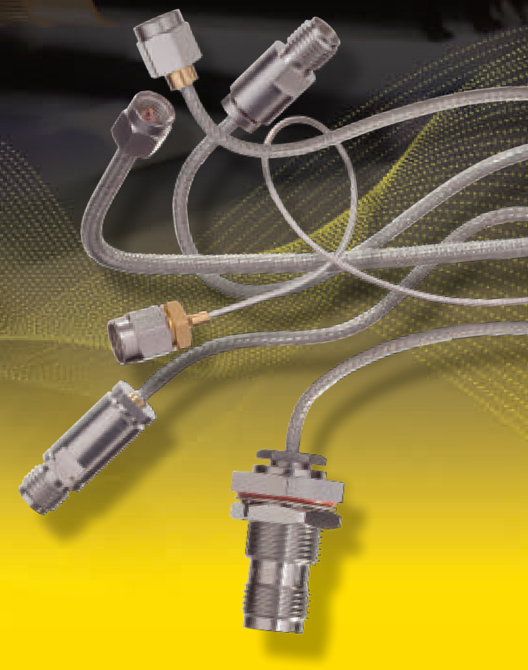

Calendar *Courses & Seminars*

NOVEMBER

AOC Live Web Course: Principles of ESM Analysis
Nov. 6-29
6 Session, 3 hrs. each
www.crows.org

IR Countermeasures
Nov. 7-10
Atlanta, GA
www.pe.gatech.edu

AOC Virtual Series Webinar: Update: Small Unmanned Aircraft Systems (sUAS) – Current Uses and Potential
Nov. 9
2-3 p.m. EDT
www.crows.org

DE Systems Symposium
Nov. 13-17
Monterey, CA
www.deps.org

Radar Principles
Nov. 13-17
Shrivenham, UK
www.cranfield.ac.uk

SIGINT Fundamentals
Nov. 14-15
Lake Buena Vista, FL
www.pe.gatech.edu

Test and Evaluation of RF Systems
Nov. 14-16
Lake Buena Vista, FL
www.pe.gatech.edu

Sensor Fusion: Architectures, Algorithms and Applications
Nov. 20-29
Shrivenham, UK
www.cranfield.ac.uk

AOC Virtual Series Webinar: Advances in Microwave Photonics for EW Systems
Nov. 30
2-3 p.m. EDT
www.crows.org

DECEMBER

EW Data Analysis
Dec. 5-6
Atlanta, GA
www.pe.gatech.edu

Test and Evaluation of RF Systems
Dec. 5-7
Online
www.pe.gatech.edu

JANUARY

Radar EW
Jan. 8-12
Shrivenham, UK
www.cranfield.ac.uk

Survivability
Jan. 8-12
Shrivenham, UK
www.cranfield.ac.uk

M&S of Phased Array Antennas
Jan. 23-25
Online
www.pe.gatech.edu

FEBRUARY

Radar Cross Section Reduction
Feb. 5-7
Atlanta, GA
www.pe.gatech.edu

Basic RF EW Concepts
Feb. 6-8
Shalimar, FL
www.pe.gatech.edu

Communications EW
Feb. 19-23
Shrivenham, UK
www.cranfield.ac.uk

Advanced RF EW Principles
Feb. 26 - Mar. 1
Atlanta, GA
www.pe.gatech.edu

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ADVOCACY AND OUTREACH

Over the past year, AOC has continued to make steady progress on the four main tenets of AOC's Five-Year Strategy: 1. enhancing EW advocacy face-to-face with military, industry, academia and government leaders with an aggressive call plan; 2. growing our membership and building even greater return on investment for members and sponsors; 3. creating more networking opportunities to allow you to take full advantage of the tremendous expertise and experience in our community; and 4. enhancing education programs and opportunities that accelerate the professional development, knowledge and expertise of you – the future of our Association.

As part of AOC's advocacy and outreach efforts, I have participated in several events over the past few months, including a panel at the Air and Space Forces Association 2023 Air, Space & Cyber Conference to discuss EW as a cross-cutting operational enabler of the Air Force operational imperatives; the AOC/Missile and Space Intelligence Center (MSIC) Surface-to-Air Missile Systems Conference; the AOC Australia EW Conference highlighting AUSUK EW/EMSO and Cyber challenges; and the 12th Annual Pacific IO & EW Symposium. Fellow board member Greg Patschke also attended the South Korean EW Conference. AOC Chapters are clearly active across the globe and the Board will continue to get out to beat the EW drum!

The worldwide demand for EW/EMSO capabilities continues due, in part, to the war in Ukraine, conflict in the Middle East, increasing tension in the Western Pacific – and we are cautiously optimistic that military and government leaders across the globe are showing awareness of EMSO's importance. USSTRATCOM, for example, recently appointed Brig Gen AnnMarie Anthony as director of the newly established Joint EMSO Center (JEC), the heart of the DOD's EMSO focus with the primary goal of restructuring accounts for force management, planning, situation monitoring, decision-making and force direction. At the July ceremony establishing the JEC, USSTRATCOM Commander Gen Anthony Cotton stated, "Today is about moving forward. It's about implementing a strategy that will advance and protect US strategic advantages in the electromagnetic spectrum – advantages that are critical for our nation's defense and security."

Our association will remain vigilant and continue to inform military and government leaders and advocate for EMSO priorities. As pointed out in my May column, we've heard leadership "talk the talk" before – unfortunately with minimal follow-through funding. It's now past the time to "walk the walk." Service budgets will indicate how well leadership recognizes the EMS as *the* critical enabler for every platform and weapon system. Regardless, you can be sure that your AOC will remain aggressive about informing leaders and highlighting the game-changing value of EW in national security. As a Crow, you can be very proud of the role you play in providing this critical enabler to mission success.

I hope you are making plans to attend AOC 2024 next month, because judging from the numbers of individual members, corporate sponsors and vendors who have already registered, this year promises to be one of our largest, if not the largest AOC Symposium ever. I hope to see you there! – *Brian "Hinks" Hinkley*

ASSOCIATION OF OLD CROWS

Association of Old Crows
1001 N. Fairfax St., Suite 300
Alexandria, VA 22314
Phone: (703) 549-1600
Fax: (703) 549-2589

UK GEARS UP TO LAUNCH COMPETITION FOR NEW TACTICAL CEMA CAPABILITY

The UK Ministry of Defence (MOD) is preparing to launch a competition for the provision of a new tactical cyber and electromagnetic activities (CEMA) capability for the British Army. Estimated to be worth up to £148 million, the eight-year program – known as Project Poynting – is designed to deliver and support equipment sufficient to field a squadron-sized CEMA unit. The intention is to source through a single UK prime who will establish and manage an "ecosystem" of suppliers to deliver both hardware and software and manage system integration of the CEMA capability.

CEMA is defined by the MOD's Development, Concepts and Doctrine Centre (DCDC) as the "synchronisation and coordination of offensive, defensive, inform and enabling activities across the electromagnetic environment and cyberspace." According to the DCDC, the intention is that CEMA capability should "enable freedom of movement and effects, whilst simultaneously, denying and degrading adversaries' use of the electromagnetic environment and cyberspace."

The MOD intends that Project Poynting "will deliver a first-in-class tactical CEMA capability to land forces." It added that the project is "aligned with the Army Executive Committee-endorsed Army Cyber Sub-Strategy and is to be delivered as part of the Land CEMA Programme.

The MOD estimates the initial four-year core contract for Project Poynting to be worth around £78 million. The higher £148 million estimate represents a value inclusive of four option years, plus additional "capability" interventions to grow the CEMA capability in line with technology change and threat evolution.

The scope-of-support requirement includes but will not be limited to, equipment design, installation, repair and maintenance, spares provisioning, test and validation, experimentation and capability evolution, design safety, contractor logistics support, security accreditation, capability resilience, reliability, documentation management and through-life updates and upgrades. Additional ad-hoc tasking may include repairs, post-design services and the procurement of additional systems, components, spares and support.

Sources have suggested that up to three candidate primes will be shortlisted following an evaluation of responses to a pre-qualification questionnaire. An invitation to negotiate is planned for issue in early 2024, with the MOD currently looking to award a contract in March 2025. – *R. Scott*

NORTHROP GRUMMAN DOWNSELECTED FOR STAND-IN ATTACK WEAPON DEVELOPMENT

Northrop Grumman has been funded to develop and demonstrate a next-generation Stand-in Attack Weapon (SiAW) for the US Air Force (USAF).

Under a $705 million Phase 2 firm fixed-price contract awarded by the Air Force Life Cycle Management Center, the company will develop the new strike weapon, conduct platform integration and complete flight testing over a 36-month period. L3Harris and Lockheed Martin, which had received Phase 1 funding alongside Northrop Grumman, both elected to opt out of SiAW Phase 2 pursuit.

Designed for integration on the fifth-generation F-35A Lightning II strikefighter, SiAW is a high-speed air-to-ground weapon that will provide strike capability to defeat rapidly relocatable targets forming part of an adversary's anti-access/area denial (A2/AD) network. The missile will incorporate multimode guidance – including an anti-radiation homing channel – to enable it to prosecute a broad A2/AD threat set including air defense systems, ballistic missile launchers, cruise missile launchers, GPS jamming platforms and anti-satellite systems.

Northrop Grumman has employed a CRJ-700 testbed to conduct flight trials of a multimode sensor suite and mission computer intended to meet SiAW requirements. NORTHROP GRUMMAN

The Air Force is targeting an initial operational capability by the end of 2026. Northrop Grumman has previously said that its tail-controlled SiAW solution – leveraging from the US Navy's AGM-88G Advanced Anti-Radiation Guided Missile

- Extended Range (AARGM-ER) missile – will deliver "desired weapons employment ranges against current and evolving threats" and support "strike aircraft weapon delivery from sanctuary."

Northrop Grumman is completing development of AARGM-ER for the US Navy. Ahead of realizing the full SiAW capability, the USAF is moving forward with the integration of a modified AARGM-ER on the F-35A as a stopgap interim combat capability. Additional capabilities required by the Air Force include a new warhead/fuze and F-35 integration (including Universal Armament Interface and Mission Planning).

SiAW has been held up as a groundbreaking Middle Tier Acquisition (MTA) large weapon program designed to implement tenets of a weapon system open architecture (WOSA), agile software development and model-based systems engineering (MBSE). The expectation is that a digital engineering environment will improve the development cycle time of the missile, while implementation of a WOSA will enable rapid future upgrades.

Under this MTA approach, L3Harris, Lockheed Martin and Northrop Grumman in August this year completed parallel Phase 1 activities. These culminated in the demonstration of open architecture digital designs at a preliminary design review-like event in an MBSE environment.

Northrop Grumman will deliver Phase 2 development in two primary increments: Phase 2.1 will conclude with a guided vehicle flight test; Phase 2.2 will conduct three additional flight tests and deliver SiAW leave-behind prototype missiles and test assets in preparation for rapid fielding. Work will be performed at the company's Northridge, Calif., facility and its missile integration facility at Allegany Ballistics Laboratory in Keyser, W.Va.

According to the Air Force, the SiAW program is planned to transition to a major capability acquisition in Phase 3 (post-MTA). This will cover full integration on the F-35A and further capability improvements. Prior to Phase 1 of SiAW, Northrop Grumman had in late 2021 begun self-funded flight trials of a multimode sensor suite and mission computer intended to meet SiAW objectives. These tests, performed using a company-owned CRJ-700 flying laboratory, were performed to de-risk and demonstrate key technologies in a representative environment. In July 2022 Northrop Grumman disclosed that it had completed further testing at Naval Air Warfare Center Weapons Division China Lake to validate the capability of the captive missile prototype to identify and discriminate modern air-defense systems and track targets. – *R. Scott*

NORWAY'S ARMY TAKES DELIVERY OF EW AND SIGINT CAPABILITY

Rohde & Schwarz (Munich, Germany) has begun to deliver new land electronic warfare (EW) systems to the Norwegian Army under the project name Heimdall.

The first increment of a three-phase recapitalization program, Heimdall will provide the Army's Intelligence Battalion with a mobile communications-band electronic surveillance capability to replace its legacy Munin 2 systems. According to Rohde & Schwarz, Heimdall will enable the Norwegian Army to detect, locate and analyze information faster in order to gain information superiority and situational awareness. Equipment deliveries commenced in June 2023.

The two further increments will follow during 2024. The first of these, known as Fåvne, will deliver an electronic attack capability in the spring of next year.

This will be followed later in 2024 by Einherjer. This will provide a capability for EW in support of the army's maneuver elements. – *R. Scott*

IN BRIEF

The US Army's Program Executive Office for Intelligence, Electronic Warfare and Sensors (PEO IEW&S) has selected **Mastodon Design LLC** (a CACI business) to begin development of its Terrestrial Layer System – Brigade Combat Team (TLS-BCT) Manpack variant. The 9-month contract, valued at $1.5 million, cover Phase 1 - Prototype Build and Demonstration. The program is being conducted an Other Transaction Authority (OTA) vehicle via the Consortium for Command, Control, and Communications in Cyberspace (C5). According to a PEO IEW&S statement, the TLS BCT Manpack system, which will complement the larger TLS BCT and TLS Echelons Above Brigade (TLS EAB) family, will be a "tailorable, modular, terrestrial capability that allows the integration of Signals Intelligence and Electromagnetic Warfare collection, processing, exploitation, reporting, and effects capabilities for SIGINT Collection Team and Electromagnetic Warfare Team elements." It added that PM Electronic Warfare and Cyber plans to transition the TLS BCT Manpack from prototyping to production in FY2024.

The UK's **MBDA** announced it has received funding from the UK MOD to "accelerate the development of the SPEAR-EW stand-in jammer," according to a statement from the company. It said the additional Rapid Design Phase funding will accelerate SPEAR-EW's development, maturing all its key sub-systems, and perform mission and planning evaluation. The SPEAR-EW jamming payload, which includes a digital RF memory capability, is being developed by **Leonardo.**

BAE Systems Hägglunds awarded a $109 million contract to Israel's **Elbit Systems** to provide its Iron Fist active protection system (APS) on BAE's CV90 Infantry Fighting Vehicles. The end user is believed to be the Slovakian Army, which ordered more than 150 CV90s in late 2022.

Verus Research (Albuquerque, N.M.) won a $17.8 million contract from the US Army for the Electronic Warfare (EW) Testing at Military Laboratories - Modular Open-systems Reconfigurable Architecture for Laboratory-based Electronic-warfare co-emulationS (MORALES) Prototype Project. The project is part of a larger effort to mitigate the impact of government 5G spectrum sell-offs on open-air testing at military test facilities. Under the contract, the company will identify which open air test systems are being affected the loss of this spectrum and developing new digital instrumentation to support direct RF injection testing of EW systems. The award was made on behalf of the Department of Defense (DoD) Test Resources Management Center (TRMC) Test and Evaluation (T&E)/Science and Technology (S&T) Program through the Training and Readiness Accelerator (TReX) consortium.

Teledyne Defense Electronics (Ranch Cordova, Calif.) received a $37.6 million contract from the Air Force Sustainment Center (Robins AFB, Ga.) to repair traveling wave tube components for the ALQ-131, -161,and -172 EW systems in service with Air Force F-16, B-1B and B-52 aircraft, respectively. Approximately $3.1 million of the funds are designated for TWTs in ALQ-131 systems on F-16s in service with air forces in Romania, Bahrain, Egypt, Thailand, Jordan, Netherlands, and Portugal.

Naval Sea Systems Command (NAVSEA), **Program Executive Office Undersea Warfare Systems (PEO UWS),** has issued a Request for Information to identify potential sources for its Submarine Tethered Expendable Buoy (STEB) system. According to the RFI, the STEB system will provide "a submerged submarine with a surface buoy platform for communications, situational awareness and collision avoidance data. It will provide data to feed a real-time operator interface and display console within the AN/BLQ-10 system and would reduce the risk of counter detection by allowing the submarine to stay submerged while it provides situational awareness related to imaging, communications, and electronic warfare data." Responses are due by November 3. The point of contact is Sydney Cline, +1 (202) 677-8237, e-mail sydney.m.cline.civ@us.navy.mil. The solicitation number is N0002424R6230.

Hawkeye360 (Herndon, Va.), a provider of satellite-based RF emitter data, received a $12.3 million contract option from the Naval Information Warfare Center Pacific (San Diego, Ca.) for commercial RF data and analytics subscription products, analytical support, and training. The work will support counter-narcotic operations for Indonesia, Malaysia, Philippines, and Thailand.

Naval Air Systems Command (NAVAIR) awarded a $55 million contract to **CAES** (Lansdale, Pa.) to produce up to 54 Low Band Consolidation (LBC) Transmitters for the US Navy's ALQ-99 Tactical Jamming System pods on the EA-18G Growler. The LBC Transmitters replace legacy Low-Band Transmitters (LBTs) on the ALQ-99 and will utilize the TJS Band 4 antenna. Deliveries are scheduled to begin in 4Q FY2025.

The Defense Advanced Research Projects Agency (DARPA), Microsystems Technology Office, has issued a Broad Agency Announcement (BAA HR001123S0051) for development of Ultra-Wide BandGap Semiconductor (UWBGS) technologies. According to the BAA, DARPA seeks "innovative proposals to develop foundational ultra-wide bandgap (UWBG) materials (substrate, device layers, and junctions) and low resistance electrical contacts necessary for realization of devices that enable UWBG applications. In particular, DARPA seeks proposals in the following areas: 1) low defect density, large area (100 mm diameter), epi-ready, UWBG substrates and 2) uniform, low defect density UWBG device layers with high doping efficiency, abrupt homo- and/or hetero-junctions with low junction defect density (1012/cm^2), and ultra-low resistance electrical contacts (2 x 10-6 ohm-cm^2)." DARPA believes that UWBG materials can support many DOD and commercial applications, "including: high-power radio frequency (RF) switches and limiters and high-power density RF amplifiers for radar and communications systems; high-voltage switches for power electronics; high-temperature electronics and sensors for extreme environments; and deep ultraviolet (UV) light emitting diodes (LEDs) and lasers." The 36-month program will consist of "one technical area (TA1) focused on UWBG substrate development and a second technical area (TA2) focused on UWBG device layers and electrical contacts." The point of contact is Dr. Thomas Kazior, Program Manager, e-mail HR001123S0051@darpa.mil. Proposals are due by December 15.

Northrop Grumman and **Raytheon** each won contracts from DARPA valued at $14.2 million and $14.8 million respectively for the Technologies for Heat Removal in Electronics at the Device Scale (THREADS) program. Under this effort, the companies will develop "technologies to overcome transistor thermal limitations and realize robust high-power density transistors that operate near their fundamental electronic limit of radio frequency (RF) output power," according to a DARPA program description. Specifically, the program will demonstrate "high efficiency, X-band (8-12 GHz) transistors and PA test vehicles whose output stage transistors have an output power density of 81 W/mm; 8X reduction in transistor thermal resistance; and reliable operation with a predicted mean-time-to-failure (MTTF) of 106 hours at 225°C channel temperature." The program will fun for 48 months and deliver at least 20 examples of each type of thermal test structures, multi-finger transistor cells and power amplifier test items/standard evaluation circuits.

SRI International received a $14.4 million contract from DARPA to develop innovative "run-time reconfigurable processors, with the specific goal to develop processors that provide autonomous radiofrequency (RF) systems with decision-directed situational awareness about complex and uncertain electromagnetic environments" under the agency's Processor Reconfiguration for Wideband Sensor Systems (PROWESS) program. DARPA had previously awarded PROWESS contracts to Arizona State University and the University of Southern California.

MetaMagnetics Inc. (Marlborough, Mass.) won an $8.7 million Small Business Innovative Research Contract from Naval Air Warfare Center – Aircraft Division (Lakehurst, N.J.) for "production and delivery of 20 fully matured, environmentally compatible, productized, hybrid auto-tune filter canceller modules, as well as associated engineering, systems integration lab, flight test, and program management support for the MQ-4C Triton Unmanned Aerial Vehicle." The Phase III SBIR award is for work under the topic, "Advanced Signal Processing and Coordination Applied to Electronic Support Measures."

AOC 2023 International Symposium & Convention

60TH ANNIVERSARY

DECEMBER 11–13, 2023
NATIONAL HARBOR, MD

PREVIEW

AOC2023.CROWS.ORG

ASSOCIATION OF OLD CROWS

Theme

ADVANCING EMS SUPERIORITY THROUGH STRATEGIC ALLIANCES AND PARTNERSHIPS

JOIN US for three full days of informative and engaging keynote sessions, breakout discussions, and tech talks at AOC's Annual International Symposium & Convention. This leading event for electronic warfare, electromagnetic spectrum operations, cyber-electromagnetic activities, and information operations professionals worldwide is taking place this December.

- **STRENGTHEN** your knowledge and skills on current and relevant topics to the EMSO community with informative sessions led by subject-matter experts.
- **ENGAGE AND CONNECT** with hundreds of stakeholders, thought leaders, and experts in the industry to expand your global network.
- **DISCOVER** cutting-edge technologies and solutions to help gain your advantage in the field with a packed show floor with 165+ exhibiting companies.

AOC 2023 is the industry's leading, three-day event, bringing together nearly 2,500 professionals from 30+ countries spanning industry, military, and government sectors.

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FEATURED KEYNOTE & SPOTLIGHT SPEAKERS

Vice Admiral Craig A. "Clap" Clapperton
Commander, Fleet Cyber Command/
Commander, TENTH Fleet

Lieutenant General Matthew Glavy
Deputy Commandant for Information
USMC

Vice Admiral
Stephen T. "Web" Koehler
Director for Strategy, Plans and Policy, J5, Joint Staff/Senior Member, Navy, United States Delegation to the United Nations Military Staff

Lieutenant General (Ret) Lance Landrum
Former 23rd Deputy Chair of The North Atlantic Treaty Organization (NATO) Military Committee

Vice Admiral Francis Morley
Principal Military Deputy Assistant Secretary of the Navy (Research, Development and Acquisition)
Navy

Learn from Experts in the Field

Whether a main-stage keynote speaker or a breakout session panelist, AOC 2023 will deliver up-to-date information from subject-matter experts and influencers from the military, government, academia, and industry.

Dive into sessions that interest you most with a packed agenda of informative sessions catered to all industry professionals, no matter the experience level.

BROWSE THE FULL AGENDA AT AOC2023.CROWS.ORG

Schedule At-A-Glance

Sunday, December 10

- **1:00 – 6:00** — **On-site Registration Open**
  (Badge Pick-up and Registration)
  Ballroom Level Pre-Function Area
- **6:00 – 9:00** — **Welcome Reception**
  POSE Rooftop Lounge
  Sponsored by L3Harris

Monday, December 11

- **7:00 – 6:00** — On-site Registration Open
- **7:30 – 8:30** — Morning Coffee
- **8:00 – 10:00** — Opening Keynote Session
- **10:00 – 6:00** — Exhibit Hall & Crows' Nest Open
- **11:30 – 1:00** — Lunch
- **1:00 – 2:00** — Spotlight Session
- **2:30 – 4:00** — Breakout Session - JADC2
- **2:30 – 4:00** — Technical Briefings
- **2:30 – 4:00** — Program Manager Briefing Series - Army Programs
- **4:30 – 6:00** — Exhibit Hall Happy Hour

As of October 11, 2023. Subject to change.
All events occur at Gaylord National Resort & Convention Center.

Schedule At-A-Glance

Tuesday, December 12

- 7:00 – 6:00 — On-site Registration Open
- 7:30 – 8:30 — Morning Coffee
- 8:00 – 9:45 — Keynote Session
- 9:45 – 6:00 — Exhibit Hall & Crows' Nest Open
- 10:00 – 11:30 — Breakout Session – Unlocking DoD Open Systems Architecture (OSA)
- 10:00 – 11:30 — Breakout Session - EMSO Warfighting Opportunities
- 10:00 – 11:30 — Program Manager Briefing Series - Air Force Programs
- 11:30 – 1:00 — Lunch
- Noon
- 12:30 – 2:00 — Breakout Session: Advancing EMS Superiority
- 12:30 – 2:00 — Breakout Session: Space EW
- 2:30 – 4:00 — Breakout Session: Acquisition in Support of EMSO
- 2:30 – 4:00 — Breakout Session: Cognitive/AI/ML T&E Fight Club
- 2:30 – 4:00 — Technical Briefings
- 4:30 – 6:00 — Exhibit Hall Happy Hour

Wednesday, December 13

- 7:30 – 2:00 — On-site Registration Open
- 7:30 – 8:30 — Morning Coffee
- 8:00 – 9:45 — Keynote Session
- 9:45 – 2:00 — Exhibit Hall & Crows' Nest Open
- 10:00 – 11:30 — Technical Briefings
- 10:00 – 11:30 — Breakout Session: Disruptive Electromagnetic Operations
- 11:30 – 1:00 — Lunch
- Noon – 1:30 — Breakout Session: Multi-National EW Partnership
- Noon – 1:30 — Program Manager Briefing Series - Navy Programs
- 2:00 – 3:30 — Closing Spotlight Session

BROWSE THE FULL AGENDA AT AOC2023.CROWS.ORG

Symposium Agenda

Monday, December 11

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

Lieutenant General Matthew G. Glavy, Deputy Commandant for Information, USMC

SPOTLIGHT SESSION | 1:00 - 2:00 PM

SPOTLIGHT SPEAKER:

Vice Admiral Craig A. "Clap" Clapperton, Commander, Fleet Cyber Command/Commander, TENTH Fleet

BREAKOUT SESSIONS | 2:30 - 4:00 PM

JADC2

Explore the history, evolution and future of JADC2, acknowledging that it is but the latest strategy incarnation in a joint all-domain capstone concept genealogy that has variously included Information Operations (IO), Multi-Domain Operations (MDO), Information Warfare (IW), Information Dominance, Operations in the Information Environment (OIE), Cyber-EW Convergence and the Combat Cloud.

SESSION MODERATOR:

Lt Gen David Deptula, USAF (Ret), former Deputy Chief of Staff for Intelligence, Surveillance and Reconnaissance, Headquarters U.S. Air Force (HAF/A2) and current Dean of the Mitchell Institute for Aerospace Studies

SESSION PANELISTS:

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

Mr. Nick Freije, SES, Assistant Chief Engineer for Mission Architecture, Naval Information Warfare Systems Command (NAVWARSYSCOM)

TECHNICAL BRIEFINGS | 2:30 - 4:00 PM

SESSION MODERATOR:

Mr. Jeff "Squeel" Kawada, EW Operations/Portfolio Analyst, OUSD (A&S), SPA Inc.

TECHNICAL SESSION PRESENTERS AND TITLES:

Enabling Access: Space-Based Radar Geolocation/Detection for New Audiences in EW

Mr. Josh Chavez, Product Manager, HawkEye 360

Direct RF FPGAs with Integrated 64 Gsps Data Converters

Mr. Benjamin Esposito, Senior Principal Engineer, Radar/EW Systems Architect, Intel Programmable Solutions Group

Addressing the Complexities of Electronic Warfare for Future Operating Environments

Mr. "Mark "Ernie" Gombo, Director, Mission Specialist, Defense Business Unit (DBU), Microsoft

Mr. Dustan Hellwig, Founder/Chief Strategy Officer, CTI

Mr. Michael DiMeo, Lead systems engineer for Space and Airborne Systems, L3Harris

PROGRAM MANAGER BRIEFING SERIES – ARMY | 2:30 - 4:00 PM

SESSION MODERATOR:

Mr. Mike Ryan, AOC Board of Director

SESSION PRESENTERS:

Mr. Ken Strayer, Project Manager, Electronic Warfare & Cyber

Mr. Dennis Teefy, Project Director, Sensors Aerial Intelligence

COL Brock Zimmerman, Project Manager, Aircraft Survivability Equipment

COL Gary Brock, Army Capabilities Manager, Electronic Warfare

LTC Nicholas Ryan, Army Capabilities Manager, Unmanned Aircraft Systems

Symposium Agenda

Tuesday, December 12

KEYNOTE SESSION | 8:00 - 9:45 AM

Vice Admiral Stephen T. "Web" Koehler, Director for Strategy, Plans and Policy, J5, Joint Staff/Senior Member, Navy, United States Delegation to the United Nations Military Staff

BREAKOUT SESSIONS | 10:00 - 11:30 AM

UNLOCKING DOD OPEN SYSTEMS ARCHITECTURE (OSA)

This breakout session will examine the current state of incorporation of DoD Open Systems Architecture (OSA) standards into weapons and capability development through the acquisition-oriented lenses of implementation, integration, operationalization and sustainment. Leaders from the DoD and Military Services – informed by international and industry partners will highlight successes, best practices, and examples of realized benefits. We will also promote a dynamic conversation with the audience regarding significant challenges including barriers to adoption and business model concerns. *The OSA breakout will also feature a unique live CMOSS/SOSA capability demonstration.*

SESSION MODERATOR:

Mr. Daniel Hettema, Director, Digital Engineering, Modeling & Simulation (DEM&S) for OUSD (R&E)

SESSION PRESENTERS:

Mr. Christopher Garrett, SES, Technical Advisor, Systems Engineering, US Air Force Life Cycle Management Center (AFLCMC)

Ms. Susan J. DeGuzman, SES, Director, Airworthiness and CYBERSAFE Office (ACO), US Navy Naval Air Systems Command (NAVAIR)

Mr. Seth Spoenlein, SSTM, Assistant Director, Systems Integration Portfolio, Engineering and Systems Integration (ESI) Directorate, US Army Combat Capabilities Development Command (DEVCOM) C5ISR Center

Mr. Jason Dirner, MOSA Chief Engineer, MOSA Management Office , Engineering & Systems Integration (ESI) Directorate, US Army DEVCOM C5ISR Center

EMSO WARFIGHTING OPPORTUNITIES

Join us for a dynamic and insightful session on Electromagnetic Spectrum Operations (EMSO) Warfighting Development, where we delve into the cutting-edge strategies, technologies, and tactics shaping modern military operations. As the electromagnetic spectrum becomes an increasingly vital and contested domain, this session will explore the essential role it plays in enhancing situational awareness, communication, electronic warfare, and overall mission success.

PROGRAM MANAGER BRIEFING SERIES – AIR FORCE | 10:00 - 11:30 AM

SESSION MODERATOR:

Ms. Lisa Fruge-Cirilli, AOC Past President

SESSION PRESENTERS:

Col Josh Koslov, Commander, 350th SWW

Col Leslie Hauck, Director, EMS Superiority Directorate, HAF A2/6L

Lt Col Marc Lewis, SML, AFLCMC/WNY System Program Office

Mr. Michael Dostie, Chief Engineer, AFLCMC/WNY

Col Albert "Fonz" Scaperotto, Chief, Weapons Division; SAF/IA

Symposium Agenda

Tuesday, December 12

BREAKOUT SESSIONS | 12:30 - 2:00 PM

ADVANCING EMS SUPERIORITY

This session will address the theme of Advancing EMS Superiority Through Strategic Alliances and Partnerships. The session will feature introductory remarks by Gen Anthony, a compelling look at the mission — rather than the strategy or architecture— side of JEMSO from the perspective of leaders and practitioners from the JEWC, JCER and JEMSO Cells (JEMSOCs), and a generous opportunity for audience Q&A on issues related to the JEMSO enterprise, capability gaps, emerging capabilities, TTPs, training, and policy.

SESSION MODERATOR:

Col William "Dollar" Young, (USAF, Ret) PhD, Disruptioneering Expert, SCASD Consulting, Former Commander, USAF 350th Spectrum Warfare Wing (350 SWW)

SESSION PANELISTS:

Air Commodore Blythe Crawford, Commandant, UK Air & Space Warfare Centre (ASWC)

Gen Stephen Wilson (USAF, Ret), Former Vice Chief of Staff of the Air Force (VCSAF)

Maj Gen David Gaedecke (USAF, Ret), Former Vice Commander, Sixteenth Air Force

SPACE EW

In an increasingly interconnected and data-driven universe, the domain of space has become a pivotal arena for electronic warfare (EW). This captivating session delves into the intricate world of Space EW, where cutting-edge technologies and strategic maneuvers are employed to gain the upper hand in the cosmic battlefield.

SESSION MODERATOR:

Mr. Nino Amoroso, At Large Director, Association of Old Crows

SESSION PRESENTERS:

Dr. Eliahu Niewood, VP Air and Space Forces, MITRE

Dr. Mark Wharton, CTO, Georgia Tech Research Institute

BREAKOUT SESSIONS | 2:30 - 4:00 PM

ACQUISITION IN SUPPORT OF ELECTROMAGNETIC SPECTRUM OPERATIONS

In today's environment where both technology and near peer competitors continue to advance at an accelerated pace, streamlined acquisition policy and processes are crucial to delivering relevant capabilities to our Warfighters. This session delves into new "adaptive acquisition" pathways, approaches and methods to contract at the speed of relevance and provides recent examples of how programs have implemented new acquisition strategies that will allow the DoD to continue to dominate in the electromagnetic spectrum.

COGNITIVE/AI/ML T&E FIGHT CLUB

Join us for this moderated open forum on the future of AI/ML-enabled electromagnetic warfare (EW) to air out the many active disagreements on topics such as the definition of cognitive EW and digital twins, verification & validation vs. accreditation, the future of reprogramming and operational testing, and more.

Session Presenters:

Mr. Brandon Stringfield, Research Scientist & Cognitive EW T&E Portfolio Lead, GTRI + Tetra

Mr. John Rafferty, Research Scientist, GTRI + Tetra

Symposium Agenda

Tuesday, December 12

TECHNICAL BRIEFINGS | 2:30 - 4:00 PM

SESSION MODERATOR:

Mr. Matt Thompson, Senior Technical Advisor, Association of Old Crows

TECHNICAL SESSION PRESENTERS AND TITLES:

Generative AI in the EMSO

Mr. Scott Kuzdeba, Chief Scientist, BAE Systems

Advances in RF Machine Learning Applied to Electromagnetic Spectrum Operations

Mr. Eric Lentz, EW / RF / ML Systems Engineering, Expedition Technology

Electronic Warfare in a World Populated by Metasurfaces

Dr. Rafael Licursi, Senior RF Antenna Research Engineer, Greenerwave

Wednesday, December 13

KEYNOTE SESSION | 8:00 - 9:45 AM

Vice Admiral Francis Morley, USN, Principal Military Deputy Assistant Secretary of the Navy (Research, Development and Acquisition)

Lieutenant General (Ret) Lance Landrum, Former 23rd Deputy Chair of The North Atlantic Treaty Organization (NATO) Military Committee

BREAKOUT SESSIONS | 10:00 - 11:30 AM

DISRUPTIVE ELECTROMAGNETIC OPERATIONS

Whether you're a seasoned military professional, a technologist, or a policymaker, this session promises to be a captivating journey into the world of disruptive electromagnetic operations. Expand your horizons, engage in thought-provoking discussions, and grasp the transformative potential of harnessing the electromagnetic spectrum as a tool for strategic influence and disruption.

SESSION MODERATOR:

Mr. Dennis Monahan, Regional Director, Association of Old Crows

SESSION PRESENTERS:

Mr. Zachary George, International Market Development Manager, CRFS Ltd.

Dr. Frank E. Peterkin, Principal Director for Directed Energy, Office of the Under Secretary of Defense for Research and Engineering (OUSD (R&E))

Mr. Andreas Roessler, 6G Technology Manager, Rohde & Schwarz

Lt. Gen. John N.T. "Jack" Shanahan, Director, Joint Artificial Intelligence Center, USAF

MULTI-NATIONAL EW PARTNERSHIP

In an increasingly interconnected world, collaboration between nations has become pivotal to address complex global challenges. This session delves into aspects for achieving EMS superiority through partnership, international cooperation and operational collaboration on EW. Join us for an insightful exploration of how multi-national partnerships on EW contribute to the broader landscape of international security.

SESSION MODERATOR:

Mr. Erik Bamford, International Director, Association of Old Crows

SESSION PRESENTER:

Col Josh Koslov, Commander, 350th SWW

Symposium Agenda

Wednesday, December 13

TECHNICAL BRIEFINGS | 2:30 - 4:00 PM

SESSION MODERATOR:

Mr. Jeff "Squeel" Kawada, EW Operations/Portfolio Analyst, OUSD (A&S), SPA Inc.

TECHNICAL SESSION PRESENTERS AND TITLES:

Lightweight Shielding Solutions for Platforms and Systems

Dr. Nate Hansen, Dale M. Jensen Professor of Computing, University of Nebraska-Lincoln

Wideband Dynamic Adversary Activity Detection and Classification in Wireless Spectrum

Dr. Mehmet Vuran, CEO, Conductive Group / Electromagnetic Security Consortium

Future Force Design RNLN: Littoral Shaping Operations in a Denied Environment

LCdr (OF-3) R. (Rick) Brekelmans MSc, Maritime Warfare Centre Royal Netherlands Navy

PROGRAM MANAGER BRIEFING SERIES – NAVY | 12:00 - 1:30 PM

SESSION MODERATOR:

Dr. James Stewart, Chief Scientist, Spectrum Warfare Systems, NSWC Crane

SESSION PRESENTERS:

CAPT Dave Reuter, Program Manager, NAVAIR PMA-234 (AEA)

Col Tamara Campbell, USMC, Program Manager, PMA-272, Advanced Tactical Aircraft Protection Systems, PEO(T)/ NAVAIR

CLOSING SPOTLIGHT SESSION | 1:00 - 2:00 PM

EMSO IN UKRAINE AND RUSSIA WAR

Get updated on the EMSO in the Russia-Ukraine War - Join us for an update on the battle for EMS superiority and the impact on progress in the War in the Ukraine. The EMSO situation on the battlefield in the Ukraine have been addressed at AOC symposiums and conferences dating back to 2016. Speakers have provided the symposium audiences with formidable insight on Russian EW, Russian wireless C2 capabilities, and the impact of EMSO on the modern battlespace. Use this opportunity to get updated once again so that you can learn from those at the front, and in so stay relevant.

SPOTLIGHT SPEAKER:

Major General Borys Kremenetskyi, UKR-Air Force & Defense Attache, Embassy of Ukraine to the USA

About the Show

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To use our customizable letter and get approval to attend, go to crows.org/2023JustificationLetter.

PODCAST

Our "From the Crows' Nest" podcast host, Ken Miller, will be recording episodes with special guests from a studio on the show floor during the event. Start listening now and be sure to subscribe to get these episodes right from the show.

Find out more at crows.org/podcasts.

SCAN ME

Hall Happenings

At the center of our bustling exhibit hall is the AOC Crows' Nest! Open during official show hours, the Crows' Nest has lounge areas for attendees to relax and network. It is also the site of the AOC membership area and store, AOC Sales Office, raffles, silent auction, JED desk, device charging stations, and coffee service.

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2023 10′ x 10′ Exhibitor Booth Rates

Member fee*	$6,200
Non-member fee	$6,700

**Company must be a corporate member.*

To view the current floorplan, visit **crows.org/2023floorplan**.

Please contact Sean Fitzgerald at **Fitzgerald@crows.org** or at **703-549-1600,** ext. 222, to book your booth space.

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As a sponsor or advertiser, your brand will be elevated at AOC 2023 beyond your standard booth footprint. We offer various level packages as well as event specific options and tailored branding packages. Act quick for the last remaining opportunities available.

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Host Sponsorship receives ten Master Pass registrations, access to the Program Manager Briefing Series, exclusive sponsor of the Crows' Nest, your company name and logo prominently displayed on event promotional materials, signs, brochures, convention website and similar marketing venues, as well as a full-page, four-color display ad in the official on-site program (outside back cover). Additionally, the Host Sponsor receives the unique benefits of being the sponsor of the annual Welcome Reception, as well as a brief welcome address by a company representative during the opening keynote session of the symposium. The Host Sponsor will receive a seat on the event planning committee. *Host Sponsorship does not include exhibit space and may only be reserved by exhibitors with a minimum of 200 square feet of contracted space.*

PLATINUM SPONSORSHIP — $25,000

Platinum Sponsorship receives four Master Pass registrations, access to the Program Manager Briefing Series, your company name and logo prominently displayed on event promotional materials, signs, brochures, convention website and similar marketing venues, as well as a full-page, four-color display ad in the official on-site program. Platinum sponsors are co-sponsors of lunch in the exhibit hall each day. *Platinum Sponsorship does not include exhibit space and may only be reserved by exhibitors with a minimum of 200 square feet of contracted space.*

GOLD SPONSORSHIP — $12,000

Gold Sponsorship includes three Master Pass registrations, access to the Program Manager Briefing Series, your company name and logo will be prominently displayed on event promotional materials, signs, brochures, convention website and similar marketing venues as well as a half-page, four-color display ad in the official on-site program. Gold sponsors are co-sponsors of happy hours in the exhibit hall both days.

SILVER SPONSORSHIP — $6,000

Silver Sponsorship entitles your organization to receive two Master Pass registrations, access to the Program Manager Briefing Series, your company name and logo prominently displayed on event promotional materials, signs, brochures, convention website and similar marketing venues as well as a quarter-page, four-color display ad in the official on-site program. Silver sponsors are co-sponsors of symposium coffee each morning.

BRONZE SPONSORSHIP — $3,000

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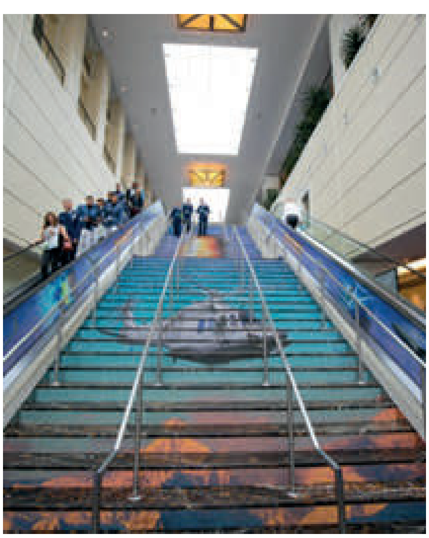

Photo courtesy of AFA

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Aethercomm
Alaris USA
AMD
American Standard Circuits
Ampex Data Systems
Analog Devices
Annapolis Micro Systems, Inc.
Anritsu Company
Antenna Research Associates, Inc.
AOC Europe 2024
ApisSys
Applied Signals Intelligence
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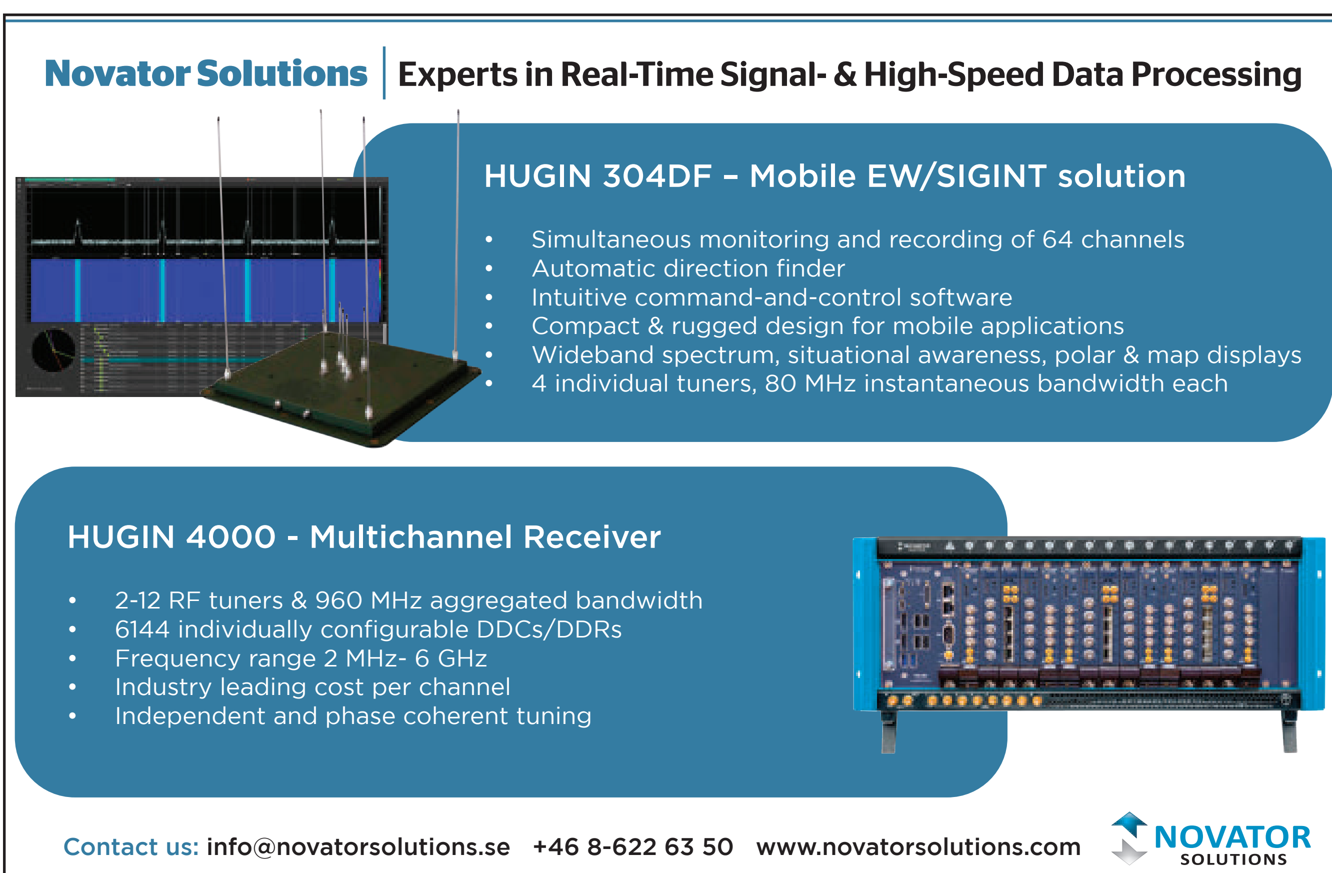
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'I Feel the Need – t

By Richard Scott

The enduring and bloody conflict in Ukraine has provided a timely reminder to practitioners of air power as to the vulnerability of both combat and support aircraft to modern anti-air guided weapons, ranging from man-portable air defense systems to mobile "pop-up" surface-to-air missile (SAM) systems and more complex layered integrated air defense systems (IADS).

Aircraft losses suffered on both the Russian and Ukrainian sides, and the inability of either nation to maintain dominance of the air environment during the conflict have underscored the importance of suppression of enemy air defenses (SEAD). This has a particular resonance for NATO at a time when its European partners are confronting serious shortfalls in SEAD capability and capacity.

Moreover, there is an understanding across NATO that – given continued advances in complex anti-access/area denial (A2/AD) – future SEAD operations will be substantially different, and vastly more complex, than missions of the past. "A single aircraft against a single SAM [surface-to-air missile] system is an outdated concept, and not applicable in modern scenarios," Generalleutnant Günter Katz, Commanding General of the German Air Force Forces Command, told the AOC Europe 2023 conference in Bonn in May this year. "We have to adjust our mindset, our doctrines and our systems and transition to a networked force with high levels of integration [and] a new concept of operations."

NATO has now set in motion plans to rebalance and modernize SEAD capabilities within the alliance. The expectation is that future SEAD will embrace a holistic "system of systems" approach using a panoply of airborne electronic warfare (EW) platforms and systems to deliver diverse and coordinated effects across all domains. Furthermore, there is a recognition that the dynamic and increasingly data-driven nature of operations will require the implementation of advanced digital technologies and techniques – such as Cloud computing and artificial intelligence (AI) – if effects are to be delivered at the right time and place.

DEFENSE SUPPRESSION

SEAD is an overarching term used to describe the methods and means to degrade, disable and/or destroy adversary air defense surveillance radars, surface-to-air missile (SAM) systems, and associated command, control and communications networks in order to achieve air superiority and freedom of action. In broad terms, suppression can be achieved in one of two ways. Airborne electronic attack (AEA), sometimes referred to as non-kinetic SEAD, uses jamming to defeat surveillance and fire control radars and disrupt communications nets, so as to open one or more pathways through the IADS screen and enable entry/egress through contested airspace. Kinetic SEAD refers to the use of anti-radiation missiles and/or precision strike weapons to destroy radar sites, SAM batteries, and command and control nodes. (Some organizations, such as the US Air Force, also refer to the lethal element of SEAD as destruction of enemy air defenses [DEAD]).

NATO forces have fielded SEAD capabilities for many decades, and the mission is well understood across the alliance. Today NATO recognizes that its current SEAD capabilities, especially among European air forces, have fallen well behind the curve. Professor Justin Bronk, senior research fellow for air power and technology at the UK-based Royal United Services Institute (RUSI), highlighted these deficiencies in RUSI's February 2023 report, "Regenerating Warfighting Credibility for European NATO Air Forces." In it, he points out that the SEAD/DEAD task "requires specialist aircrew training, weapons and sensors that no European air force currently fields at anything like the scale required."

This shortfall, he added, has not come about overnight. "Even during the supposedly European-led Libya intervention in 2011 against a largely static and completely outdated air defense system, other NATO partners were dependent on the US to conduct SEAD/DEAD before they could operate effectively," Bronk noted. "The challenge that would be faced from a near-peer such as Iran, let alone against Russian forces in Eastern and Northern Europe, is almost incomparably more serious, with layered long-, medium- and short-range SAM coverage provided by highly mobile systems linked to a range of multi-static and multi-frequency radar systems by modern C2 vehicles and communications architectures."

According to Bronk, regenerating a SEAD/DEAD capacity at scale against modern, mobile SAM systems should be an urgent priority for NATO's larger European air forces. If not, he warns, European NATO states "will be unable to establish control of the air in any scenario where the US is either unable or unwilling to commit major resources to doing so itself. This is not simply an issue for deterring Russian forces, but also for maintaining military options against near-peer states."

Bronk's RUSI paper advocates for investment in a broad range of non-kinetic and kinetic effects. In the former case, he points out that airborne electronic attack (AEA) – delivered from stand-off platforms, escort jammers accompanying a strike package, or miniaturized stand-in decoys/jammers – offer a highly responsive and cost-effective means of degrading the radar systems that provide situational awareness and guidance for hostile SAM systems.

However, while fully accepting the vital contribution of EA, Bronk argues that jamming "cannot create the condi-

he Need for SEAD’

NATO saw its SEAD capability atrophy following the end of the Cold War. The ALARM anti-radiation missile (pictured here under a Tornado GR4) was retired from RAF service a decade ago without replacement. UK MINISTRY OF DEFENCE/CROWN COPYRIGHT

tions for lasting air access in airspace contested by modern air defense systems alone [and] must form part of the mix of SEAD capabilities that can open temporary access opportunities for key strike operations.”

Bronk asserts that only the destruction of a significant portion of the ground-based SAM threat “will provide Western airpower with the sustained access it needs with the majority of its conventional aircraft to attain control of the air.” This will demand suitable stand-off precision strike and anti-radiation missiles “available in sufficient numbers to seriously attrite the multi-layered Russian IADS quickly, both in terms of overall stockpile, and carriage capacity per aircraft.”

THREAT LANDSCAPE

Part of the challenge for NATO’s air platform survivability community is conveying a message that while SEAD is essential to any offensive air campaign, the tools and tactics of the Cold War era are increasingly irrelevant to the current threat environment. Potential adversaries, with Russia and its security partners writ large, have invested in increasingly complex, coordinated and resilient multi-layered IADS that draw Red “threat bubbles” at ranges measured in hundreds of kilometers – and extending well beyond home borders.

A number of trends are apparent, with potentially significant implications for aircraft survivability. For example, counter-stealth radar systems operating in very low bands outside of conventional radar frequencies have eroded the advantage hitherto enjoyed by low-observable aircraft. Passive radar systems, employing multiple distributed sensing nodes, are proliferating, So too are a new generation of software-defined radars designed for rapid adaptation and upgrade with new and novel waveforms.

Thus, NATO planners and aircrew alike recognize that the future operations are likely to take place in heavily contested airspace, and the emergence of increasingly sophisticated and highly resilient IADS has fundamentally changed the risk calculous in the minds of campaign planners and operational analysts.

This new strategic setting has forced NATO to confront two uncomfortable truths: first, that the existing Alliance capability is unbalanced given an over-dependence on US assets; and second, there is a need to develop a modernized, multi-faceted and credible SEAD capability able to deliver diverse and synchronized effects.

Going back to 2014, NATO's Wales summit agreed a defense planning package with a priority for demanding air operations in order to inform defense investments and to improve the capabilities available in allied national inventories. Vision papers for AEA and SEAD, both approved by the Conference of National Armaments Directors (CNAD) in 2018, identified four principal focus areas: diversity of effects; survivable delivery systems; coordinated information capture and exchange; and synchronization of effects. Concepts of employment were subsequently developed for both AEA and SEAD, with these being approved in 2020.

While the effective delivery of SEAD is very much back on NATO's agenda, there is still a misconception that SEAD is an operational effect that can be delivered through a handful of specialist fast jets armed with anti-radiation missiles, according to General Katz. The reality of the modern threat environment, he told the AOC Europe 2023 audience, is somewhat different.

"In the past, the threat consisted of a surface-to-air missile, with mostly analog technology, and big electronic countermeasures. Due to [the limitations] of old technology, there was an emphasis on early warning and air interception to mitigate the weaknesses of the surface-to-air missile defense system, which would usually be arranged as a SAM cluster protecting critical infrastructure.

"Blue forces were able to jam the early warning systems, and able to suppress the enemy air defense. Therefore, self-protection systems on 'Blue' force platforms were sufficient, and increased the probability of survival."

Advances in technology have, however, now rendered such assumptions obsolete. "We now encounter a highly redundant and networked system of newer and older weapon systems," said General Katz. "This means you have to change our mindset from a pure [one-on-one] 'duel' situation to an anti-access/area denial scenario."

He amplified. "Today, the new threat is characterized through the [amalgam] of many different and modern system components, [such as] short- and long-range SAM systems, radars, and communications posts. The threat, as described in the NATO Suppression of Enemy Air Defense employment concept, is layered, decentralized, complex, frequency diverse, highly automated, and networked."

This new threat landscape, characterized by increasingly advanced systems and high levels of interconnectivity, means that "conventional" SEAD tactics and technology are less effective. Instead, said General Katz, NATO needs to recapitalize and modernize its capability. "This means implementing long-range sensors, long-range weapons, long range reconnaissance/geolocation, modern cross-platform self-protection systems and a modern airborne electronic attack capability."

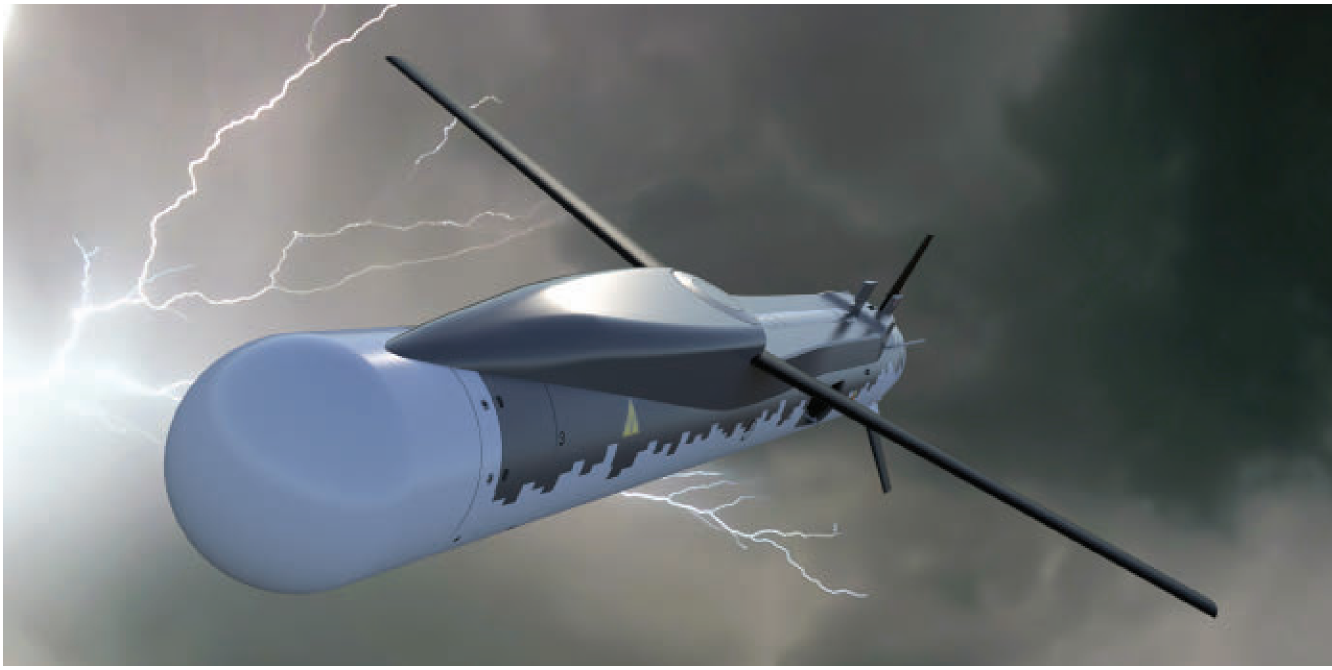
Effecting this change requires the adoption of a new cross-domain SEAD concept of employment (CONEMP) blending a mix of different but synchronized effects. "We must say goodbye to old doctrines, and adjust our mindset," General Katz said. "To tackle the adversary's network, we have to develop capabilities to deny, degrade or disrupt these networks. And in order to defeat the new threat, we need specialized aircraft, weapons and technology, with the integration of all aspects of modern electronic warfare, to saturate the enemy's air defense systems."

This will demand the development of a highly networked SEAD system-of-systems capability capable of delivering effects in all domains and dimensions. Moreover, these effects must be flexible and tailored to the mission.

Germany's own Luftgestätze Wirkung im Elektromagnetischen Spektrum (luWES) program breaks out the delivery of AEA effects into three complementary parts. Stand-off jamming, performed by a large non-penetrating air platform operating at a safe distance outside the "threat bubble," is designed to "open a channel" in the IADS screen by suppressing long-range radars operating in lower frequency bands and disrupting IADS communications networks.

Escort jamming will be performed by penetrating aircraft which accompany the strike package into defended airspace in order to suppress fire control/missile guidance radars systems so that the force can survive once inside the missile engagement zone. Stand-in jamming – a relatively new addition to the SEAD armory – uses an unmanned and

Airbus Defence and Space has proposed a stand-off jammer adaptation of its A400M Atlas airlifter as a potential solution for Germany's luWES program. RICHARD SCOTT



SPEAR-EW is being developed by MBDA to meet UK requirements for a stand-in jammer. MBDA

expendable air vehicle to deliver an EA payload close to a victim radar(s) so as to protect the following strike package as it approaches the weapons release area.

"We envisage that our [luWES] stand-off and escort jammers need to be coordinated with unmanned combat drones to saturate, attack and locate the adversary's threat systems," said General Katz. "Also, due to the expected high mobility of these threat systems, most of these effects need to be time-critical."

ENABLERS

The challenge is to engineer a next-generation SEAD system of systems, underpinned by integration and networking, that will enable tailored, flexible effects to be delivered in all domains and dimensions. One potential enabler for this future capability is Cooperative Electronic Support Measure Operations (CESMO), a digital protocol adopted by NATO (codified under STANAG 4658) to allow participating units – air, land or maritime – to share information on emitters.

Germany acts as a framework nation for CESMO in NATO, and the Luftwaffe's Tornado ECR force is serving as a technology development asset for the capability. "CESMO uses all data networks, like Link 11, Link 16 and Link 22, and provides the collected information from any unit to all participants in the network," General Katz explained. "It improves situational awareness by allowing each unit to find, fix and track emitters in near-real time outside the range of their own sensor suite."

A proposed evolution of CESMO, known as CESMO++, is already looking at an extension of the current message set to incorporate additional capabilities – for example, reporting hyperbola and hyperboloid data (hybrid geolocation); joint restricted frequency bands; and meaconing, intrusion and jamming.

Dietmar Thelen, head of Electronic Warfare Military Air Systems for Airbus Defence and Space, explained: "Right now CESMO is like a Link 16 for SIGINT. The next step is to coordinate non-kinetic effects – jamming, spoofing and deception. Historically, we fed jammers with [threat] library data. But today, we need to be more dynamic [and] measure the received signal as it appears. We are seeing changing [RF] patterns and modulations in real-time – we can no longer rely on empirical emitter libraries. In CESMO++, we will start to implement this process. It will be essential to choregraphing the delivery of effects."

Two other enablers are seen as critical to realizing the SEAD system of systems vision. First, the implementation of some form of 'Combat Cloud' to enable decentralized and disaggregated command and control of SEAD effects. Second, the introduction of advanced AI techniques – not just for ultra-fast data mining, but to also provide instantaneous reaction if and when a threat switches to a "war mode" or emits previously unknown signals not in the EW system's threat library.

NIAG STUDY GROUP

The alliance established a NATO Industrial Advisory Group (NIAG) earlier this year to explore AEA/SEAD concepts and technologies that could meet NATO's needs for 2030 and beyond. Chartered through the CNAD, the NIAG Study Group 286 (SG-286) on SEAD Capabilities held a kick-off meeting in May. The study activity, lasting for approximately 18 months, will deliver a capability audit against NATO's previously drafted AEA and SEAD CONEMPs.

Speaking at AOC Europe 2023, Alex DeFazio, NATO's capability area facilitator for AEA and SEAD, said the capability audit process was intended to evaluate what sort of capabilities were feasible by the end of the decade, and to inform and influence the NATO defense planning process. "Based on what we say we need in 2030, [we will ask ourselves] what do we currently have now in hand," he said. "Then we will compare those results and do a gap analysis [and then] we will figure out how we get the stuff that we don't have right now."

The Italian Air Force completed operational testing of the AGM-88E AARGM missile from the Tornado ECR in April 2018. NORTHROP GRUMMAN

DeFazio added that SG-286 – involving over 40 companies from 12 nations – was now beginning to review capabilities against the CONEMP. "We've asked those industry experts what they think is in realm of the possible by 2030, and what have we missed in the CONEMP that could be relevant as we move this roadmap forward.

"We want their recommendations on what capabilities we should be pursuing. And then we'll take on board those recommendations to try and [influence] how we do our NATO defense planning process."

SG-286 is due to complete its work at the end of 2024. Alongside the NIAG study, a team of subject matter experts largely drawn from the NATO Air Force Armaments Group is providing NATO EW support to SEAD (NEWS) input to the capability audit. A key part of this work is examining integrated threat environments, and different technology options with regards to platform types, weapon concepts and jamming techniques.

"The next step will be the gap analysis," said DeFazio. "The NEWS team will be part of that, [and] we'll use modelling and simulation being offered from the United States to try to help the NATO defense planners fine tune their assumptions when they do the stress testing of the minimum capability requirements. We will also look to industry to help us with solutions that address areas highlighted in the gap analysis."

The outputs of the capability audit study will also inform further updates to policy and doctrine. "That's starting to happen already," said DeFazio. "We've seen changes in NATO SEAD doctrine, changes in our policies [and] we now have a new NATO Electromagnetic Spectrum strategy. All that came out of the questions arising from the CONEMP and vision paper."

Emitter Location (Part 5)

Precision Emitter Location Techniques

By Dave Adamy

Precision emitter location techniques are generally those considered accurate enough for targeting, providing location accuracy in tens of meters. Two techniques are typically used for precision emitter location: Time Difference of Arrival (TDOA) and Frequency Difference of Arrival (FDOA). They are often used together, and normally used in conjunction with less accurate location systems. This month, we will focus on the TDOA approach.

TDOA METHOD

Last month, we discussed the calculation of a propagation distance from the signal transition time. The signal travels at the speed of light, so if we know when the signal left the transmitter and arrived at the receiver, we know the path length. When dealing with cooperative signals (such as GPS) or our own data link, coding on the signal can allow the determination of the time of departure. However, when dealing with hostile emitters, we have no way of knowing when the signal left the transmitter. The only information we can measure is when the signal arrives. However, by determining the difference between the times of arrival at two sites, we can know that the transmitting site is located along a hyperbolic curve. If the TDOA is measured very accurately, the emitter location will be very close to the line, but since a hyperbola is an infinite curve, the location problem is not yet solved.

Figure 1 shows two sites receiving signals from a single transmitter. The two sites form a baseline. The area of uncertainty is the area which might contain the emitter of interest. Note that the difference between the two distances determine the time of arrival difference. Figure 2 shows a few of the infinite number of hyperbolas. Each curve, representing a specific time of arrival difference, and is called an "isochrone."

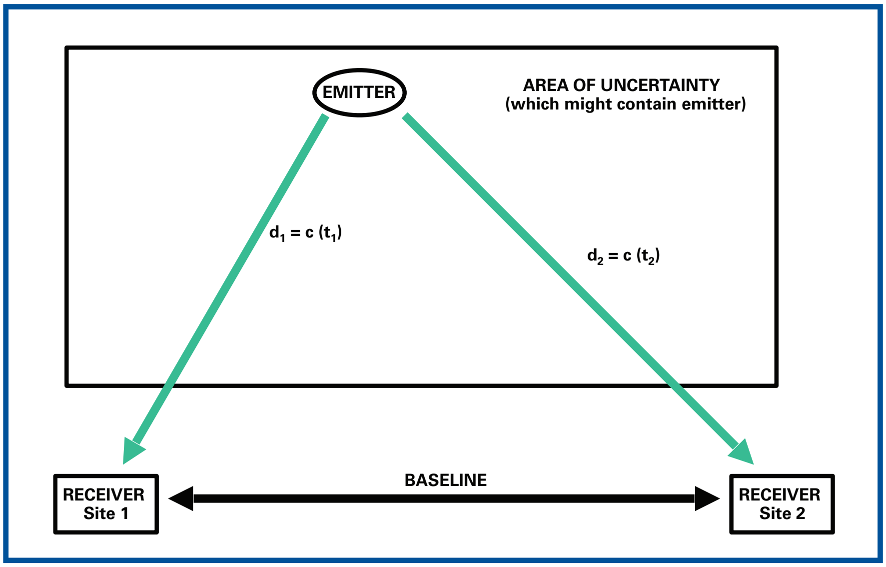


Fig. 1: *Two receiver sites form a baseline against which the relative distances to an emitter can be calculated from the differences in the propagation time.*

PULSE EMITTER LOCATION

The determination of the time difference of arrival is fairly easy if the transmitted signal is a pulse – given that there is a very accurate clock at each receiver location and that the measured times can be transmitted to a common location. As shown in Figure 3, the leading edge of the pulse gives a dependable time-measurement event. One issue is that the two receivers must measure the same pulse. The time between pulses is usually large compared to the pulse duration, so this is not too difficult. Since only a few pulses must be measured to determine the emitter location, very little data link bandwidth is required to carry the time of arrival data to the processing location – where the time difference of arrival (TDOA) is calculated.

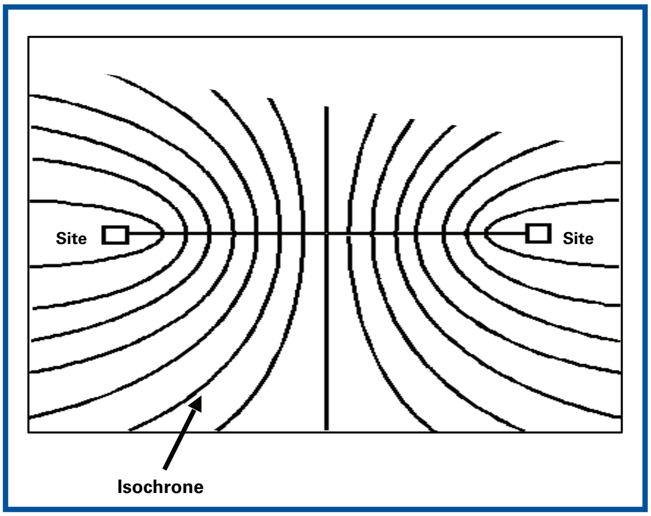


Fig. 2: *An isochrone is a hyperbolic line containing all of the locations at which an emitter could be located for a fixed difference in propagation path length to the two sites, causing a fixed time difference of arrival for a signal.*

ANALOG EMITTER LOCATION

Now consider the case of a signal with analog modulation. This type of signal has a continuous carrier (at the transmit frequency) and carries its information in the modulation of the frequency, amplitude, or phase of that carrier. The carrier repeats every wavelength (typically less than a meter), so the only attribute of the signal that we can correlate to determine the time of arrival at two receivers is the modulation. The time-of-arrival difference is determined by sampling the received signal many times with a varying time delay at one of the receivers. This time delay must be varied over sufficient range to cover the minimum to the maximum time difference possible over the area in which the emitter could be located. The samples are digitized, time coded and sent to a common point at which the correlation between the two samples can be calculated.

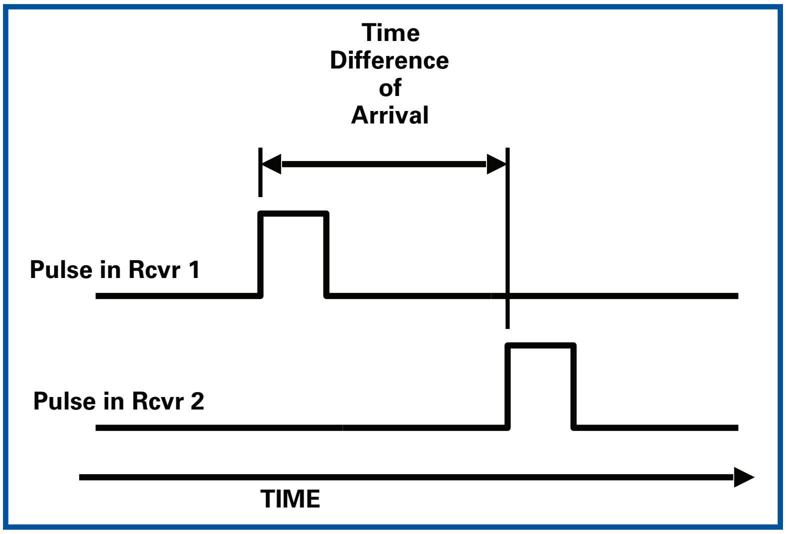


Fig. 3: If the time of arrival of a pulse at each receiver is measured with an accurate clock, the calculation of the time difference of arrival is straightforward.

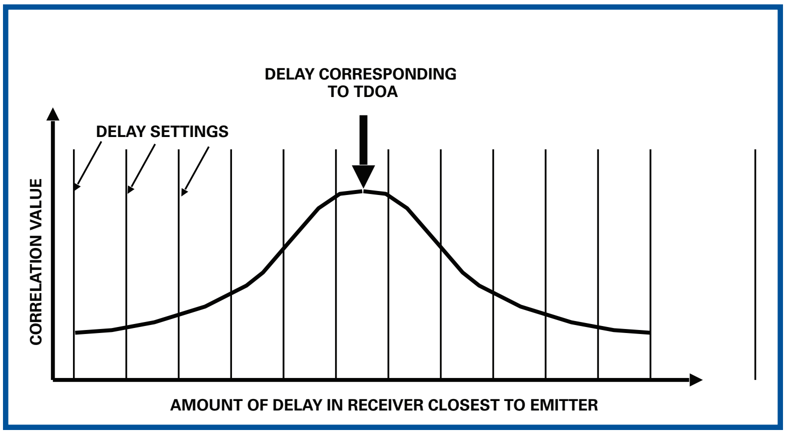


Fig. 4: The correlation between the signals arriving at two receivers as a function of the delay of the signal in one receiver peaks at the delay value equal to the time difference of arrival. For analog signals, the curve has a soft peak

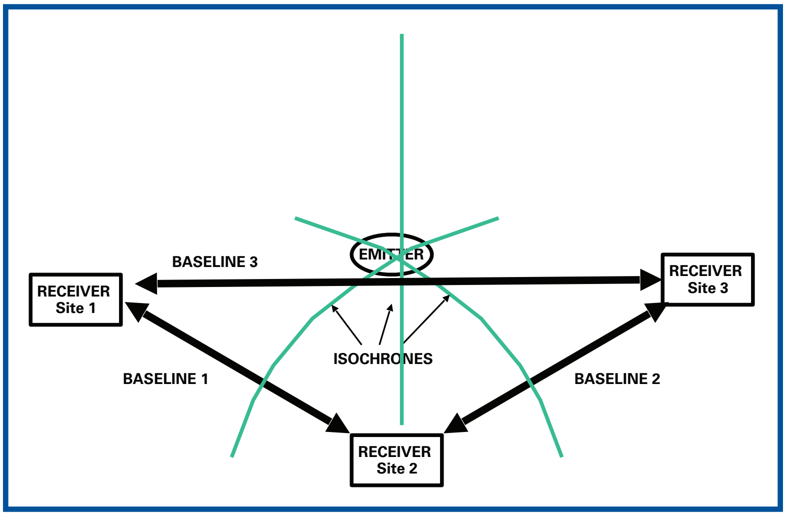


Fig. 5: Three receiving sites allow three baselines. The isochrones from these baselines cross at the emitter location. Each baseline generates an isochrone curve.

Since the samples from the two receivers are digital, the correlation is the percentage of the bits from the two signals that are the same (e.g., if half of the bits agree, the signals are 50% correlated).

The correlation changes as a function of the differential delay, as shown in Figure 4. The correlation peak occurs at the differential delay value equal to the time difference of arrival. Note that this correlation curve has a fairly smooth top, but that the peak is typically determined to the order of 1/10 of the delay increments.

The TDOA process is relatively slow for analog signals because many samples must be taken, and it requires significant data transmission bandwidth because many bits per sample are required for adequate location accuracy.

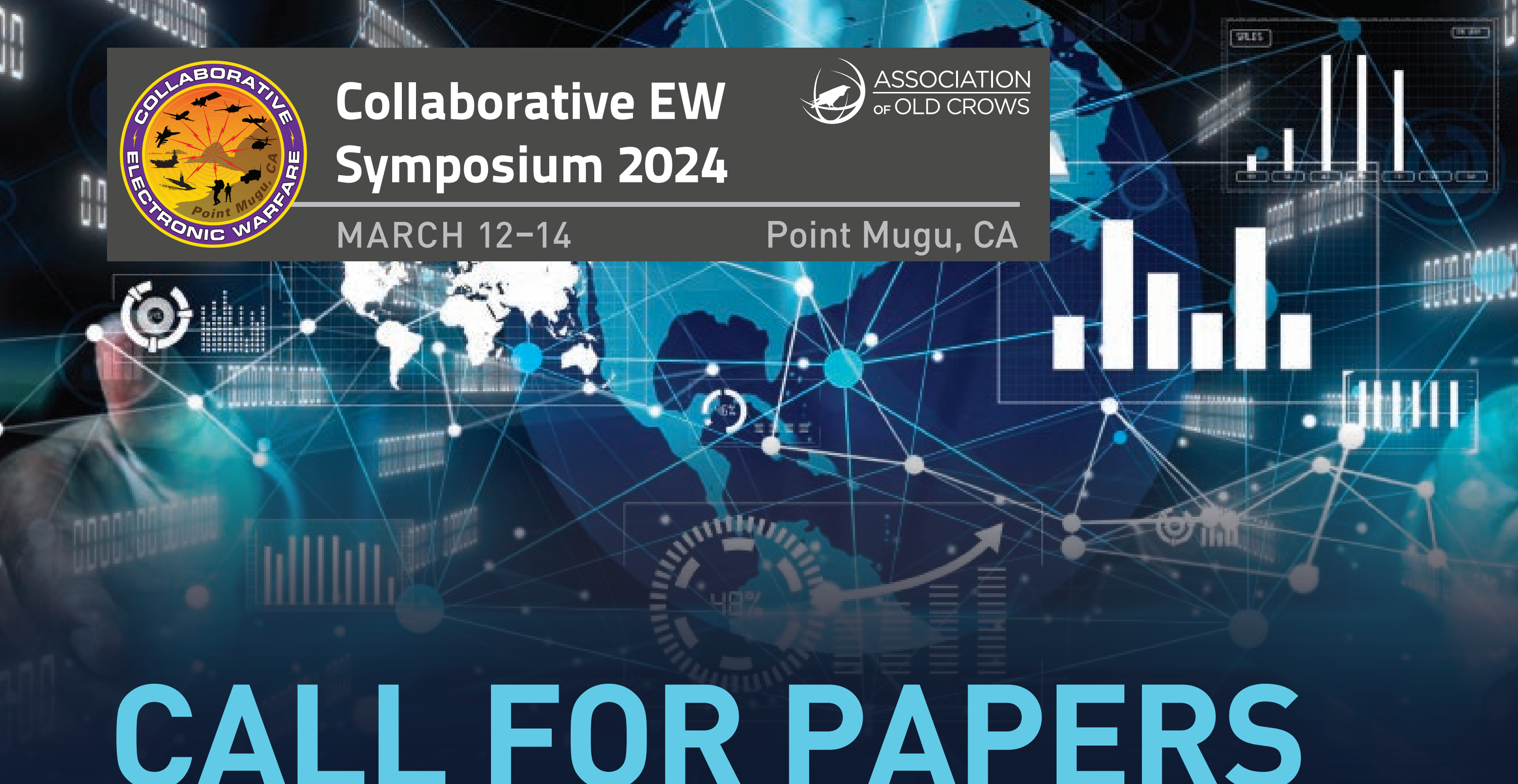
LOCATION

Determining the actual location of the emitter requires a third receiver site so that there will be three baselines. As shown in Figure 5, each baseline forms a hyperbolic isochrone. These three hyperbolas cross at the emitter location. There is a location ambiguity in that each pair of hyperbolas may cross in two locations. However only one of these locations would be expected to lie within the area of uncertainty (shown in Figure 1).

In order to provide an accurate emitter location, it is necessary that the receiver site locations be accurately known. With the availability of GPS, accurate locations are available for small vehicles and even dismounted operators. If the receivers are moving, it is, of course, necessary consider the instantaneous receiver locations when making the isochrone and emitter location calculations.

WHAT'S NEXT

Next month, we'll continue our coverage of precision emitter location with a discussion of FDOA and combined TDOA/FDOA approaches. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.



Collaborative EW Symposium 2024

ASSOCIATION OF OLD CROWS

MARCH 12–14 Point Mugu, CA

CALL FOR PAPERS

ABSTRACTS DUE BY NOVEMBER 29, 2023

THEME: EW at Scale – EW Capabilities for Near Peer Force on Force Warfighting

Classification of Sessions: U.S. Secret

Potential presenters are challenged to explore collaborative EW through innovation and invention. Presentations or demonstrations from US DoD, Industry, and Academia are requested for the following topics:

- **Scaling up currently existing EW capabilities for US and Allied Forces**
- **Designing New EW Systems for Rapid and Affordable Capability Expansion**
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- **Sharing EW Mission Capabilities across Services**
- **Warfighter Perspective**

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Contact Sean Fitzgerald at Fitzgerald@crows.org

RICH NELSON RECEIVES DISTINGUISHED SERVICE AWARD

Richard Nelson, past-president of the Palmetto Roost Chapter, received the Association of Old Crows Distinguished Service Award. He is a founding member and inaugural president of the Palmetto Roost Chapter of the Association of Old Crows.

Nelson served as chapter president from 2009-2023, achieving Chapter of the Year every year since its inception. Over these years, the Palmetto Roost held 11 classified EW/Cyber conferences recognizing the importance of convergence years before anyone else saw the wisdom of this perspective.

Nelson was responsible for initiating a partnership with Charleston Southern University (CSU) to extend the chapter's presence in the STEM community and to encourage new membership. Through this collaboration, the Palmetto Roost sponsored the CSU Cybersecurity Team, which allowed them to travel to Capture-the-Flag events such as the University of Connecticut Cyber SEED competition, Georgia Tech Hungry, Hungry Hackers and the Montreat College Retr3at Conference.

Nelson also established an annual CompTIA Network+ Bootcamp for Lowcountry students, providing all materials, textbooks and computer resources with a 100% exam pass-rate of students that chose to take the exam following the bootcamp. He also initiated the establishment of the Rosemary Wenchel Memorial Scholarship at CSU.

GRANITE STATE ROOST EDUCATIONAL FOUNDATION AWARDS SCHOLARSHIPS TO 2 UNH STUDENTS

The Granite State Roost Educational Foundation has awarded Tony Grieco Scholarships to Jonathan George and Daniel Rinden, who are each majoring in science or engineering at the University of New Hampshire. The Grieco Scholarship is named after the Pentagon's former Deputy Director for Electronic Warfare, Tony Grieco, who was well known in defense and Congressional circles for his strong support of electronic warfare issues. The Tony Grieco Scholarship is awarded to students who show promise in science and engineering and who are enrolled in a college-level science or engineering program.

DIXIE CROW CHAPTER GIVE $1,500 EACH TO HOUSTON, BIBB COUNTY ROBOTICS TEAMS

The Dixie Crow Chapter proudly presented $1,500 to each of the Houston County and Bibb County Robotics Teams to support their 2023-24 school year competitions. Jordan Kelsey, L3Harris, and Brandon Head, Northrop Grumman, representing the Dixie Crow Chapter's Board of Directors, were on hand to make the presentations during the STEM City EXPO Summit held on Aug. 11 at the Museum of Aviation Nugteren Hangar.

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Glorianne O'Neilin
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JED Sales Offices

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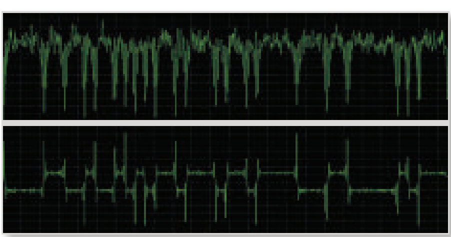
SIGNAL ANALYSIS "DECRYPTED"

By Gerd Brandmeier, *Director Product Management, PROCITEC GmbH*

In the first part of this article (JED April, 2023), we discussed the importance of signals analysis for modern radio signals monitoring systems. The basics for analysis using the 'Signal Analyzer' software and the use of those results to adapt to new signals were described in detail. In this article, I would like to focus on the analysis methods used and how they work.

Various modulation methods are used in radio technology to transmit data (including digitized speech). The sender's signal is modulated by one or more parameters according to the information to be transmitted. Generally, the basis is a sinusoidal signal which is modified in its amplitude (ASK), its frequency (FSK) or its phase (PSK). A combination of two parameters would be e.g. amplitude and phase (QAM).

In **time domain analysis**, plots of the amplitude, frequency and phase over time are displayed. Depending on the modulation type, symbols at ASK and FSK or peaks in the frequency with PSK become visible; also, a constant value e.g. at the amplitude gives hints.



Amplitude and frequency plot of FSK2 modulation

For this reason, time domain analysis can be used to recognize the modulation methods ASK and FSK and to determine parameters like shift (frequency spacing), the symbol duration or the order (number of signaling states used).

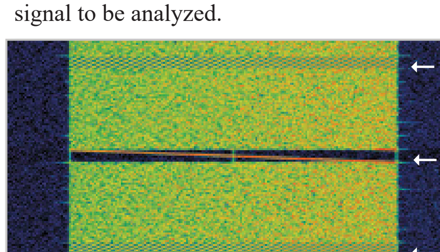
Another important method is **spectral analysis**, which includes e.g. the graph of energy over frequency, the spectrum. With it, the bandwidth of a signal can be measured or the type of modulation can at least be estimated on the basis of its appearance.

A special feature is the spectrum over the squared input signal. This measurement method is used to identify phase modulated signals (PSK). Starting from a sinusoidal signal, squaring doubles not only the frequency but also phase shift in the signal, as used in PSK for data transmission. With each squaring, the order can be halved until an unmodulated sinewave remains; a peak therefore appears in the middle of the signal's spectrum. This is the indication of the PSK modulation; from the number results the order.

Spectra are also very good at detecting periodic changes in signals. This is ideal for measuring the symbol rate, since the data symbols are transmitted at fixed intervals. To detect only the changes in the signal, the derived signal is calculated. Since the direction of the change (values rising or falling) is irrelevant, the absolute value is formed and from this the spectrum is calculated. At the position of the symbol rate a peak can be found, its value can be easily read.

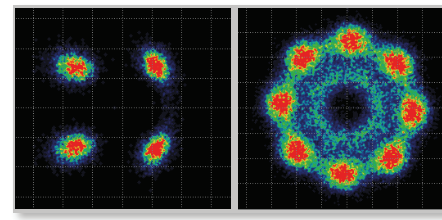
If there are fixed patterns or repetitions in the data, this can lead to further peaks with the repetition rate of the patterns, which can even represent the maximum according to their incidence. A simple example would be to transmit each symbol twice over a longer period of time, one would only be able to measure every second change and therefore measure half the value. Such cases are fortunately rather undesirable in the transmission technology, since the recovery of the information (demodulation) can lose quality. With channel coding, this behavior is generally excluded. The periodicity analysis described later aids the exclusion of such cases in the framework of the analysis.

Another important graph in the context of spectral analysis is the spectrogram. This 3D plot shows the behavior of the spectra over time, the signal's energy levels are indicated by their color. The graph is well suited to visualize changes in the frequency spectrum over time, e.g. the start or end of a transmission, or to distinguish it from neighboring signals. For this reason, in the Signal Analyzer software the spectrogram is used at the very beginning of the analysis to select the signal to be analyzed.



Spectrogram showing synchronization patterns

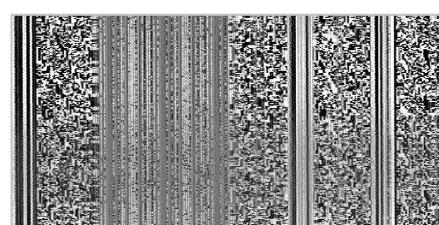
Phase- and Amplitude-modulated signals (PSK, QAM) can be analyzed easily with the **constellation diagram**, also called I/Q display. The graph uses a complex coordinate system and shows the In-phase (I) and Quadrature (Q) components of the modulated signal. Phase and amplitude states are shown as points or point clouds, if noise is present. The order can be counted from the number of points; the modulation/version from their geometry. As a variant there is the **differential I/Q display**. Here, not the absolute phase value is displayed, but the phase difference to the previous value. This allows differential phase modulation (DPSK) and variants such as π/4-QPSK to be identified by its constellation. Another advantage is that the constellation is visible even if the center frequency is not set exactly.



Differential and absolute I/Q display of π/4-QPSK modulation

For synchronization between sender and receiver, often repeating patterns are transmitted. The **periodicity analysis** uses a mathematical function to find such repetitions, the autocorrelation. The signal is compared with itself at different delays, and local maximum values at the time differences of the repetitions become visible.

In Signal Analyzer, an additional **Hellschreiber graph** is used to make these patterns visible. Here, different analysis values are displayed as brightness values line-by-line below each other. The duration of a line corresponds to the repetition time of the patterns; thus they always arrange themselves at the same position below each other, vertical lines become visible. Such frame widths are very typical for communication systems.



Hellschreiber graph showing repetitions

These and other analysis methods are part of the Signal Analyzer product from PROCITEC's go2signals product line. Bi-annual updates guarantee that the functionality is continuously expanded and adapted to the ever-evolving signal world. With release 23.2 (July, 2023), for example, new functions for Multitone (MFSK) modulation analysis and a signal parameter database have been added. In the near future we will add demodulation and bit analysis functions by adding an universal demodulator.

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