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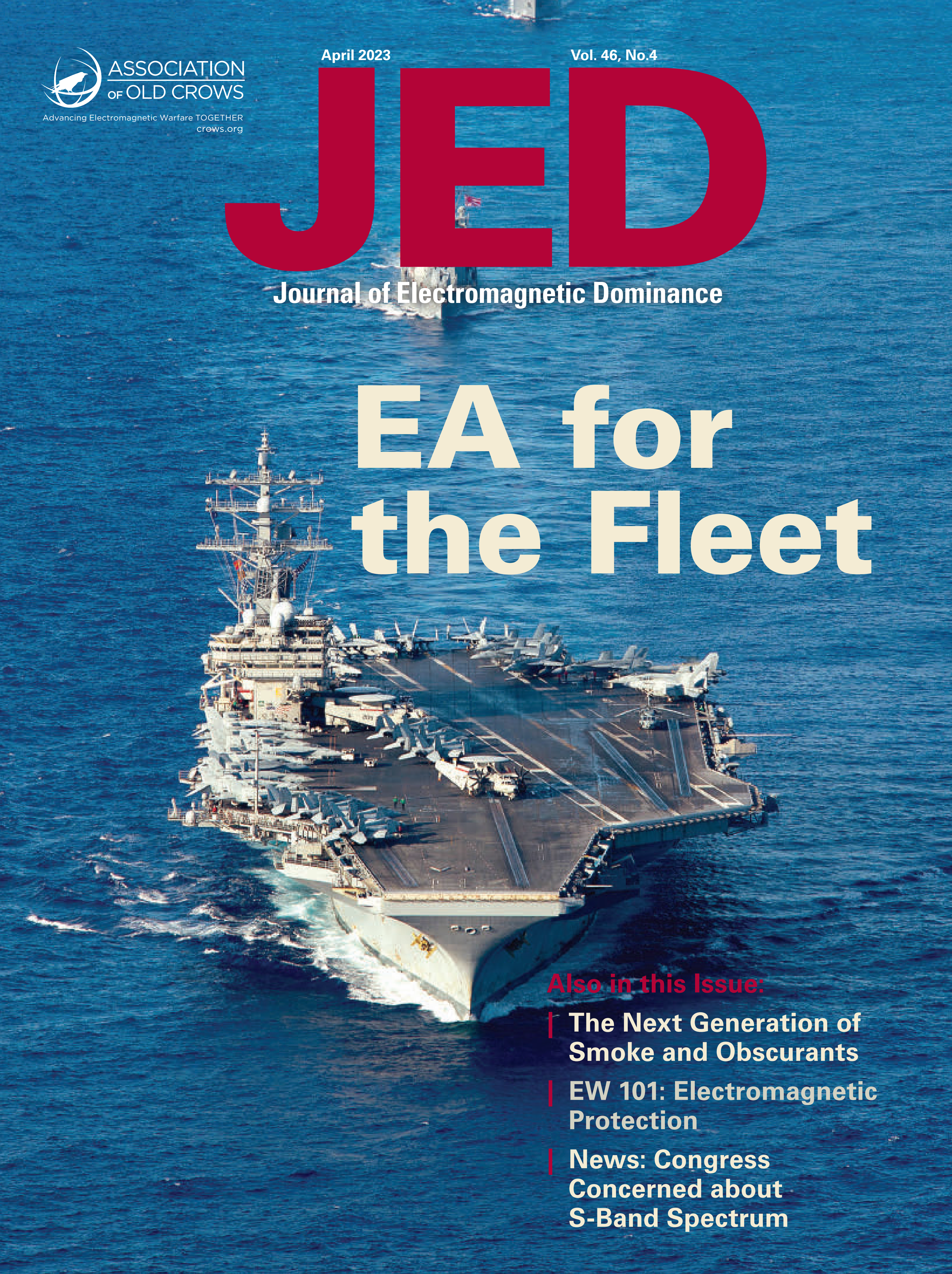
JED
Journal of Electromagnetic Dominance



EA for the Fleet

Also in this Issue:

- The Next Generation of Smoke and Obscurants
- EW 101: Electromagnetic Protection
- News: Congress Concerned about S-Band Spectrum

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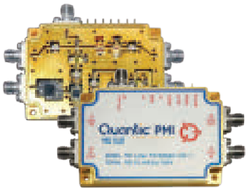

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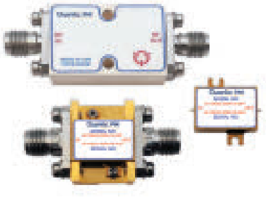

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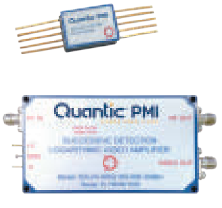

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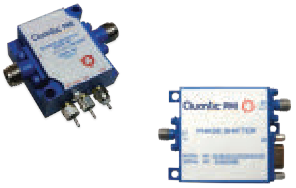

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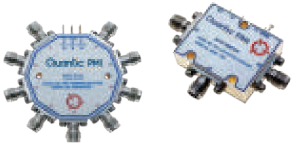

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JED CONTENTS

Journal of Electromagnetic Dominance

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US NAVY

Read more at JEDonline.com

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

At Australia's Avalon 2023 aerospace and defense expo last month, the country's deputy prime minister, Hon. Richard Marles MP, announced that the Royal Australian Air Force (RAAF) will re-form No. 9 Squadron to operate its three MQ-4C Triton unmanned aerial systems on order from Northrop Grumman. The Triton aircraft, which include ESM and ELINT payloads, will perform maritime ISR missions alongside 10 Squadron, which will soon transition from AP-3C Orion aircraft to Gulfstream MC-55A Peregrine ISR aircraft, and 11 Squadron, which operates the P-8A Poseidon. Chief of Air Force, Air Marshal Robert Chipman, noted No. 9 Squadron's emblem, which shows a black-browed albatross. "The black browed albatross is renowned for spending a long time on in overwater flights," he said, "which makes it the perfect symbol, for the perfect Squadron for us to establish the MQ-4 Triton capability." RAAF PHOTO

Departments

COVER PHOTO COURTESY OF US NAVY

ADVERTORIAL

SIGNAL ANALYSIS – THE KEY IN UPDATING RADIO SIGNAL MONITORING

By Gerd Brandmeier

Director Product Management, PROCITEC GmbH

Modern radio monitoring solutions prosecute complete radio frequency bands by receiving and processing hundreds of emissions simultaneously. They process the signals fully automatically; this is practically ‘a must’ in order to be able to process a large number of parallel signals efficiently. The operators essentially focus on evaluating the results of their predefined SOIs (Signals Of Interest).

These automatic methods are not always able to process the signals completely; poor reception quality or new, unknown radio signals are among the most common causes. This is where expertise in radio signal analysis come into the play. Based on signal recordings, experts use special software applications with in-depth analysis methods for further processing.

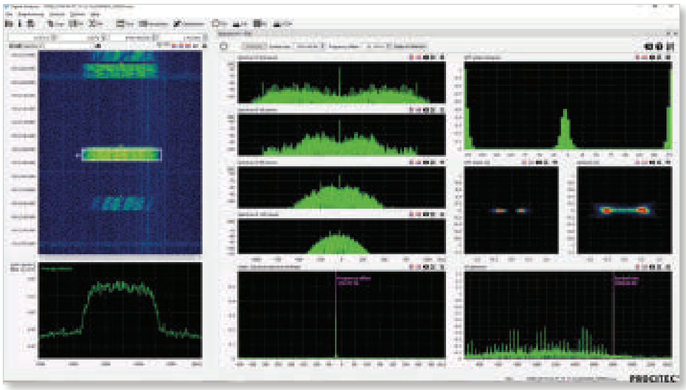
PROCITEC‘s Signal Analyzer software solution was newly developed especially for this application. The main design goal was to create an easy-to-use radio signals analysis tool that quickly produces high-quality analysis results. For example, typical analysis steps can be performed automatically, and for frequently used signal types (e.g. FSK or PSK modulation), there are predefined analysis sets with all the methods required for analysis in a measurement template.

With the new software, PROCITEC combines the knowledge of our inhouse experts with the experience of our customers. In accordance with the company‘s philosophy, further development is open to customer requests and feedback. Suggestions are incorporated into new software releases at six-month intervals along with functional enhancements.

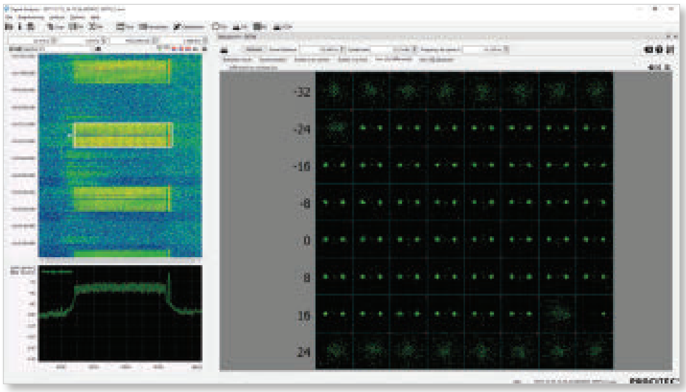
What does analysis now look like?

First, load the signal recording and select a signal section for analysis within a spectrogram display (time/energy versus frequency). It’s easy, but it is an important step. As mentioned before, signal quality can vary strongly within a recording, so analyzing the signal at different times and durations can be a key to success.

There is no real ’single procedure’ for the next steps. If there is already a suspicion of a certain signal type, one changes directly to the corresponding measurement template and checks the hypothesis based on the expected results of its measurement functions.



Template for PSK signal analysis



OFDM analysis example showing multiple IQ-Display

As an example, a PSK signal (Phase Shift Keying, phase-modulated radio signal with content) can thus be identified based on the displays »spectra over the multiply squared time signal«, »display of the signal in complex number space«, »frequency distributions over differential phases«, and so on.

If there is no hypothesis yet, analysis of behavior in the time domain may help. This analysis assumes a sinusoidal carrier signal. This can be modulated (changed by the data for transmission) in amplitude, frequency, phase or a combination of the parameters.

Accordingly, the three mentioned values are shown in their ‘time behavior’. Depending on the signal type, typical graphs result. For example, an FSK signal (Frequency Shift Keying, frequency-modulated radio signal with digital content) shows the transmitted data bits directly in the displayed frequency graph.

This basic principle of hypothesis, verification by specialized methods for detection and measurement of technical parameters can be applied to all types of radio signals. Signal Analyzer already offers a variety of well-known methods specialized in digital radio signals (transmission of binary content) such as FSK, PSK, multichannel modulation, OFDM, etc.

But what if I have absolutely no idea about a signal?

This is where the modulation type classifier of the Signal Analyzer helps. At the push of a single button it classifies all common signal types from analog speech, Morse, ASK, FSK, PSK, QAM, MPSK, OFDM, etc. and measures their technical parameters.

An outstanding feature is the direct classification of the used modem type (specialized on communication signals in the HF, VHF, UHF and satellite ranges).

How can I further use the derived results optimally?

Signal Analyzer is a product from PROCITEC‘s go2signals product line. Monitoring solutions based on these products are compatible with each other. They are open for enhancements by the operating professionals and can thus be adapted to the constantly changing signal world.

Feeding back the results attained with Signal Analyzer extends the monitoring solution in automatic processing in the future, especially in the case of new radio signals.

NOT SO OBSCURE

One observation about the electromagnetic warfare (EW) discipline that I often share with people is that we're a "community of communities." We have groups, like the airborne electronic attack (AEA) community (comprised of smaller groups like the Growler community and the Compass Call community), as well as the rotary-wing EW community and the Wild Weasels. EW has a fast-growing CEMA community and a rapidly evolving space community. We have a surface ship EW community. For me, EW also includes the COMINT and ELINT communities (even if these groups don't always see it that way). What ties all of these together into a true EW community is the shared objective to control the EMS, but in a very humble way: monitor and control a specific number of frequencies in certain geographic locations for brief periods of time. It's important to recognize that the EMS is a vast warfighting domain and our EW resources are understandably limited in comparison.

Another observation is that each of these EW communities comprises all types of people, from weapons system operators and maintainers to program managers and systems engineers to technology developers and academics. Again, we comprise a vast range of EW professionals, some of whom may not think of themselves as "typical" members of the EW community.

Just as EW represents a "community of communities" and a "profession of professions," the same is true for technologies. There is no single technology or system that defines EW. Any technology that can be used to protect friendly maneuver in the EMS (electromagnetic protection), passively sense the EMS (electromagnetic warfare support) or deny adversary maneuver in the EMS (electromagnetic attack) is part of the EW toolbox. This brings me to this month's *JED* and Andrew White's excellent article about smoke and obscurants. This topic is about as niche as you can get in EW, yet at the same time it is just as much a part of EW as wideband digital receivers, DRFMs or quantum cascade lasers.

Andrew's article looks at the state of technology for smoke and obscurants and where it is headed. Part of his article covers DARPA's Coded Visibility program, which aims to create tunable obscurants with asymmetrical effects that enable friendly sensors to "see" through them in one direction while denying adversary sensors from seeing through them in the opposite direction. Coded Visibility clearly has applications for traditional smoke and obscurants applications, such as protection ground vehicles and small boats targeted by electro-optic sensors and laser-aided weapons. However, it also offers interesting possibilities for protecting aircraft from RF- and IR-guided weapons. It's worth noting that the contracting agent for Coded Visibility is the Air Force Research Lab.

I like Andrew's story in part because represents the idea that EW technology never dies; it just gets updated and re-introduced in new ways. I hope you enjoy our smoke and obscurants feature story and the rest of this month's *JED*. Your letters and comments are always welcome, and we are happy to publish them, with your permission. – *J. Knowles*

JED
Journal of Electromagnetic Dominance

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Calendar *Conferences & Trade Shows*

APRIL

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

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

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

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

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

MAY

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

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

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

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

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

JUNE

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

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

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

2023 Aircraft Survivability Equipment Missile Summit
June 27-29
Atlanta, GA
Darrell.L.Quarles.civ@army.mil

JULY

F-AIR Colombia
July 12-16
Rionegro, Colombia
www.f-aircolombia.com.co

AUGUST

Cyber DSA 2023
August 15-17
Kuala Lumpur, Malaysia
www.dsaexhibition.com

AUTOTESTCON 2023
August 26-29
National Harbor, MD
www.2023.autotestcon.com

DECEMBER

60th Annual AOC Symposium and Convention
December 11-13
Washington, DC
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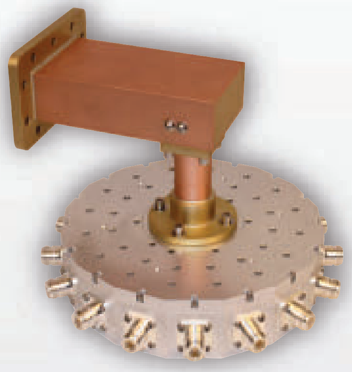
D8454	8-Way	370-450	10,000	50,000	0.25	1.30:1	3 1/8” EIA, N-Female
D5320	12-Way	470-860	500	5,000	0.30	1.30:1	All N-Female
D10119	4-Way	700-4200	2,000	15,000	0.30	1.35:1	13-30 DIN-Female, N-F
D10603	32-Way	900-925	50,000	150,000	0.15	1.25:1	WR975, 7/16-Female
D10795	32-Way	900-930	25,000	150,000	0.25	1.20:1	WR975, 4.3-10-F
D9710	8-Way	1000-2500	2,000	10,000	0.30	1.40:1	1 5/8” EIA, N-Female
D8182	5-Way	1175-1375	1,500	25,000	0.40	1.35:1	1 5/8” EIA, N-Female
D6857	32-Way	1200-1400	4,000	16,000	0.50	1.35:1	1 5/8” EIA, N-Female
D11896	4-Way	2000-2120	4,000	40,000	0.25	1.40:1	WR430, 7/16-Female
D11828	4-Way	2400-2500	3,000	25,000	0.20	1.25:1	WR340, 7/16-Female
D10851	8-Way	2400-2500	8,000	50,000	0.20	1.25:1	WR340, 7/16-Female
D11433	16-Way	2700-3500	2,000	20,000	0.30	1.35:1	WR284, N-Female
D11815	16-Way	2700-3500	6,000	40,000	0.30	1.35:1	WR284, N-Female
D12101	6-Way	2750-3750	2,000	20,000	0.35	1.40:1	WR284, N-Female
D9582	16-Way	3100-3500	2,000	16,000	0.25	1.50:1	WR284, N-Female
D12102	6-Way	5100-6000	850	4,500	0.35	1.35:1	WR159, N-Female
D12484	6-Way	8200-8600	600	700	0.35	1.25:1	WR112, SMA-Female
D12485	6-Way	9000-11,000	500	700	0.40	1.35:1	WR90, SMA-Female

Specifications subject to change without notice.





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APRIL

AOC Virtual Series Webinar: EMS as the Context of Military Operations
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Basic Antenna Concepts
April 11-13
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Basic RF EW Concepts
April 11-13
Atlanta, GA
www.pe.gatech.edu

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

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

Adaptive Arrays: Algorithms, Architectures and Applications
April 25-28
Atlanta, GA
www.pe.gatech.edu

MAY

Threat Radar Systems
May 1-5
Atlanta, GA
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M&S of Phased Array Antennas
May 2-4
Online
www.pe.gatech.edu

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

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

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

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

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

JUNE

Basic RF EW Concepts
June 6-8
Atlanta, GA
www.pe.gatech.edu

AOC Virtual Series Webinar: Current State – Way Forward – EW Insights
June 22
2-3 p.m. EDT
www.crows.org

JULY

AOC Virtual Series Webinar: EMS Conflict in Space – Threats to C4ISR
July 6
2-3 p.m. EDT
www.crows.org

AOC Virtual Series Webinar: How IADS and SAMs Work: Metric Accuracy, Transition to Track, and Hand-Offs
July 20
2-3 p.m. EDT
www.crows.org

EW DevOps
July 24-27
Online
www.pe.gatech.edu

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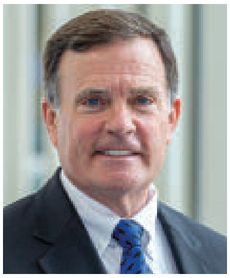
President's Message



INVESTMENT

This month's *JED* features a cover story about the US Navy's substantial long-term investment in surface-ship EW capabilities. While Navy EW programs, such as the Surface Electronic Warfare Improvement Program (SEWIP), Nulka decoy upgrades and Airborne Offboard Electronic Warfare (AOEW), represent a solid commitment to winning the fight in the electromagnetic operational environment (EMOE), the time it takes from identification of an EW requirement to fielding a new capability remains painfully long. Once these capabilities are fielded, the Navy will still take years to train with them and learn how to use them in the most effective ways.

About 15 years ago, a good friend and EW mentor of mine, Dennis Gronseth, used to give an eye-opening brief to Navy leadership on anti-ship missile defense (ASMD). Dennis would begin by asking the audience to guess how many anti-ship missiles (ASMs) had been shot in combat against surface ships around the world over the previous 40 years. They usually would be astounded to learn that there had been 126 attacks between 1967 and 2007. (Our international partners would have understandably been much less surprised.) The audience was even more surprised to learn about the disparity between the effectiveness of hard-kill weapons versus soft-kill in defending the ships. Out of 126 ASM attacks, when a defending ship used soft-kill countermeasures (chaff or active EA) not a single missile ever hit its intended target. While it may be surmised that some of these attacks may have missed due to weapon failure or poor targeting, the fact remained that when EW was employed, ships defeated over 100 ASMs. No ship employing soft-kill had ever been hit in that 40-year window.

In contrast, ships using hard-kill weapons alone (SAMs, gunnery, small arms) only destroyed one ASM in those same 40 years. Despite lessons learned by navies around the world, our tendency is to still prioritize investment in hard-kill weapon systems over soft-kill countermeasures. And even when navies do invest in EW capabilities, the dearth of focus on non-material challenges has exacerbated the problem. Are our Sailors educated and trained sufficiently in EW? Are our crews and watch teams able to execute techniques, tactics and procedures flawlessly? Are our battle groups integrated into a cohesive unit and ready to fight in a congested and contested EMOE when they deploy? Are our EW readiness metrics accurate? EW subject matter experts who are close to the details of the material and non-material issues are still losing sleep at night over the thought of a missile impacting a US warship.

Historically it is very difficult to convince people to invest in things they can't see. We have a long way to go, but it is important for our community to persevere in our efforts to advocate for what we know is game-changing, life-saving EW capability. – *Brian "Hinks" Hinkley*

DOD LEADERS DISCUSS EMSO IN CONGRESSIONAL TESTIMONY

The DOD released its FY2024 budget request as this issue of *JED* was going to press. In the days before, the House Armed Services Committee (HASC) and the Senate Armed Services Committee (SASC) started the process of annual hearings to receive testimony from DOD officials and other defense experts on a range of national security topics, including Electromagnetic Spectrum Operations (EMSO). In particular, the Strategic Forces subcommittees of the HASC and SASC, as well as the HASC's Cyber, Innovative Technologies and Information Systems (CITIS) subcommittee, had the opportunity to address EMSO-related questions to DOD officials from the Office of the Secretary of Defense, US Strategic Command and US Space Command. From these hearings, it was clear that Congress is focusing on two major areas of interest: the DOD's future path in EMSO, and the DOD's plans for potentially vacating or sharing portions of the S-Band spectrum, specifically 3.1-3.45 GHz.

John Sherman, the DOD's Chief Information Officer, testified in front of the HASC's CITIS subcommittee for its hearing on "Defense in a Digital Era: Artificial Intelligence, Information Technology, and Securing the Department of Defense." In his written statement to the committee, he described a range of initiatives within his office, including those related to EMSO, sharing DOD spectrum with the commercial sector, 5G and implementing the DOD's positioning, navigation and timing (PNT) strategy.

He wrote, "As the Department's senior official responsible for coordinating across the EMS Enterprise, we are employing and refining our governance processes to ensure synchronization and harmonization of all developments and activities necessary for the successful implementation of the 2020 Electromagnetic Spectrum Superiority Strategy (EMS3). The C3 Leadership Board and the EMS Senior Steering Group has broad participation from stakeholders across the Department, and work to drive towards the EMS3 vision of achieving freedom of action within the EMS at the time, place, and parameters of our choosing while denying the enemy the same."

During the hearing, Rep. Rich McCormick (GA-6) asked Sherman if DOD was investing enough into communications and counter-communications capabilities. Sherman responded, "So what you're talking about, sir, Electromagnetic Spectrum Operations, what we did in Vietnam, we had to do in Desert Storm and Bosnia and elsewhere, but to different degrees in Afghanistan and Iraq. But as we get ready for China, we better be able to fight and dominate in this space. So to you point, sir, I think investments from what I've seen are sufficient now. But this is something I'm going to 'bird dog' very carefully from my office here, particularly as we see the services starting to regenerate electronic warfare and other capabilities both to put the enemy back on their heels and ensure our NCOs and our trigger pullers can stay in touch with one another – as we've seen on the Ukrainian battlefield. All the dynamics with EMSO, with how the Russian's are trying to use it and the Ukrainians are using it, we cannot be cut off on this – to be able to make sure we can conduct combat operations." He added, "I think we need to keep a close eye on it here and monitor as we regenerate this capability that we had in the Cold War and that we had to somewhat turn away from during the War on Terror. As we regenerate it, I'm going to assure this committee I'm going to keep a close, close sight on this as we move forward."

Regarding spectrum sharing, Sherman stated in his written testimony, "The DOD supports efforts to ensure US dominance in 5G and next-G development. Previous DOD success in making spectrum available for commercial use through the Advanced Wireless Services -3, Citizens Broadband Radio Service, and America's Mid-Band Initiatives Teams are testaments to this commitment. DOD maintains numerous operational equities throughout the spectrum which must be preserved to enable DOD the ability to protect the homeland, test equipment, train for overseas contingencies and operate in all domains."

Sherman also wrote, "The Department remains committed to making mid-band spectrum available for industry while meeting our mission requirements. Within the 3100-3450 [MHz] band, the DOD relies on hundreds of air-, sea-, and land-based radars for a wide range of missions. It would be untenable for DOD to outright vacate these systems from the parts of the spectrum in which they currently operate. To do so would take decades, cost hundreds of billions of dollars, and cause significant mission impacts to the Joint Force's warfighting readiness and capabilities.

"We continue to make strong progress in the spectrum-sharing study of the 3100-3450 band, as required by the Infrastructure Investment and Jobs Act (IIJA). To inform this study, DOD is coordinating closely with the Department of Commerce and leveraging the technical expertise of government, industry, and academia. We will report our findings to the Department of Commerce by September 2023 as required by the IIJA."

Later in the hearing, Congressman McCormick addressed concerns about the DOD "giving up" spectrum to commercial telecoms providers. Sherman clarified the DOD's position: "Not giving it up, congressman, but figuring out how we could share it. Sharing in terms of time, in terms of geography and in terms of radio frequency, so we can conduct our military training operations here in the US and [for] homeland defense, but also giving our economy an ability to stay ahead of the Chinese in areas like 5G." He later added, "We wouldn't want to vacate, where we're shoved out and never to return again… But the band you noted, sir, this 3.1 to 3.45 [GHz], it's beachfront property – both for long-range radars, as well as telecom needs. And to the chairman's [earlier] point about competition and dominating against China, I have the CIO equities for DOD. I want our radars to work, be able to protect this homeland and keep our citizens safe. But I also know economic dominance matters. We have a study we're undertaking right now, per the Infrastructure and Investment Jobs Act that Congress tasked us to do and that culminates on 30 September. No decisions would be recommended be made until we can do our diligence and figure out if sharing is even possible."

In addition to the CITIS Subcommittee, both the SASC and HASC Strategic Forces subcommittees were interested in the S-Band spectrum study. Several senators on the SASC Strategic Forces Subcommittee discussed this with Gen Anthony Cotton, USAF, commander, US Strategic Command and General James Dickinson, commander, US Space Command, hoping to get an estimate of the cost should DOD vacate the 3.1- to 3.45-GHz spectrum. However, neither provided a solid cost estimate.

In the HASC Strategic Forces subcommittee hearing, however, Assistant Secretary of Defense for Space Policy Dr. John Plumb provided a conservative figure in response to HASC Strategic Forces

subcommittee chairman Rep. Doug Lamborn (CO-5). Dr. Plumb said, "That particular portion of the band, the S Band from 3.1-3.45 [GHz], is absolutely essential for DOD operations. The Department of Defense is conducting a study with the Department of Commerce on whether we can share the spectrum. For DOD, we need to be able to maintain our operational capability and readiness in any result. We've looked at what it might take to vacate, by which we mean to leave that band and go somewhere else. We don't know where else we would go. And it would cost easily $120 billion – probably more – just to create the pieces. But that isn't the same as getting the studies and the physics done or the recapitalization; it could take easily 20 years. It's a really difficult problem for us. And so we think the only viable way forward would be, is there some way to share so DOD can operate there and so other commercial companies might be able to use that, as well, without impeding us."

Congressman Lamborn asked Plumb, "Did you say $120 million or billion?"

Plumb responded, "That's billion with a 'b,' and that's kind of our low estimate. I don't want that to be confused with what it would actually cost, because that's really just if you look at what would it cost [for example] to make a new AEGIS radar. But that's not the same as figuring out the physics and all the testing that would go into figuring out what bands we would have to use it in, let alone the decades of experience we have with the equipment now to understand how they work." At the very least, SASC and HASC members wanted assurances that the DOD would not take any action on the S-Band spectrum until after the study was finished and released for review.

The Strategic Forces subcommittees of the HASC and SASC also addressed the status of EMSO across the DOD in their hearings with General Cotton, who oversees USSTRATCOM's Joint EMSO office. He stated in his written testimony, "Per the Unified Command Plan (UCP), CDRUSSTRATCOM is responsible for advocating for JEMSO and electromagnetic warfare capabilities, providing contingency electronic warfare support to other CCMDs [combatant commands], and supporting CCMD joint training and planning related to controlling the EMS. Potential adversaries understand our dependency upon the EMS and have developed technology to effectively contest our use of it. Additionally, increased civil and commercial use of spectrum bandwidth significantly congests the EMS and constrains DOD use. Multiple USSTRATCOM assessments have identified JEMSO readiness shortfalls, which are growing. Our adversaries have dramatically increased their offensive and defensive capabilities in recent years; the DOD must similarly improve our ability to operate in a degraded electromagnetic warfare environment."

His statement continued, "We must continue to pursue a DOD-wide effort to achieve EMS superiority and mission success. To support the goals of the DOD EMS Superiority Strategy, USSTRATCOM is executing twelve assigned tasks, including establishing an organization, led by a 2-star, called the Joint Electromagnetic Spectrum Operations Center (JEC). The JEC will lead execution of the eleven other USSTRATCOM assigned DOD EMS Superiority Strategy tasks. Additionally, USSTRATCOM has led development of JEMSO cells at other CCMDs to enable these functions. We are also working with the DOD Chief Information Officer to develop a software system for use by CCMD JEMSO cells in planning, coordinating, and controlling the EMS. Following multiple assessments from Northern Edge – USINDOPACOM's tier 1 exercise – USSTRATCOM is pursuing accreditation authorities for Joint Force EMSO readiness that will help close capability gaps. USSTRATCOM is also establishing an EMSO training and education capability to coordinate DOD EMS joint training, streamline training processes, and promote standardization."

During the HASC Strategic Forces subcommittee hearing, Congressman Lamborn said to General Cotton, "On the issue of EMSO, as I emphasized in my opening statement, I think DOD needs to commit to fixing EMSO, and plugging the holes identified in the Northern Edge exercise. I understand that this has the attention of Secretary Hicks and Admiral Grady, and I hope that we will have good progress on this." He then asked General Cotton what were some the warfighter needs that would be essential for competing with Russia and China in the future.

General Cotton responded, "We need to ensure that we have spectrum for employment of forces, to maintain situational awareness, to assure communications via all domains – space, maritime, air, and land – and to assure positioning with PNT, with positional navigation systems. What we're doing within STRATCOM, my top priority is to execute the DOD EMS Superiority Strategy Implementation Plan. What we're going to do is, we're actually in the midst of standing up a two-star Joint EMS Operations Center known as the JEC – a direct report to me that raises and aggregates force readiness across the Department. We'll continue to ensure that the Joint Force appropriately is organized and equipped to handle EMS. I am responsible for advocating the proper training when it comes to EMS ... What makes this particularly helpful to me is the fact that my direct report will be the Deputy Secretary of Defense, who can direct services to take action."

Next month, *JED* will provide more reporting on the EMSO aspects of the DOD's FY2024 budget request. – *J. Knowles*

UK FUNDS SPEAR-EW RAPID DESIGN, STUDIES JOINT EFFORT WITH SWEDEN

As it advances plans to introduce the SPEAR-EW stand-in jammer on Royal Air Force (RAF) Typhoon and F-35B Lightning II combat aircraft, the UK Ministry of Defence (MOD) has revealed that it has begun parallel studies with Sweden to explore the potential for a joint stand-in jammer program.

Derived from the MBDA (Stevenage, UK) SPEAR network-enabled mini-cruise missile, which is already planned for integration with both Typhoon and F-35B, SPEAR-EW has been conceived as a long-range stand-in jammer and decoy to support the suppression of enemy air defenses and thereby increase the survivability of offensive air in complex and contested airspace. While re-using the same basic turbojet-powered air vehicle as the kinetic SPEAR missile, the SPEAR-EW derivative dispenses with the seeker package and warhead in order to accommodate additional fuel (increasing range and loiter time) and a miniaturized DRFM electronic attack payload supplied by Leonardo (Luton, UK).

MBDA in September 2019 commenced a technology demonstrator program funded by the MOD. This was designed to de-risk the integration of the Leonardo EA payload into the air vehicle and wider weapon system, identify the necessary design adaptations, and inform the MOD's investment case.

The TDP, which concluded in March 2021, established the feasibility of a stand-in jamming capability utilizing the SPEAR Cap 3 airframe. It also confirmed the that the stand-in jammer variant could retain the same weapon body, mass and center of gravity characteristics as the kinetic weapon: maintaining these physical characteristics is seen as critical in order to make significant financial savings in weapon/aircraft integration costs.

A follow-on SPEAR-EW Rapid Design Phase, planned to last 24 months, commenced in November 2022. According to the MOD, this activity will gather evidence to inform a future investment decision, amass component parts, complete design plans and produce evidence needed to deliver a small number of SPEAR-EW effector kits to support subsequent rapid qualification.

In parallel, the MoD has disclosed that the UK and Sweden in September 2022 began a bilateral stand-in jammer concept study. This 12-month program of work is aimed at determining if he two nations can agree a joint stand-in jammer requirement set, and consider options for a potential joint development program.

MBDA has already undertaken preliminary studies with Saab (Järfälla, Sweden) to examine the integration of Saab's "sovereign" small form-factor Arexis EA payload with the SPEAR-EW air vehicle and weapon system architecture. Saab has looked to offer the Arexis air-launched decoy/stand-in jammer to current and potential customers for its JAS 39 Gripen fighter. – *R. Scott*

IN BRIEF

The **Air Force Research Lab Sensors Directorate** (Wright-Patterson AFB, OH), Spectrum Warfare Division, RF Electronic Warfare Branch (AFRL/RYWE), has issued a Notice of Contract Action (NOCA) under its Kaiju Broad Agency Announcement (BAA FA8650-22-S-1004) indicating that it is preparing to solicit proposals for its Colossus effort (Call 02 under the BAA). According to the program description, "The overall objective of Call 02 is to develop capabilities that will directly feed future AFRL advanced 6.3 programs. COLOSSUS will develop and utilize the following Kaiju technical objectives: Electronic Warfare (EW) Adaptive Management, Electronic Attack (EA) Demonstrative and EW Advanced Threat Defeat." Colossus funding is expected to reach $15 million over 4 years. This includes $5 million for "Advanced EW," $8 million for modelling simulation and analysis, and $2 million for model-based systems engineering. The technical point of contact is Weston Earick, AFRL/RYWE, (937) 713-4021, email weston.earick.1@us.af.mil. An AFRL solicitation requesting white papers is expected in the coming weeks.

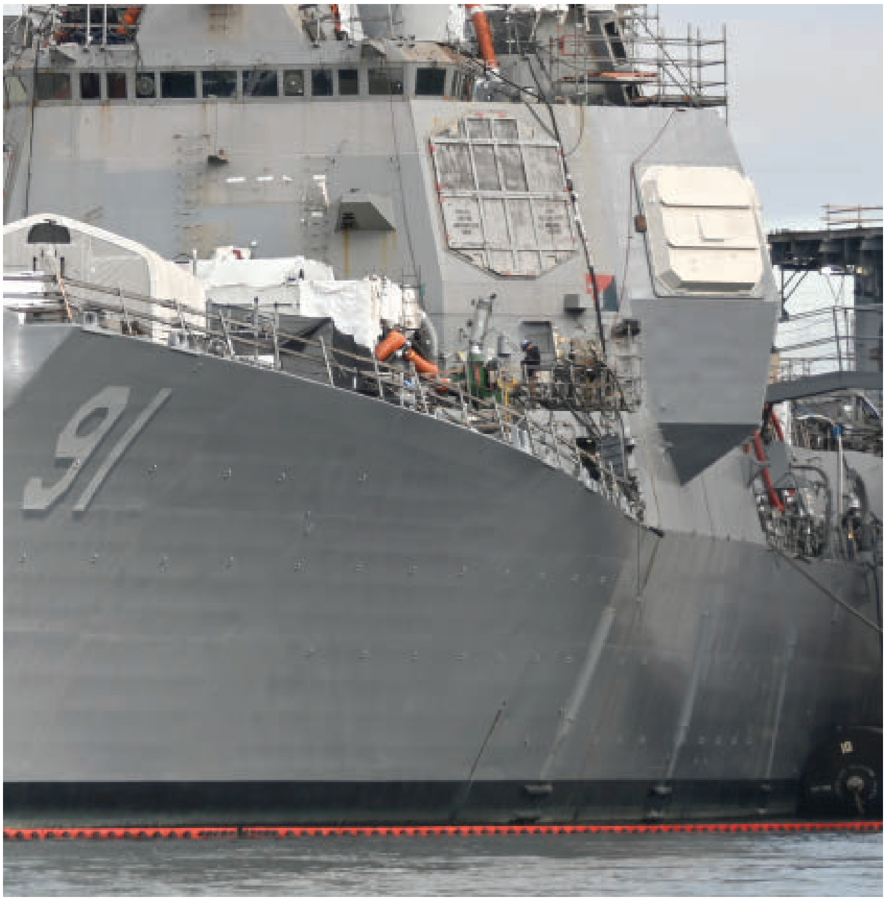
Elettronica (Rome, Italy) has won a contract to provide EW suites for the Angolan Navy's new BR71 Mk II corvettes. Abu Dhabi Ship Building announced the order for up to three corvettes in late February in a deal potentially worth up to €1 billion. In other company news, it announced plans to collaborate with Mitsubishi Electric in Japan and Leonardo in the UK ahead of a possible teaming arrangement for the tri-nation (Japan, UK and Italy) Global Combat Air Program's (GCAP) Integrated Sensing and Non-Kinetic Effects & Integrated Communications Systems (ISANKE & ICS).

Northrop Grumman said it has transitioned a new wideband sensor, the Electronically-Scanned Multifunction Reconfigurable Integrated Sensor (EMRIS), to an integration and test phase. According to the company, "EMRIS's fully digital Active Electronically Scanned Array (AESA) utilizes technology from the Defense Advanced Research Projects Agency Arrays on Commercial Timescales (ACT) program combined with government open-architecture standards. By applying the flexibility of a digital AESA, EMRIS can perform functions including radar, electronic warfare and communications simultaneously."

US Space Command has re-designated the 380th Space Control Squadron, a unit of the 710th Operations Group, as the **380th Electromagnetic Warfare Squadron** in a ceremony at Peterson AFB, CO. The 380th EWS mission will not change. It will continue to monitor satellite communications links with the Bounty Hunter system to detect and geolocate satellite sources of communications jamming and interference, as well as other signals of interest.

Electronic Attack i Reinvests in Non-K

By Richard Scott



The DDG 51 Flight IIA destroyer USS Pinckney is the first ship to receive the SEWIP Block 3 EA subsystem. The new hemispherical antenna array (hidden by a protective cover) is fitted on a new deckhouse sponson. CHRIS CAVAS

As it continues to modernize key electronic warfare (EW) capabilities across its surface fleet, the US Navy will later this year see its next-generation shipborne electronic attack (EA) system go to sea for the first time.

The Surface Electronic Warfare Improvement Program (SEWIP) Block 3 introduces what the Navy believes will be the most advanced onboard EA system of its kind anywhere in the world. Developed by Northrop Grumman, it constitutes the latest increment in an overarching EW recapitalization effort, which is delivering significantly improved electronic support and countermeasures capabilities to the surface force.

More is to come, including a new podded airborne Advanced Offboard Electronic Warfare (AOEW) payload under development by Lockheed Martin is now in flight test with the MH-60S/R helicopter and early work is underway on a next-generation long-endurance active offboard decoy.

Meanwhile, the fleetwide rollout of the SEWIP Block 2 electronic support (ES) sensor continues to major surface combatants, nuclear-powered aircraft carriers (CVNs) and large amphibious ships. A first major technology refresh for Block 2 is now in progress.

SEWIP ORIGINS

Emerging in 2002 in the aftermath of the cancelled AN/SLY-2(V) Advanced Integrated Electronic Warfare System (AIEWS) program, SEWIP is a spiral block upgrade program based on integrating technology advances and incrementally adding functionality into the legacy AN/SLQ-32(V) system to improve ES (emitter detection, analysis, identification and threat warning) and EA (to counter anti-ship missile threats) performance. There are currently three established block upgrades, with a fourth planned.

SEWIP Block 1, delivered by General Dynamics Mission Systems, comprises a series of low-risk, near-term upgrades to address obsolescence and at the same time improve anti-ship missile defense (ASMD), counter-targeting and counter-surveillance capabilities. The Block 1A fit, of which 121 were completed, introduced an updated Improved Control and Display (ICAD) human machine interface and electronic surveillance enhancements. This updated the obsolete AN/SLQ-32 display and pulse processing with a much-needed refresh based on commercial-off-the-shelf (COTS) technology.

s Back – US Navy inetic Defense

Block 1B1 added a standalone Specific Emitter Identification (SEI) capability using the Naval Research Laboratory (NRL)-developed AN/SSX-1 Small Ship Electronic Support Measures module (comprising the AS-1200A antenna, AN/UYX-4 processor unit, CS-5020C receiver/tuner, and a standalone laptop for display). Block 1B2 integrated this SEI functionality into the ICAD/Q-70 console environment, and added network centric and mission planning capabilities. General Dynamics completed 148 Block 1B1 and 1B2 systems.

A further sub-block, known as Block 1B3, introduced a High-Gain High-Sensitivity (HGHS) capability. Implemented through the addition of an HGHS processor and mast antenna, the Block 1B3 is an adjunct threat correlation/situational awareness sensor forming a critical sub-component of the AN/SLQ-32(V)6 system architecture realized in SEWIP Block 2.

Following competition, Lockheed Martin was selected in 2009 by Naval Sea Systems Command (NAVSEA) to deliver SEWIP Block 2 (the Block 1B3 HGHS adjunct sensor and Block 2 units are installed in conjunction to create the AN/SLQ-32(V)6 system). The Block 2 embodiment introduces a major ES upgrade comprising a new antenna array and new digital receiver to deliver improved emitter detection and measurement accuracy, plus a new open combat system interface.

Lockheed Martin's technical solution promoted the maximum use of COTS electronics, with an architecture based on Mercury Systems' Echotek Series microwave tuner and digital receiver products. Another key subcontractor for SEWIP Block 2 is CAES, which supplies the interferometer-based antenna array panel assemblies for AN/SLQ-32(V)6. As well as a fine angular resolution, SEWIP Block 2 also provides elevation measurement.

A first low-rate initial production (LRIP) contract was awarded in January 2013. SEWIP Block 2 transitioned into full rate production (FRP) in 2016. An initial AN/SLQ-32(V)6 installation was completed on the guided missile destroyer USS *Bainbridge* (DDG 96) in 2014 for at-sea testing. The system has subsequently been rolled out to DDG 51 destroyers, large amphibious ships and CVNs as both a backfit and for new construction.

"We are continuing full rate production, and to date we have delivered over 130 [SEWIP Block 2] systems," says Joe Ottaviano, Lockheed Martin's Director, Maritime Airborne Cyber Electronic Warfare. "The number and complexity of threat signals is increasing all the time, and Block 2 is giving the Navy the ability to detect and analyze those more complex emitters."

A compact SEWIP Lite variant, known as AN/SLQ-32C(V)6, has entered production to provide early detection, signal analysis and threat warning for smaller combatants ships where topside margins are more limited. This followed the rapid build and demonstration of an engineering development model which was tested at sea in late 2014/early 2015.

Initial deliveries of AN/SLQ-32C(V)6 are supporting the US Coast Guard *Heritage*-class Offshore Patrol Cutter program, says Ottaviano. This scaled variant is also in production for the Littoral Combat Ship, and is slated for the new FFG-62 *Constellation*-class frigate.

Lockheed Martin is now implementing a first substantial tech refresh for SEWIP Block 2, for which Mercury Systems is providing new hardware. The first increment of hardware deliveries began last year, to be followed in 2024 by the introduction of RF-system-on-a-chip (RFSoC) technology into the

Lockheed Martin has now delivered over 130 SEWIP Block 2 systems to the fleet. US NAVY

The SEWIP Block 3 EDM seen during testing at Northrop Grumman's Baltimore facility. The EDM was delivered to the Surface Combat Systems Center at Wallops Island in mid-2021. NORTHROP GRUMMAN

system. RFSoC will rationalize part count, increase reliability and offer greater bandwidth.

ENTER BLOCK 3

Lockheed Martin teamed with Raytheon to bid for SEWIP Block 3, which adds an advanced EA module to AN/SLQ-32(V)6 to create the AN/SLQ-32(V)7 system. However, following a protracted competition, NAVSEA in February 2015 selected a rival bid from Northrop Grumman for Block 3 design and development. General Dynamics Mission Systems, as subcontractor, is leading on human systems integration and training tasks.

SEWIP Block 3 will introduce an integrated EA capability, based on wideband active electronically scanned array (AESA) technology, to provide non-kinetic defense against RF-guided threats. Block 3 additionally encompasses a government software development effort for a Soft-Kill Coordination System (SKCS) to provide direction and scheduling for both onboard and offboard RF decoys; SKCS also incorporates Softkill Performance and Real-Time Assessment (SPARTA) algorithms designed to measure EA effectiveness and perform real-time assessment and adjustment of effects.

RADM Seiko Okano, Program Executive Officer for Integrated Warfare Systems (PEO IWS), confirmed to January's Surface Navy Association (SNA) annual symposium, that SEWIP Block 3 will go to sea this year. "This system is going to be just unprecedented in capability," she added. "It will provide us with a critical electronic warfare capability as the pace and complexity of emerging threats continues grow."

According to Mike Meaney, Northrop Grumman's vice president, Land and Maritime Sensors, the big advantage on an onboard EA system is that it provides the command with a near inexhaustible "deep magazine" to complement hard-kill weapons. "You can defend yourself against the threats that Navy ships face in a number of ways," he explains. "But when you're protecting yourself kinetically – launching missiles against missiles – eventually you will run out of missiles. Non-kinetic offers that opportunity so you can defend yourself for a long time against a wide range of different threats."

Each SEWIP Block 3 system is comprised of 16 AESA arrays, split into four faces per quadrant (two for receive, two for transmit). "Because we can steer beams near instantaneously, we can put out multiple beams simultaneously to jam multiple threats," Meaney says. "Also, an AESA allows you to generate a very narrow and focused beam."

Under the SEWIP Block 3 Engineering and Manufacturing Development (EMD) phase, Northrop Grumman has built a production-representative Engineering Development Model for laboratory and field testing. Following the completion of contractor testing at its Baltimore site, the EDM was in mid-2021 shipped to NAVSEA's Surface Combat Systems Center at Wallops Island, VA, for evaluation.

Northrop Grumman received an order in late 2018 for two SEWIP Block 3 LRIP units following a Milestone C acquisition approval. The first of these units has now been installed on board the DDG-51 Flight IIA destroyer USS *Pinckney* during the ship's refit in San Diego, and will go to sea later in 2023.

In September 2020, NAVSEA awarded Northrop Grumman a contract for FY 2020-24 SEWIP Block 3 electronic attack subsystem full-rate production and AN/SLQ-32(V)7 integration. In September 2022, the company received a five-year, sole-source contract, valued at up to $83.5 million, for Design Agent services in support of the SEWIP Block 3 EA subsystem.

"We are moving forward on all cylinders," says Meaney. "That first installation is underway on the west coast and is proceeding well. At the same time, we have our [EDM] continuing testing at Wallops Island, and that is proceeding well.

"In parallel, we have production underway in our factory in Baltimore. We currently have nine systems under contract, with further options available to the Navy to exercise."

The US Navy is currently looking at approximately 20 SEWIP Block 3 backfit installations on DDG-51 Flight IIA destroyers as part of its DDG MOD 2.0 effort. The DDG MOD 2.0 upgrade will also introduce the AN/SPY-6(V)4 Air and Missile Defense Radar, an AESA based system that features four array faces (each with 24 radar module assemblies) covering 360 degrees and the Baseline 10 version of the Aegis combat system.

DDG 51 Flight IIA ships are receiving the AN/SLQ-32(V)7 Hemisphere configuration, with sponson-mounted installations on the port and starboard sides of the main deckhouse block. A modified Quadrant configuration, using distributed and repackaged hardware building blocks, is planned for the CVNs and *Wasp*-class amphibious assault ships.

"Last year we finished the Quad design, which is aimed at those large deck ships," Meaney explains. "That design is complete and the technical data package has been handed over to the Navy and accepted. As part of their planning process, they're now thinking about when they go buy some of those [Quad] configuration systems. In most ways it is the same system, but just configured differently for a much larger ship."

It is noteworthy that Northrop Grumman's SEWIP Block 3 solution has leveraged technology and techniques previously matured and de-risked under the Office of Naval Research's (ONR) Integrated Topside (InTop) Innovative Naval Prototype (INP) program. Begun back in 2009, InTop sought to demonstrate a scalable suite of EW, information operations (I/O) and line-of-sight communications hardware and software for use on naval surface platforms. Northrop Grumman was subsequently selected to lead on the development of an integrated Multibeam EW/IO/Comm Advanced Development Model (ADM) embodying multifunction, multi-band and multibeam wideband arrays.

"ONR had the vision of combining all these functions [EW, IO and communications] together," says Meaney. "We built very wide frequency band apertures, we built the resource manager and then we demonstrated an entire series of very complex, simultaneous mission capabilities for ONR and the Navy in general."

The Multibeam EW/IO/Comm ADM was delivered to NRL's Chesapeake Bay Detachment (CBD) facility in 2014; testing performed in late 2015 demonstrated simultaneous EW, IO and communications functionality for the first time. Evaluations have subsequently continued at CBD, with the Multibeam EW/IO/Comm ADM directly supporting technology maturation relevant to SEWIP Block 3.

In advance of the arrival of AN/SLQ-32(V)7 in the fleet, the US Navy has deployed two threat-specific interim EA systems derived from NRL's Transportable Electronic Warfare Module (TEWM) program to address separate Urgent Operational Needs Statements (UONS) raised by the US Sixth Fleet (Europe) and Seventh Fleet (Pacific). The SEWIP Block 3T program has introduced the AN/SLQ-59 system to address the Seventh Fleet UONS, while a separate TEWM exploitation, codified as AN/SLQ-62, has entered service to meet a classified Sixth Fleet UON.

EO/IR COUNTERMEASURES

A still nascent SEWIP Bock 4 has conceived of adding a shipborne electro-optical/infrared countermeasures (EO/IRCM) capability. ONR's Combined EO/IR Surveillance and Response System (CESARS) Future Naval Capabilities effort, begun in 2016, has informed potential SEWIP Block 4 requirements and helped to de-risk enabling technologies with a view to transitioning into a program of record.

CESARS embraced two distinct functional components: the Shipboard Panoramic EO/IR Cueing and Surveillance System (SPECSS); and Multispectral EO/IR Countermeasures for Advanced Threats (MEIRCAT). SPECSS was focused on wide field of view target detection and tracking, with subsequent cueing of MEIRCAT high-resolution sensors to perform target re-acquisition, tracking, classification/identification, 3-D ranging, threat assessment, countermeasures execution and countermeasures effectiveness monitoring.

Three contracts were let by NRL in support of MEIRCAT: BAE Systems Information and Electronic Systems Integration was awarded a $4.9 million in February 2016; Lockheed Martin's Aculight laser business was awarded a $10.6 million contract in March 2016; and L-3 Cincinnati Electronics received a $6.9 million contract in April 2016.

No details of MEIRCAT prototype testing have been publicly released, but Lockheed Martin earlier this year displayed a model of the system at the SNA annual symposium, describing it as an advanced laser EO/IRCM system for ship protection. In an accompanying infographic, the company said that MEICAT – as the CESARS "response system" –


Exploitations of NRL's Transportable Electronic Warfare Module (TEWM) program have been developed to address UONS raised by the US Sixth Fleet (Europe) and Seventh Fleet (Pacific). The SEWIP Block 3T program introduced the AN/SLQ-59 system to address the Seventh Fleet UONS (the antenna is visible above the SEWIP Block 2 array on USS Spruance); a separate TEWM exploitation, codified as AN/SLQ-62, has entered service to meet a classified Sixth Fleet UON.
US NAVY

Lockheed Martin's AOEW Active Mission Payload - designated AN/ALQ-248 – is a self-contained EW pod hosted by an MH-60R/S helicopter. LOCKHEED MARTIN AND RICHARD SCOTT

was designed to provide long-range EO/IRCM to support layered defense, and employed a "high power laser and agile turret for multi-threat countermeasures." In addition, Lockheed Martin noted the adoption of a modular open system architecture design to enable easy integration and interfacing with Navy ship systems.

ADVANCING AOEW

Another key component in the Navy's non-kinetic defenses is a new helicopter-borne, long-endurance AOEW Active Mission Payload (AMP) being developed by Lockheed Martin. The system, which will be hosted as an external store by MH-60R and MH-60S multi-mission helicopters, is a self-contained pod – designated AN/ALQ-248 – providing both high sensitivity receiver and EA subsystems. CAES, as Lockheed Martin's partner and major subcontractor for the AN/ALQ-248 system, is supplying phased array transmit and receive antennas.

Operating independently, or in coordination with the shipborne AN/SLQ-32(V)6/(V)7 systems, the AOEW AMP is designed to provide Navy battle groups with enhanced electronic surveillance and ASMD countermeasure capabilities. In the former case, the pod will use its own high-sensitivity receiver system to detect, identify and track threat emitters, and then cue the advanced EA subsystem to generate and transmit the appropriate RF jamming techniques. In the coordinated mode, the shipborne AN/SLQ-32(V)6/(V)7 system will detect incoming anti-ship missile threats, then cue and control the AN/ALQ-248 system (via Link 16) using its SKCS function.

Following receipt of an AOEW AMP preliminary design contract in late 2016, Lockheed Martin received an EMD award from NAVSEA in September 2017. A number of Engineering Development Models are now supporting AOEW AMP test and certification; the program has also been required to complete MH-60R/S Avionics Operating Program software development to enable flight certification.

Initial operational test and evaluation is planned for the third quarter of FY 2026. "We received a first LRIP contract, for two systems, in September 2021," explains Lockheed Martin's Ottaviano. "LRIP2 followed in September last year, again for two systems. And we are now in discussion with the Navy on LRIPs 3 and 4."

LEED ASTRAY

Looking beyond AOEW, the US Navy is developing plans for a new persistent offboard ASMD decoy under the Long Endurance Electronic Decoy (LEED) program. LEED has conceived of an expendable autonomous off-board countermeasure – marrying a flight vehicle and an RF payload – able to integrate with the AN/SLQ-32(V)6/(V)7 system to provide the fleet with enhanced EW coordination and capability, including the ability to stretch engagement timelines and counter heterogeneous missile attacks. The decoy flight vehicle will include a communications link for command-and-control updates in order to reposition and realign to the threat; a modular design philosophy is intended to allow for the rapid modification and evolution of the EW payload to stay ahead of new RF threat capabilities.

LEED countermeasure development is being executed under a Middle Tier rapid prototyping acquisition strategy. Lockheed Martin Missiles & Fire Control (Grand Prairie, TX) has been selected as prime contractor to lead the rapid development effort for LEED.

While information on LEED development remains limited, a summary note in the FY2023 DOD budget request indicated that Phase 1 development – including component integration, prototype build, preliminary demonstration testing and countermeasure performance testing – is planned to run through to the end of FY 2024. A follow-on Phase 2, running from FY2024 to FY2025, will build on the critical technologies from Phase 1 to develop a production-representative Engineering Development Model for delivery in mid-FY2025.

Phase 3, planned to start in FY2025, will procure and field initial units to the fleet, while the transition to major capability acquisition for full production and sustainment is executed. According to budget documents, operational demonstration assessment testing is planned to run in late FY2026

LEED is leveraging technology outputs from the ONR's Long Endurance Airborne Platform (LEAP) project, which began in FY 2021. The Navy believes that inputs from LEAP will accelerate the development cycle and support earlier LEED fielding

The NRL has previously prototyped a low-cost rotary-wing mini-UAV known as NOMAD [Netted Offboard Miniature Active Decoy] as a part of ONR's NEMESIS (Netted Emulation of Multi-Element Signatures Against Integrated Sensors) Integrated Naval Prototype (INP) effort. The NEMESIS INP set out to develop a system of systems providing the ability to synchronize EW effects across a variety of distributed platforms so as to create a coherent and consistent EW response that confuses adversary surveillance and targeting systems. As well as the development of modular and reconfigurable EW payloads, the program also encompassed decoy and unmanned air and surface platforms and the implementation of EW functionality and decoys with autonomy, networking and countermeasures coordination techniques.

The tube-launched NOMAD vehicle developed by NRL features flip-out counter-rotating coaxial rotors located at either end of a longitudinally-extending body. A soft-launch CO_2 ejection system is used to eject the round, which can be deployed as either as a single unit, or in a coordinated "nest" of multiple decoys

First at-sea launches of NOMAD were performed from the destroyer USS *Pinckney* during mid-2016 as part of the RIMPAC 2016 exercise. During testing, the air vehicle achieved 30 minutes flight time

Lockheed Martin displayed a model of the MEIRCAT laser EO/IRCM system at the SNA annual symposium in January 2023.
RICHARD SCOTT

– twice the expected endurance – so allowing NOMAD to keep up with the ship for more than 8 nautical miles, including transit at 20 knots.

Further testing of NOMAD was performed from the Littoral Combat Ship USS *Coronado* in August 2017. In this series, multiple NOMAD vehicles were launched in quick succession, conducted formation flying operations, and were then recovered sequentially on board. This marked the first time that the NOMAD multi-launch/recovery technology had been trialed on a US ship.

NULKA UPGRADES

The US Navy has funded development of new RF payloads for the MK 234 Nulka active offboard decoy system under the Advanced Decoy Architecture Program (ADAP). In September 2015, L3Harris was awarded a three-year contract to develop ADAP payloads leveraging from earlier research and engineering development performed by the NRL under the ONR's E-Nulka program.

Nulka is an expendable soft-kill countermeasure designed to seduce radar-guided anti-ship missiles in their terminal homing phase. The original MK 234 electronic decoy cartridge combines a hovering rocket payload carrier vehicle (produced by BAE Systems Australia) atop which is mounted a broadband RF repeater payload (produced by Lockheed Martin) designed to seduce RF homing anti-ship missiles away from their intended targets. In US Navy service, the Nulka round is fired from the Mk 53 decoy launching system.

The ADAP payload upgrade effort was instigated by the US Navy as a rapid deployment capability (RDC) to field an improved Nulka decoy to address more advanced anti-ship missile threats. More specifically, ADAP incorporates an advanced transmitter and improved signal processing to target specific threats that the original payload on the Nulka decoy did not.

DOD budget documents have revealed the existence of two ADAP variants known as Nulka-X and Nulka-Y. Nulka-X – the first variant to be fielded with an ADAP payload as an RDC – is believed to form part of an EW/soft-kill chain tailored to defeat the threat posed by the Yakhont (SS-N-26 Strobile/SSC-5 Stooge) supersonic anti-ship missile threat in the eastern Mediterranean and the Black Sea.

Alongside the Nulka X/Y payloads introduced under ADAP, information released as part of the FY2023 budget submission reveals the existence of a Nulka Advanced Payload (which provides additional threat-based capability through the introduction of an advanced transmitter and increased signal processing capability). The exact relationship between the ADAP program and the Advanced Payload developments has not been publicized.

NAVSEA in September 2021 awarded L3Harris a contract worth up to $124 million to supply ADAP payloads (MK 234 Mod 10/11/12/13) to both the US And Australian navies.

Son of Sidekick?

Following the attack on the USS *Stark* in May 1987, the US Navy raised an urgent requirement to introduce an EA capability on FFG-7 Oliver Hazard Perry class frigates equipped with the passive-only AN/SLQ-32A(V)2 ES suite. This RDC effort led to the fielding of a small and lightweight point defense jammer known as Sidekick; the AN/SLQ-32A(V)2 system in combination with Sidekick received the nomenclature AN/SLQ-32(V)5.

Some 35 years later, the US Navy is again giving consideration to the acquisition of a compact EA system tailored to smaller surface combatants. And while the Navy has yet to stand up a program of record, industry is already investing its own dollars to explore potential solutions should the requirement solidify.

Northrop Grumman, for example, is pursuing a scaled down "Ultra-Lite" derivative of SEWIP Block 3 in anticipation of a possible requirement for an onboard EA capability for smaller ship classes. "We think any ship going in harm's way should have some form of protection [and that] putting a non-kinetic system on any ship represents outstanding value for money," says Northrop Grumman's Mike Meaney.

Two key drivers are foremost in mind, adds Meaney. "First, it has to have high if not total compatibility with what already exists today in the [SEWIP Block 3) system, both in terms of parts and software. Also, as you scale the system down, we're thinking about that ship install process – with a much smaller system it becomes much, much easier to integrate on board a ship. Right now, a full SEWIP [Block 3] system is an extensive undertaking, so we're creating a more platform-agnostic and flexible design."

In January, Northrop Grumman revealed that key components of its Ultra-Lite EA solution were demonstrated in collaboration with the NRL on board a DDG-51 destroyer as part of last year's RIMPAC 2022 exercise. In this case, the company integrated Ultra-Lite EA transmit/receive technology with NRL's expeditionary EA antenna subsystem. According to the company, the combined system was "successfully demonstrated over many RIMPAC exercise events" and proved that the scaled EA solution "can effectively support US Navy missions."

Additional concept demonstrations are planned to run during 2023 to further demonstrate the reliability and scalability of the system to the US Navy. "This will include lab trials, land-based tests and further at-sea demonstrations," says Meaney.

Lockheed Martin is also looking at how it could address the Navy's nascent requirement for a small surface combatant EA solution. Its candidate – dubbed Scaled EA – derives from the company's experience with both SEWIP Block 2 and AOEW.

Ease of ship installation figures large in the mind, with Lockheed Martin looking at a ship fit availability typically lasting 60-90 days. A demonstrator system was tested during RIMPAC 2022, and more tests are planned during 2023. *– R. Scott*

Seeing (and Fighting)

By Andrew White

The Screening Obscuration Module (SOM), developed by the Joint Program Executive Office for Chemical, Biological, Radiological and Nuclear Defense (JPEO-CBRND) and L3Harris Technologies, can be mounted on a variety of ground vehicles. Above, the SOM on a Utility Task Vehicle is autonomously activated during the Robotic Complex Breach Concept (RCBC) on Yakima Training Center in Yakima, in April 2019.

USMC PHOTO BY LCPL NATHANIEL Q. HAMILTON

In August 2021, NATO completed its controversial withdrawal from Afghanistan, drawing to a close more than two decades of counter-terrorism and counter-insurgency operations in central Asia. Just months later, Russia invaded Ukraine for the second time in less than a decade. Today, the conflict is still raging and spearheading the pivot away from counter-terrorism and counter-insurgency operations and towards increased focus on conventional warfare.

Heavily backed by Western governments, Ukrainian Armed Forces (UAF) now find themselves at the tip of the spear, engaging a highly capable and well-equipped adversary on land, in the air and at sea. Western nations are learning many lessons from the conflict, including greater attention on protecting mounted and dismounted ground units from detection, identification and targeting by long range, precision fires. This includes consideration of "Camouflage, Concealment, Deception & Obscurant" (CCD&O) tactics, techniques, procedures and technologies that enable main battle tanks (MBTs), infantry fighting vehicles (IFVs), mobile rocket, artillery and mortar (RAM) platforms and dismounted teams to avoid attacks by the enemy.

Active Protection Systems (APS) are not yet mature and cost effective enough to support the UAF. However, there are alternative means to better protect armor on the battlefield from Russian precision fires. Some of these solutions include smoke and obscurants, which can be deployed by vehicles and dismounted personnel, as well as air and maritime platforms.

According to a report published by the UK's Royal United Services Institute (RUSI) on 30 November entitled "Preliminary Lessons in Conventional Warfighting from Russia's Invasion of Ukraine: February-July 2022," the defeat of precision fires has been "critical to unit survival." It also says, "For land forces, the pervasive ISTAR [intelligence, surveillance, targeting and reconnaissance] on the modern battlefield and the layering of multiple sensors at the tactical level make concealment exceedingly difficult to sustain. Defeating precision could be achieved by preventing a launcher from accurately determining its position, even with very small displacements, by preventing the enemy determining the precise location of the target or through direct interference with the mechanism for precision strike," the report suggested.

"The latter did not always require expensive methods. When Russian reconnaissance troops began to mark Ukrainian defensive positions with laser designators, for example, it was found that having laser warning indicators over strongpoints could alert personnel being targeted, who could then pop smoke grenades to disrupt the accuracy of the strike. This would also blind the defenders, making them vulnerable to assault," the report continued. However, the report also suggested Ukrainian soldiers had also "tended to sacrifice camouflage for clear identification (using colored bands) for their maneuver forces, relying on speed rather than concealment for survivability."

Even before NATO's withdrawal from Afghanistan and Russia's latest invasion of Ukraine, NATO members have paid close attention to protecting expensive armored assets on the modern and future battlefield. In November 2022, the European Defence Fund (EF) completed an €40 million, five-month study focused on identifying disruptive technologies to support CCD&O solutions. "Improved and new CCD&O solutions and operating procedures are required to prevent land systems (including their weapons) to be detected, identified or their intentions disclosed," an EDF solicitation described. "Potential countermeasures include passive camouflage,

Through the Smoke

mobile systems, weapons, active camouflage, including smart materials, deception methods, obscurants, and deceptive technologies," it continued before outlining a variety of activities undertaken including threat analysis which ranked risk areas on military platforms and soldiers as well as spectral range threats. "These considerations should reflect night-time and daytime scenarios, situations of degraded visual environment given in woodland, arid and snow situations. The threat analysis should also contain reference on the physics of camouflage for each spectral band," the solicitation stated.

CODED VISIBILITY

In August 2022, the US Defense Advanced Research Projects Agency (DARPA) initiated work on its Coded Visibility (CV) program which is designed to provide US and allied troops on the ground with an "asymmetric" advantage on the future battlefield. According to DARPA, the program is focused on identifying a "next-generation of battlefield obscurants" which could be used to protect mounted and dismounted personnel from detection by adversary vision and sensor systems.

"The problem with current obscurants is that they also degrade visibility and sensor performance of friendly troops. Additionally, obscurants designed to counter infrared (IR) systems are made of metallic flakes that are dangerous to breathe, requiring troops to wear respirators in combat," DARPA documents suggested at the time.

DARPA's CV program manager, Rohith Chandrasekar, describes smoke and obscurants as a "critical tool" for modern armed forces to protect them from detection by the enemy. Although the CV program was initiated ahead of Russia's February 2022 invasion of Ukraine, its application across the modern battlespace is clearly important today and in the future as the US and the rest of NATO prepare for more conventional warfare against peer/near-peer adversaries.

"We're actually pushing in areas to advance the technology that should have impact five,10, 20 years from now," Chandrasekar says, before warning, "The program kicked off just about six months ago, so we're still in very early days." According to Chandrasekar, CV's

Obscuration is important to land warfare, but it also plays a role in naval warfare and amphibious operations. Above, amphibious assault vehicles assigned to the USS Boxer (LHD 4) deploy smoke screens prior hitting the beach during exercise Ssang Yong in March 2016. Ssang Yong is a biennial combined amphibious exercise conducted by US forces, the Republic of Korea Navy and Marine Corps, Australian Army and Royal New Zealand Army Forces.
US NAVY PHOTO BY MASS COMMUNICATION SPECIALIST SEAMAN CRAIG Z. RODARTE

main effort is aimed at developing "tailorable, tunable, safe obscurants that provide warfighters with an asymmetric advantage, enhancing their visibility while suppressing adversary vision and detection systems." He adds, "Coded Visibility aims to develop new types of obscurant particulates that can be tailored to allow US and allied forces to see the enemy through the plume in one direction, while the adversary is unable to see through the plume in the opposite direction. This is known as passive asymmetry or 'Technical Area 1.' [of the CV program] We'll also explore active asymmetry [Technical Area 2] using novel materials that can be tuned in real time to potentially enable dynamic adaptation of the obscurant's properties during a mission. Passive and active asymmetry both can be achieved by leveraging recent insights in scattering media, plasmonics, metamaterials, light-matter interactions, biochemical compounds, and large-scale plume modeling," he said.

DARPA has selected a variety of industry and academic partners to support the CV program. Raytheon Technologies Research Center, Rice University and Palo Alto Research Center will support TA-1, which aims to develop a series of new obscurants composed of multiple particulates with tailored properties to demonstrate asymmetric vision capabilities in lab, pilot and field tests.

To support TA-2, the agency selected research teams comprising Northeastern University, City University of New York, University of Pennsylvania and Polaris Sensor Technologies; Signature Research and Duke University; and Georgia Tech Research Institute, to investigate "new tunable particulates and associated active modulation mechanisms to demonstrate asymmetry on-demand in lab and pilot tests."

"In both technical areas, teams will also develop new obscurant modelling and simulation tools to engineer plumes and assess performance against sensors. Additionally, all new obscurants developed under CV must be safe to inhale compared to current obscurants that can be hazardous and require troops to wear respirators in the field," Chandrasekar adds.

Rheinmetall Protection Systems GmbH makes a variety of smoke and obscurant dispensers and munitions. Above, 40-mm obscurant rounds are deployed from the Rapid Obscuration System-Land (ROSY-L) on a Boxer armored fighting vehicle. RHEINMETALL PHOTO

According to DARPA, obscurants in service today – even those used by modern armed forces – can date back decades. "If we look at the kind of obscurants that we have today, the kind of materials and tools that we have in our arsenal, like brass flakes, are pretty similar to materials used back in World War II. More recently, we have things like carbon fiber, and we have things like titanium dioxide, which are actually not used in the field, but more for training. So, if you look at all of these materials, in general, one of the major limitations is they have very low extinction values [the means of measuring obscurant efficiency], which means that you need a lot of material in order to protect yourself from detection," Chandrasekar explains. "So, in some cases, I might need kilometer deep material plumes in order to really disintegrate visibility. But putting out that much of material in a short amount of time is also a significant challenge," he explains.

Because of this response, the CV program is considering how DARPA can design obscurants with much higher extinction coefficients in such a way that less material can be deployed – but with even greater effectiveness in degrading visibility.

"We're looking at reduced size and weight," Chandrasekar says, "and increasing the efficiency so a vehicle, for example, could carry more countermeasures than it might ordinarily, which means it could put up plumes more rapidly providing the same level of degradation of visibility and potentially with less material."

Referring to TA-1, Chandrasekar describes how the CV program is considering ways to develop capabilities in mid- and long-wave infrared, in addition to looking at new materials that could lead to "much more efficient obscurants, where we could achieve far greater degradation of the adversary's visibility with less material – and starting to better understand the trades as to how those materials impact visibility of the sensor." He adds, "One of the key things that this program is also looking at is that we actually don't have great tools to simulate how an obscurant degrades visibility. We have tools that take this extinction value and estimate, but they don't take into account the temporal dynamics of the plume." For example, he asks, "What happens when I deploy this plume with different mechanisms? And will the spatial variation of the plume impact whether I'm able to see things in a certain part of the scene or others? So our ability to simulate obscurants and integrate them with sensor models is something that we simply don't have today. Part of TA-1 is developing those models."

CV Phase 1 is scheduled to wrap up by the start of 2024, with Chandrasekar expecting TA-1 program participants to have successfully demonstrated passive asymmetry in a meter-cubed chamber in lab conditions. "This test would be the first demonstration where we can actually achieve this kind of asymmetry in aerosolized form, which is a fundamental challenge, justifying the need to go further into the program and demonstrate at greater scale."

Turning his attention to TA-2, Chandrasekar describes how program participants are looking at various mechanisms for modulation, including an electromagnetic source used to rotate particles which he said, requires very high levels of power. "'How do we reduce power?' is part of the trade-off that we're looking at," he says. "And how can we actually achieve this in the air over a certain distance with an actual practical source? This is all a trade space that needs to be looked at quite thoroughly in order to understand whether there's a practical possibility here for asymmetry."

TA-2 will also consider acoustic sources to rotate particles in the air with Chandrasekar suggesting this had been done for a long time in applications like micro-fluidics and lab-on-a-chip. "In all those cases, you're in a fluid, and so now the question is, how do you achieve it in the air and over greater distances? Similar to TA-1, they need to develop the same kind of tools, where they can understand the impact of these obscurants on our ability to actually identify and detect. Being able to incorporate these kinds of active methodologies into tools that assess image quality or assess our ability to see through obscurants is yet another layer of modelling that does not exist." By the end of Phase 1, the TA-2 team must prove their modelling tools and use experimental demonstrations or modulation to show it is possible to achieve active asymmetry.

"They're not going to be ready for lab demos yet, simply because there's so much more physics that we need to understand," Chandrasekar says. "And as we move into phase two, we're going to start to see the first lab demonstrations in a meter-cubed chamber which is around 30 months from now."

Working with the US Army's Combat Capabilities Development Command's Chemical Biological Center; US Naval Research Labs and US Army Night Vision Labs, DARPA is already identifying potential use cases for active and passive asymmetrical solutions. These include operations in dense urban environments, where, according to Chandrasekar, operational scenarios dictate the distances over which troops would need to obscure themselves. "Part of our program is to understand certain use cases that could be near term applications. So, we're trying to assess that," he says.

ART OF THE POSSIBLE

Should some kind of CV capability be deployed operationally in the future, it could see dismounted soldiers, ground vehicles and even surface vessels, equipped with dispensers capable of launching active or passive asymmetrical smoke and obscurant countermeasures. Personnel and platforms would also be equipped with an additional portable device that would allow them to successfully manipulate those obscurants in the air for active asymmetrical effects. But Chandrasekar suggests the art of the possible goes even further beyond that, should the full potential of CV be fully understood and realized. "What's the next step? What goes beyond that?" he asks, "That's the kind of question that is always interesting to me. How do you achieve true coordination between an obscurant and a sensor? Our sensors have the ability to change their spectrum and dynamic range, so is it possible that we could achieve that same level of control of an obscurant? And importantly, could we co-operate that obscurant with a sensor for some kind of time-locked synchronization between our sensors and obscurants. This would require a whole different level of manipulation of obscurants in both space and time. This is really what I wanted to go after initially."

"I think we're only scratching the surface of the art of the possible," he adds, "and we can go far beyond in

Lacroix developed obscurant rounds, as well as offering complete vehicle countermeasures systems, such as Galix and the Soft-Kill Advanced Protection System (S-KAPS). LACROIX


US ARMY

co-operating with obscurants in ways that we have never done before. If we are successful in the CV program, we are yet to actually determine the art of the possible with obscuration."

Finally, Chandrasekar considers the wider application of active and passive asymmetrical solutions in electronic warfare (EW) in the future operating environment. "Everything that we're studying now, in the electro-optic/infrared, certainly can apply to the bands of relevance for EW," he says. "The question always comes down to: what are the use cases, and what are the constraints that are applied to the problem to try to find a disruptive solution? Similar models would be needed in other spectral ranges to understand how such an asymmetric capability could be developed. I don't see any reason why we couldn't achieve this. Simply, we need the materials to do so and an understanding of sensory modalities," he concluded.

DSTL

The UK MOD's Defence Science Technology Laboratory (Dstl) is another research organization heavily involved in considering the next-generation in smoke and obscurants. They explained how smoke and obscurants have a long history of use on the battlefield for visible and thermal obscuration, as well as signaling.

According to Dstl's Mark B [who must remain anonymous for operational security concerns], principal scientist of the pyrotechnic and countermeasure team for air platforms, and Mark Elson, air platform survivability lead, described how their application "may change from time to time but in the main, both the basic chemistry and the application remain as they have for many years."

According to Dstl, there have been few major developments in recent years in terms of smoke and obscurant technology used by land forces on the battlefield and training arenas. Mark B explains, "Smokes are generated in a number of ways. Large scale obscuration can be achieved on land and at sea from fog oil generators vaporizing mineral oil into a cloud of dense white smoke. If a faster response is required to protect military vehicles on land and ships at sea, a rapid plume is required and often for weight saving we want the largest amount of smoke that can be obtained from the smallest package. There is nothing yet discovered that can compete with phosphorous in this regard. It also has the advantage of providing a thermal screen." He adds, "If you want to add some color for signaling, then you need to volatilize a dye using a low temperature pyrotechnic heater composition. A huge range of colors are possible and can be used to obscure but more often are used to signal. For example, to identify a landing zone for a helicopter or attached to the ankle of a skydiver."

Recalling a January briefing regarding the ongoing conflict in Ukraine by the US Supreme Allied Commander in Europe (SACEUR), Elson highlights how Russia had lost some 2,000 tanks and ground vehicles, clearly identifying the need for countermeasures on board land platforms. "The vulnerability of armored vehicles has been highlighted throughout the Russian invasion," he says. "The portability, speed and effectiveness of modern anti-tank guided munitions shows that very little time is available for the blooming of an ejected obscurant, when used as a reactive countermeasure. However, we've not seen much potentially life-saving obscuration and maneuver tactics deployed from Russian armored vehicles."

Elson also recalls discussion regarding the impact of unmanned aircraft systems (UAS) on the battlefield, adding, "I think that's an issue for land as much as it is an issue for air as well. Smoke and obscurants have a place, but I expect there'll be some additional counter-UAS capability which is also essential on land vehicles going forward as part of a layered approach. Just operating using smoke to mask the UAS sensor isn't going to be the answer on its own."

LEARNING FROM AIR

Dstl suggested ground platforms could benefit from technologies used in the air to help protect aircraft from adversarial threats. Mark B highlighted a piece of work undertaken several years ago that deployed experimental airborne countermeasures (using a modified dispenser from the CH-47 Chinook) from the British Army's Challenger main battle tank in an attempt to improve current capability.

Similarly, Dstl's Elson explained how electronic architecture from NATO's Next Generation Air Survivability (NGAS) program is being shared with land components to allow ground vehicles to benefit from maximum levels in situation awareness in order to optimize the deployment of countermeasures. "Whether in the air or on land, the system needs the same core open architecture such as NDAS [NATO Defensive Aids System STANAG 4781]," Elson says. "There are actions with NATO to explore the broader application of NDAS and the [British Army] has a mature program already looking at its approach." Specifically, an additional opportunity offered by this approach is the ability to program tactics using algorithms such as the Tactical Advice and Dispense Automation (TADA) solution, integrated on board a DAS controller, to use the platform's sensor suite to identify and react autonomously to a threat. In terms of programming countermeasures ahead of or during a mission, Dstl is also considering how to utilize emerging technologies capable of reprogramming smoke and obscurants.

"Technology is aligning," Mark Elson explains. "The development of 'Smart and Conditional Dispensing' techniques exploits threat detection sensors and provides the ability to blend angle of approach with the platform dynamics in order to optimize the use of [the NDAS] Smart Store Communication Interface aligned with smart effectors, multi-part payloads and steerable dispensing. These technology building blocks will enable air to exploit obscuration as part of a future countermeasure tactics." Such a capability would enable the programming of expendables, including active decoys like Leonardo's BriteCloud solution in addition to Chemring's smart programmable countermeasures.

Finally, Dstl is also considering more environmentally friendly smoke and obscurants with a spokesperson suggesting, "Smokes, by their nature, are particles or droplets suspended in the air. They are therefore prone to being absorbed, inhaled and ingested. Obsolete military smoke compositions contained toxic dyes and organics, such as hexachloroethane and naphthalene. Much work has been carried out over the years to find less toxic alternatives. On the whole this has been achieved. However, phosphorous is still used extensively. The risks of the degradation of these types of smokes, resulting in the release of the highly toxic gas phosphine is well understood and is managed via modern manufacturing techniques and regular safety surveillance of stored items. This is accepted due to the exceptional performance of phosphorous as an obscurant."

UK MOD

INDUSTRY SUPPORT

Development of next-generation smoke and obscurant solutions are heavily supported by the defense industrial base. Participants include French defense company Lacroix which describes how smoke and obscurants are even more relevant today given the ongoing situation in Ukraine. "The Ukrainian conflict is a dramatic reminder of the vulnerability of combat vehicles in high intensity conflict," a company spokesperson explains. "Image analysis given by the press seems to demonstrate the low use of smoke or obscurants, which can partly explain the very large number of vehicles destroyed on the battlefield. Effective protection by masking would certainly provide a solution to reduce this number."


US ARMY

Considering lessons learned from the war in terms of CCD&O, Lacroix's spokesperson continues, "The considerable number of destroyed combat devices demonstrates several elements including poor use or even absence of masking clouds by the belligerents, either for lack of ammunition, or by the inability to detect an incoming threat and therefore by the impossibility of determining the relevance of generating a cloud of protection at the right time. Also, [we are seeing] inappropriate vehicle protection concepts against battlefield threats and new threats. Most vehicles are equipped with dismounted troop protection based on smoke generators and not soft-kill protection of the vehicle itself. And probably reduced effectiveness of masking clouds with minimal or no multi-band protection."

In response, Lacroix is focused on the development of self-protection solutions based on the combined use of several broadband masking principles in the optical field (from UV to far Infrared); in addition to masking aerosols to obtain immediate protection (less than 1 sec); and smoke payloads with the same properties to increase the duration of protection. "These products are in operational use and 'combat proven,'" the spokesperson says. "Lacroix is also studying an extension of these masking ammunitions in the millimeter domain in order to be able to counter dual- or tri-mode guidance threats."

Lacroix remains adamant armed forces must upgrade their employment of CCD&O technologies across contemporary and future operating environments. The spokesperson explains, "Modern combat demonstrates the importance of using extended performance smoke. However, this use must be optimized to ensure real protection. Optimization begins with instant triggering, which must be adapted to the type of threat and the temporal duration of the engagement. This point implies that it is essential to detect the threat beforehand. Then, a protective cloud is very dependent on the air conditions of the combat zone. This environment must be taken into account during the evasive maneuver that generally follows the implementation of a cloud of protection. Several ways of improvement are being studied, including the extension of the bands of the electromagnetic spectrum (optical and millimetric); the placement of the cloud according to the threats and the aerological conditions; and the speed of the implementation, without forgetting the reduction environmental impacts."

Lacroix solutions include its Soft-Kill Advanced Protection System (S-KAPS), which performs several functions, ranging from threat detection, analysis of the tactical situation and the implementation of protection and its optimization. According to the spokesperson, "S-KAPS and its multi-band ammunition can be integrated on all platforms, whether they are already equipped with Galix launchers or other calibers. It is an incremental system that can be upgraded as the user needs and technological developments. The ammunition and the system have backward and forward compatibility. New ammunition can be implemented by old systems and old ammunition in Galix format can be used by a latest generation system."

US ARMY

Similarly, Germany's Rheinmetall is also exploring emerging technologies to support the CCD&O requirements of armed forces. A company spokesperson described how the proliferation of "imaging sensors and top-attack weapons and drones" in Ukraine required better protection for mounted and dismounted units operating at the tactical edge. "Reduction of target information (position, identification etc.) by screening is effective against the new imaging technologies," the spokesperson explained. "Actually, the majority of obscurants are used in duel situations like tank vs tank. Obscurants against top-attack are also under development and could be available in the short term." They went on to say, "Information reduction by screening has a significant potential against all threats using imaging sensors and modern algorithms, independent of the environment. The most effective countermeasure is the combination of information reduction/screening and false target generation, either by decoying or electronic measures. Both measures have to be precisely coordinated in the timeline and placement."

LOOKING TO THE FUTURE

Considering the future operating environment, Dstl's Mark B and Elson believe there is a role for next-generation smoke and obscurants for aircraft, ground vehicles and naval vessels. Specific areas of interest being explored by the laboratory include the utility of UAS to deploy smoke and obscurants to protect vehicles, ships and personnel in addition to increased speed of blooming; continued development of multi-spectral screening; and blending of obscurants with other effectors.

Also looking to the future, Lacroix says smoke and obscurants will continue to be present in conflicts to limit or prevent actions on the battlefield. "Most threats have a guidance mode managed by an operator or man in the loop," the spokesperson explains. "Masking is particularly well adapted and effective to defeat these types of threats. They will have to be efficient in the face of the means of observation and guidance of the future. The new threats highlighted in the Ukrainian conflict will probably require the addition of other functionalities to guarantee effective protection: EM means of action or IR or EM decoys. Much work is currently in progress." Also, "The world's armies have just been reminded about vehicle vulnerability [in the Russia-Ukraine War]. This awareness will bring heavy changes in the concepts of protection of land vehicles. Hard-kill solutions that are expensive and complex to integrate will not be able to meet all needs. It will be necessary to continue to use masking agents, but more effectively by combining detection, analysis and a more efficient and optimized reaction. The era of protection assistance is beginning in land conflicts," the spokesperson concluded.

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Electromagnetic Protection (Part 12)

Dicke Fix and Burn-Through Modes

By Dave Adamy

Author's note: Sorry, I had a brain cloud and promised a column on pulse compression – having forgotten that I did that in two columns a year ago. This column is on two other EP techniques: the Dicke fix and burn-through modes.

ANTI-AGC JAMMING

To begin with, let's consider the radar dynamic range problem. A radar's dynamic range is the signal strength range over which it can track targets. The return signal from a minimum size target at the maximum range is very small. The return from a large target at minimum range is huge. The radar receiver needs an optimum return signal level to perform its processing. Therefore, a radar must have automatic gain control (AGC), as shown in Figure 1, to extend its dynamic range to many dB. The signal level at the input to the processor is measured, and there is either an attenuator as shown in the figure or an amplifier with gain control in the receiver front end. One way or the other, the signal level into the processor is brought to the optimum level to perform its function. When a strong jamming signal is present, that signal causes the AGC to turn the processor input level down so far that the processor cannot perform its function. Thus, the radar cannot track targets. It is said that the jammer *captures* the AGC.

The Dicke fix function as shown in Figure 2 prevents this AGC jamming from being effective. A pulsed radar signal has a wide bandwidth, so the front end of the radar receiver must be wide. In the Dicke fix, the output of this circuit is limited to reduce the power of strong jamming signal pulses. The limiter is set at the level of the noise in the amplifier. The output of the limiter is passed to a narrower circuit, where the automatic gain control is performed. This prevents the jammer from capturing the radar's AGC function, allowing the radar to perform normally over its dynamic range.

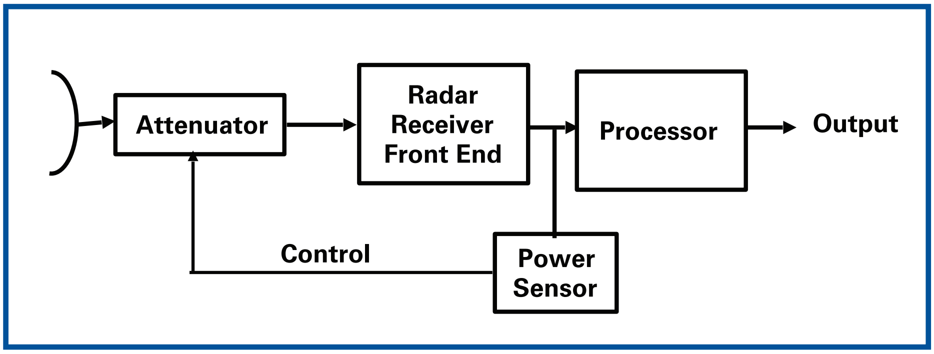

Fig. 1: *Automatic gain control involves sensing a receiver output before processing and increasing attenuation to bring the input to the processor to the optimum level. This allows the receiver to have a large dynamic range.*

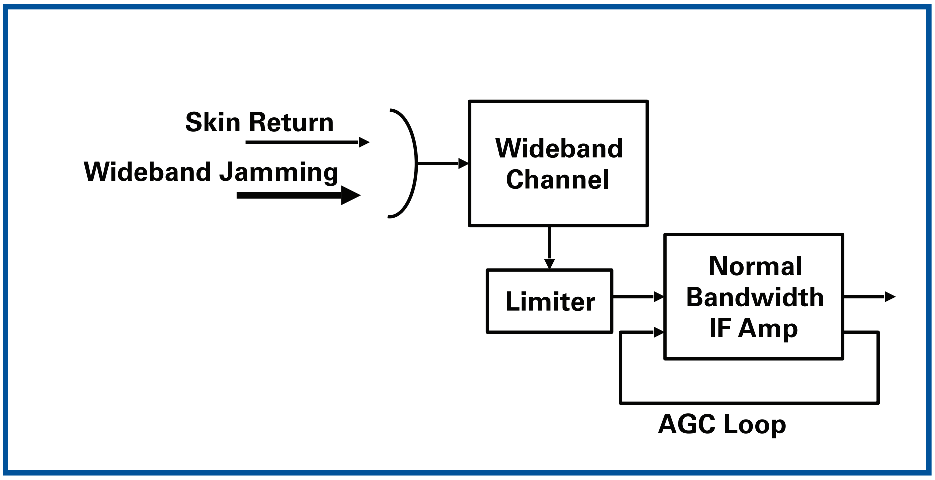

Fig. 2: *The Dicke fix limits the output of a wideband signal channel at the level of the noise in the system. After the limiter, the signal is passed to an optimum bandwidth circuit where the automatic gain control is performed.*

BURN-THROUGH MODES

Burn-through occurs when a radar can reacquire a target in the presence of jamming. We will consider this for two jamming geometries: "self-protection" and "stand-off." The range from the jammer to the radar at which the radar can require the target in the presence of jamming is called the "burn-through range."

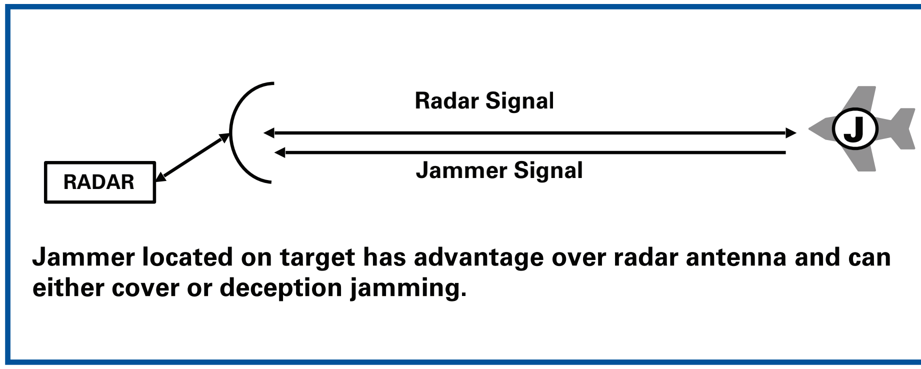

Fig. 3: *Self-protection jamming involves a jammer collocated on a target. The range from the radar to the target is thus the same as the radar's range to the jammer.*

Self-Protection Jamming

Self-protection jamming, as shown in Figure 3, has a jammer carried on the radar's target – protecting that target.

The formula for jammer to signal ratio (J/S) for self-protection jamming is:

$$J/S = ERP_J - ERP_S + 71 + 20 \text{ Log } R - 10 \text{ Log } RCS$$

Where: *J/S* is the jamming to signal ratio in dB,
ERP_J is the effective radiated power of the jammer in dBm,
ERP_S is the effective radiated power of the radar in dBm,
R is the range from the radar to the target in km, and
RCS is the radar cross section of the target in square meters.

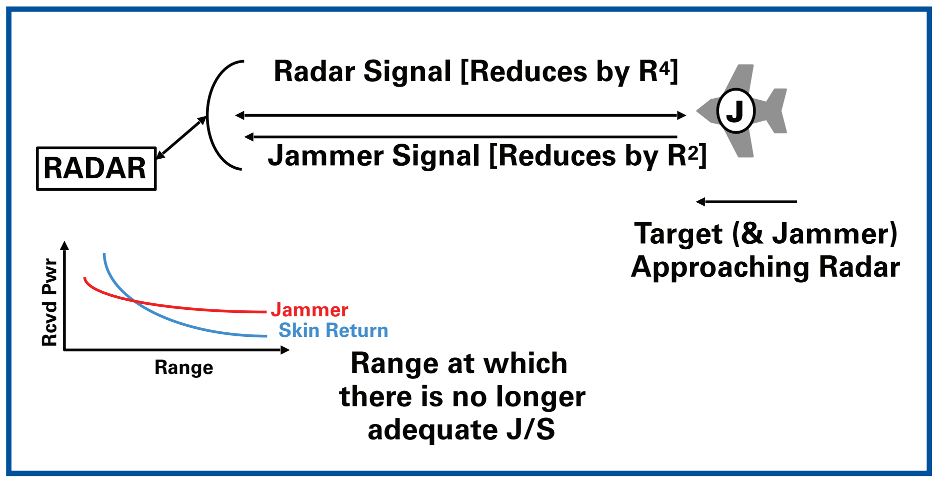

Fig. 4: *As the target approaches the radar, the return signal power increases as the fourth power of the reducing range. The jammer power received by the radar increases only as the square of the decreasing range. At the burn-through range, the J/S is reduced enough that the jammer can no longer protect the target.*

As the target (carrying the jammer) approaches the radar, the jamming to signal ratio (J/S) decreases, as shown in Figure 4. The red line shows that the jamming signal increases as the square of the decreasing range, while the blue line (the return signal from the target) increases as the fourth power of the reducing range. For some kinds of jamming, the burn-through range is the range at which the J/S is zero dB (i.e., where the red line crosses the blue line). However, for some kinds of jamming, a positive J/S is required. The burn-through range is the range at which the jammer can no longer protect the target. This is usually defined as the range at which the radar can reacquire the target in the presence of jamming. It is given by the formula:

$$20 \text{ Log } R = ERP_S - ERP_J - 71 + 10 \text{ Log } RCS + J/S \text{ (Required)}$$

The "J/S required" term depends on the type of jamming.

Stand-off Jamming

When the jammer is separated from the radar's target, it is said to perform stand-off jamming. In stand-off jamming, as shown in Figure 5, the radar is aimed toward its target and the jammer can be anywhere else. This means that a jammer aimed at the radar will be received in a side lobe of the radar's antenna, while the return radar pulse will be returned at the boresight of the radar's main beam.

The jamming-to-signal ratio for stand-off jamming is:

$$J/S = ERP_J - ERP_S + 71 + G_S - G_M - 20 \text{ Log } R_J + 40 \text{ Log } R_T - 10 \text{ Log } RCS$$

Where: *J/S* is the jamming to signal ratio in dB,
ERP_J is the effective radiated power of the jammer in dBm,
ERP_S is the effective radiated power of the radar in dBm,
G_S is the side lobe gain of the radar antenna,
G_M is the main beam boresight gain of the radar antenna,
R_J is the range from the jammer to the radar in km,
R_T is the range from the radar to the target in km, and
RCS is the radar cross section of the target in square meters

Consider Figure 6. As the target approaches the radar, the received return signal increases as the fourth power of the decreasing range, just as it does for self-protection jamming. However,

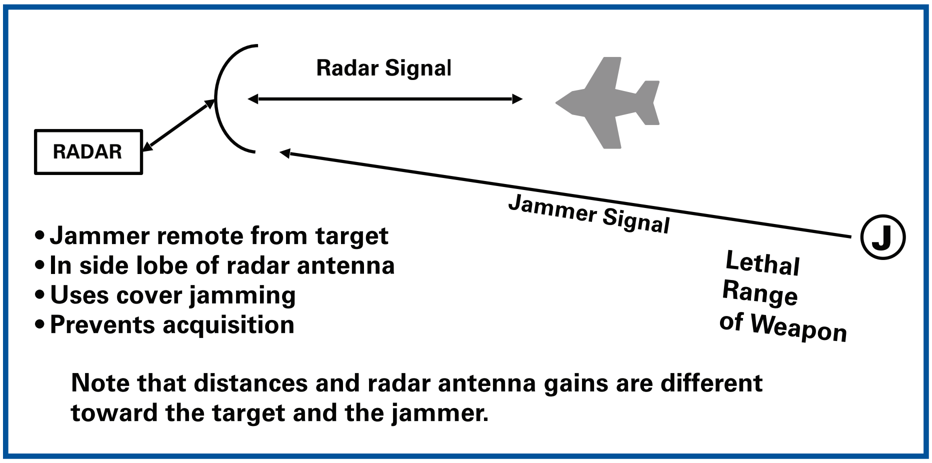

Fig. 5: *Stand-off jamming involves a jammer on a platform located away from the radar's target – often in another aircraft. The angle and distance to the jammer are different from those to the target.*

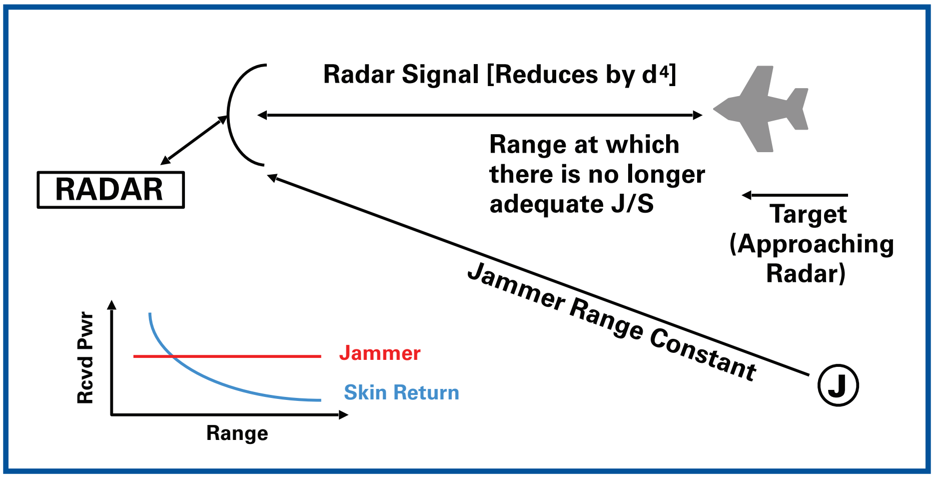

Fig. 6: *As the target approaches the radar, the return-signal power increases as the fourth power of the reducing range. The jammer power received by the radar increases only as the square of the decreasing range. At the burn-through range, the J/S is reduced enough that the jammer can no longer protect the target.*

the jammer is often considered to remain in a fixed location through the whole engagement. This would cause the jamming signal received by the radar to remain constant during the whole engagement. The J/S would thus be reduced as the engagement proceeds. Again, the J/S would eventually be reduced to the point that the jammer could no longer protect the target. If the jammer is on a maneuvering platform, the received jammer power would not be constant, but the stand-off jamming can still be effective if the jammer power and jammer distance are appropriate. The formula for the range at which this occurs is determined from the following formula:

$$40 \text{ Log } R_T = ERP_S - ERP_J - 71 - G_S + G_M + 20 \text{ Log } R_J + 10 \text{ Log } RCS + J/S \text{ (Required)}$$

Again, the "J/S Required" term is determined by the jamming technique employed.

BURN-THROUGH MODES

Since radars operate on energy, jamming aims to make the received jamming energy as large as possible in comparison to the received return pulse power. For electromagnetic protection, the radar's transmitted energy is increased. This can be either by increasing the effective radiated power or by increasing the duty factor of the radar signal.

Radar power is often reduced during operation, to minimize signal detectability and eliminate wasted power. However, if jamming is suspected, the radar ERP can be increased by as much as is practically needed. This will reduce the J/S, making the radar more effective. The radar's received energy can also be increased by increasing the duty cycle – longer pulses or greater pulse repetition frequency. The greater duty cycle will increase the received signal energy vs. the jamming signal energy, thus making the radar more effective.

WHAT'S NEXT

Next month, we will discuss three final electromagnetic protection techniques: frequency diversity, PRF jitter and home-on-jam. Dave Adamy can be reached at dave@lynxpub.

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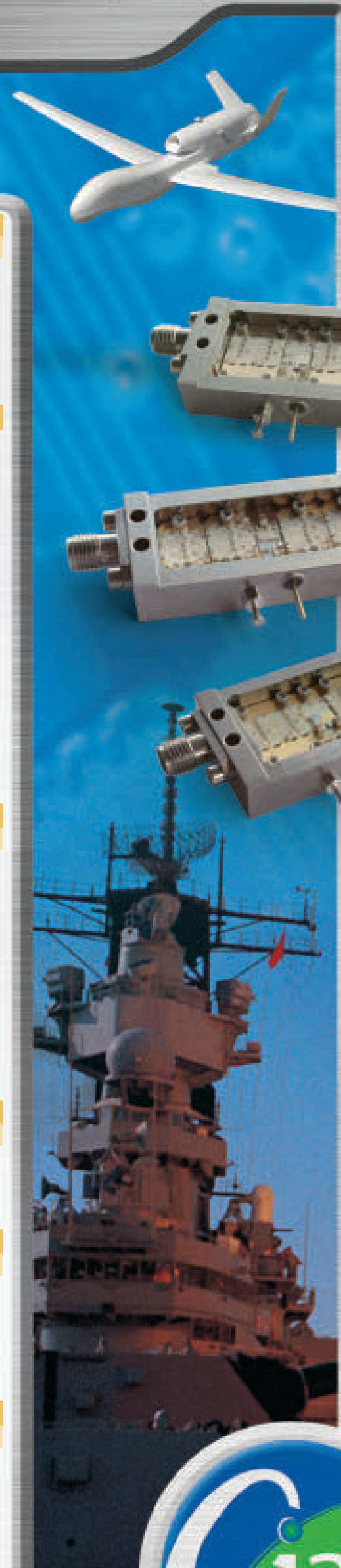

OCTAVE BAND LOW NOISE AMPLIFIERS

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

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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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