JANUARY 2019
Vol. 42, No. 1

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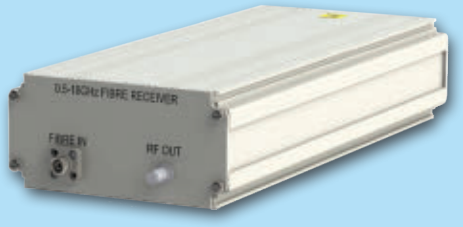

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The Journal of Electronic Defense

US Air Force 1st Lt Jonathan Wright, 390th Electronic Combat Squadron and Electronic Attack Squadron 135 (VAQ-135) "Black Ravens" EA-18G Growler pilot, completes his first combat flight Nov. 19, 2018, at Al Udeid Air Base, Qatar. Wright is the first US Air Force pilot to operate a Growler during a combat mission.
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THE YEAR OF THE EM DOMAIN

This month, *JED* begins 2019 by naming it "The Year of the EM Domain." *JED* has been advocating for an EM Domain for many years, beginning with this editorial column in our October 2009 issue. We were not the originator of the EM Domain concept, by any means. In 2009, NATO, through the work of Wg Cdr John Clifford OBE (RAF Ret.), was already well into the process of recognizing the EM Environment in its doctrine. In the months and years that followed, John, along with Jesse "Judge" Bourque and Col Jeff Fischer wrote several articles in *JED* supporting the need to recognize the EM Domain, especially in the US.

The idea of an EM Domain has gained significant traction within the DOD, and the 2017 DOD EW Strategy asked if the Department should recognize the EMS as a warfighting domain. Arguments were made for and against this idea. In 2018, having weighed the various inputs, the Electronic Warfare Executive Committee (EW EXCOM) rejected the idea – without providing further explanation.

In the wake of the EW EXCOM's decision, the messaging has been anything but clear. The theme of the 55th AOC International AOC Symposium and Convention, which was held in November, was "Winning the Electromagnetic Spectrum (EMS) Domain: A Culture and Mind Shift." DOD leaders came to speak and, to their credit, they tried to articulate various positions on the EMS as a maneuver space. But without an official explanation or rationale for the EW EXCOM's decision, the DOD leaders could only offer their personal views on the topic, which varied widely.

With such an unsatisfying situation, it is time to advance the EM Domain discussion further. The failure to convince the EW EXCOM and the wider DOD leadership about the EMS Domain ultimately lies with those of us in the EW Community. Clearly, we need to do a better job of explaining the EM Domain concept.

This month, as a formal kick-off to "The Year of the EM Domain," we have started a new "EM Domain" department in *JED*. The first installment, on page 28, takes a look at the way DOD leaders discussed the EMS Domain theme at the 55th Annual AOC Symposium. Using this as a starting point, we plan, over the next year and more, to explore the EM Domain issue from several perspectives to offer a more in-depth discussion about why the EMS is a warfighting domain and why this recognition is so important to the US National Defense Strategy. We hope this conversation will help to change the minds of those who doubt the EM Domain concept, provide greater clarity to those who are unsure and encourage the voice of those who do see the EMS as a warfighting domain. We, as a community, have a lot of work ahead of us, and we at *JED* look forward to a robust debate! – *J. Knowles*

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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

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CA01-2111	0.4 - 0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8 - 1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2 - 1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2 - 2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7 - 2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7 - 4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4 - 5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25 - 7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0 - 10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75 - 15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35 - 1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1 - 3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9 - 6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0 - 12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0 - 12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2 - 13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0 - 15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0 - 22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

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

LIMITING AMPLIFIERS

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

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

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

LOW FREQUENCY AMPLIFIERS

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

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Directed Energy Test and Evaluation Conference
January 15-17
Albuquerque, NM
www.deps.org

Surface Navy Association 31st Annual National Symposium
January 15-17
Arlington, VA
www.navysna.org

Battlespace Surveillance – Owning the Night
January 16
Chepstow, Monmouthshire, UK
www.cranfield.ac.uk

Electronic Warfare Asia 2019
January 29-30
Singapore
https://asia-decs.com/ewa

FEBRUARY

Modern Threats: Surface-to-Air Missile Systems Conference
February 5-7
Huntsville, AL
www.crows.org

IDEX 2019
February 17-21
Abu Dhabi, UAE
www.idexuae.ae

Aero India 2019
February 20-24
Bengaluru, India
www.aeroindia.gov

Avalon 2019
February 26 - March 3
Geelong, Victoria, Australia
www.airshow.com.au

AFA Air Warfare Symposium
February 27 - March 1
Orlando, FL
www.afa.org

MARCH

Dixie Crow Symposium 44
March 24-27
Warner Robins, GA
www.dixiecrowsymposium.com

AUSA Global Force Symposium and Exposition
March 26-28
Huntsville, MD
www.ausa.org

APRIL

48th Annual Collaborative Electronic Warfare Symposium
April 2-4
Point Mugu, CA
www.crows.org

Annual Directed Energy Science and Technology Symposium
April 8-12
Destin, FL
www.deps.org

2019 Army Aviation Mission Solutions Summit
April 14-16
Nashville, TN
www.quad-a.org

Directed Energy to DC (DE2DC)
April 29 - May 2
Washington, DC
www.deps.org

Security Cooperation Symposium: Interoperability, EW & FMS 2019
April 30 - May 2
Atlanta, GA
www.crows.org

MAY

Sea-Air-Space
May 6-8
National Harbor, MD
www.seaairspace.org

Electronic Warfare Europe 2019
May 13-15
Stockholm, Sweden
www.eweurope.com

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January 7-11
Swindon, Wiltshire, UK
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Guided Weapons
January 14-18
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Military Avionics
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Vehicle Systems Integration
January 28 - February 1
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FEBRUARY

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Communications Electronic Warfare
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NATO Joint Electronic Warfare Course
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www.natoschool.nato.int

Weapon Systems Performance Assessment
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Modeling and Simulation of Phased Array Antennas
February 12-14
Atlanta, GA
www.pe.gatech.edu

NATO Electronic Warfare Operational Planning Course
February 18-22
Oberammergau, Germany
www.natoschool.nato.int

Introduction to Pyrotechnics
February 25-27
Swindon, Wiltshire, UK
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Advanced Electronic Warfare Principles
February 25 - March 1
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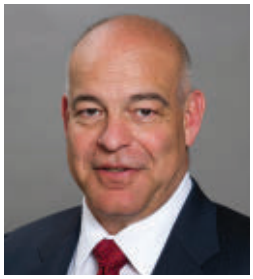

LET'S GET TO WORK!

I thank you for electing me as your AOC President for the next two years. It is a great honor to serve you, and I am humbled by it. As I step into this role, I would like to present my vision of the challenges and opportunities that lie ahead of us.

The first objective is to promote the wider recognition of the Electromagnetic Spectrum (EMS) as a warfighting domain. Our 55th AOC International Symposium focused on this strategic issue, and we must continue this discussion until we have a clear answer. We employ Electromagnetic Spectrum Operations (EMSO) to dominate the EMS contest against our adversaries, and this includes developing the joint and coalition operational tactics to be able to dominate or at least achieve superiority in the EMS when and where we need it. Finally, we must develop new technologies that support EMS dominance.

Today, we are in a fight where information warfare is critical to our success, and we need to think offensively and defensively about how EMSO supports information warfare strategy. We need to be able to sense and maneuver in the EM Environment; we need to be able to deliver kinetic and non-kinetic effects from multiple platforms and weapons; and we need to be able to protect our platforms, weapons, bases, systems and networks using offensive and defensive capabilities.

In order to achieve this, we must work together to remove the current stovepipes that exist between EW, Cyber, Directed Energy, SIGINT, radar and communications. The technological stovepipes between these areas are already eroding with the emergence of multi-function technologies enabled by software defined radios and electronically scanned arrays. However, we must focus our efforts on developing multi-domain and cross-domain strategy and doctrine in order to take full advantage of machine learning, autonomy, collaborative and swarming manned and unmanned systems. We need to help government and military leaders get past the on-going discussions and debate on cyber and EW, SIGINT and ESM, directed energy and electronic attack and focus their attention on kinetic and non-kinetic effects, delivered on the battlefield, to achieve the commander's objective.

The AOC can be the leader in this area by helping to shape policy and doctrine with open and honest debate and engagement. We can advocate for greater investment in technology and provide education and opportunities to collaborate via our, educational forums and publications.

This is my focus for the AOC, and we as an organization can help break down stovepipes, inform leaders and influence the efforts to develop and bring to fruition these concepts, strategies, policies, technologies and supporting activities. It will take all of us – active members, vibrant chapters, engaged industry partners and an energetic STEM program – to make this happen and build the cornerstone of our future. It will be an exciting two years filled with challenges, but more importantly, opportunities. Let's get to work! – *Muddy Watters*

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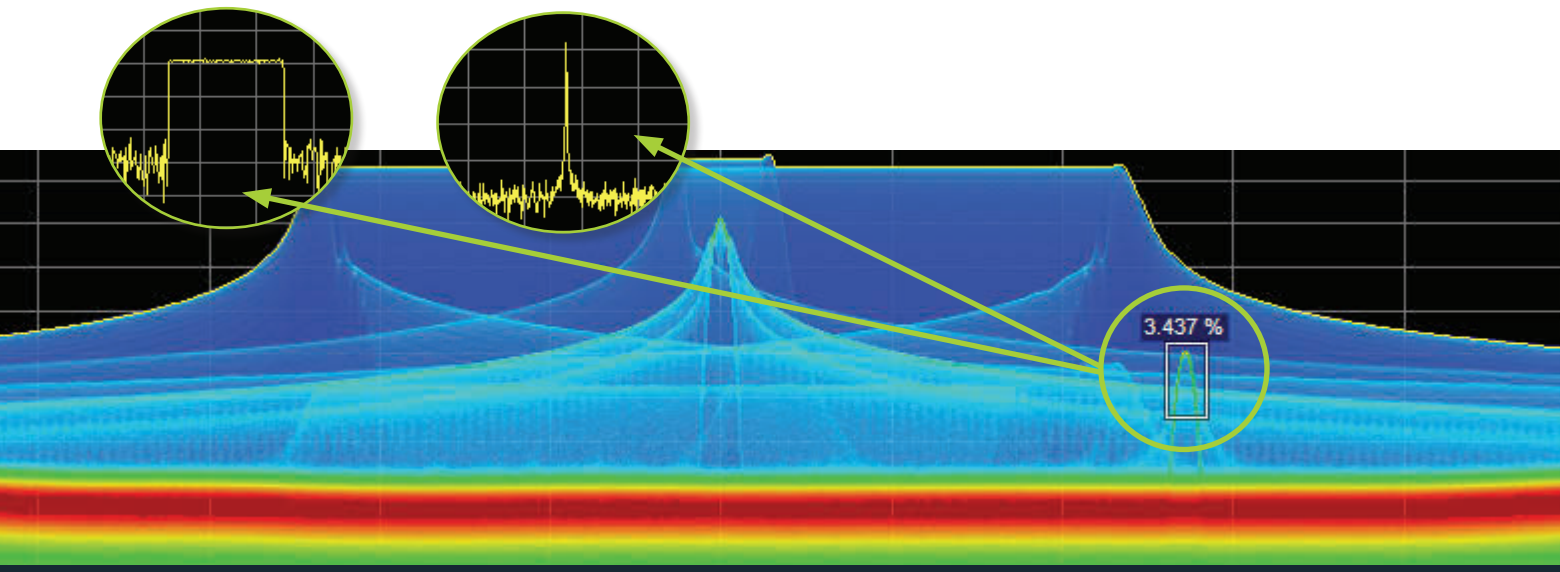

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the monitor news

US ARMY SEEKS "NON-TRADITIONAL" TECHNOLOGY-DEVELOPMENT PARTNERS

The Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASA(ALT)) is seeking sources to "highlight opportunities for nontraditional defense partners to collaborate with the Army to tackle the most poignant Army modernization challenges," including pitching novel "technology solutions – a new application for an existing technology or an entirely new technology concept."

Named the "Expeditionary Technology Search (xTechSearch)," the initiative will be featured at the Association of the United States Army (AUSA) Global Force Meeting in Huntsville, AL, March 26-28. As described in the announcement, "the Army must enhance engagements with the entrepreneurial funded community, small businesses, and other non-traditional defense partners, by: 1) understanding the spectrum of technologies being developed commercially that may benefit the Army; 2) integrating the sector of nontraditional innovators into the Army's research and development ecosystem; and 3) providing mentorship and expertise to accelerate, mature, and transition technologies of interest to the Army."

As part of the program, the nontraditional innovators will be integrated into the Army's Science and Technology (S&T) "ecosystem" by providing cooperative research opportunities with Army labs, including access to the Army's organic intellectual and technical capital. The Army will also provide "non-dilutive seed prizes" for the companies to demonstrate proof of concept in an Army-relevant challenge area. Technology focus areas for the initiative run the gamut of Army interest areas including: Long Range Precision Fires, incorporating non-kinetic strike options, enhanced guidance/navigation for weapon systems and next-generation radars; Next Generation Combat Vehicle (NGCV), incorporating vehicle protection against advanced threats; Future Vertical Lift (FVL), incorporating aviation protection and aircraft survivability, and improved situational awareness; Networking, incorporating Cyber Electromagnetic Activities (CEMA), Assured Position, Navigation and Timing (PNT), and Persistent Intelligence, Surveillance and Reconnaissance (ISR); Missile Defense, incorporating high-energy lasers; Soldier Lethality; Medical Technologies; and Military Engineering.

The xTechSearch program is organized around four phases, with Phase I being submission of a Concept White Paper to be reviewed by a panel of Army subject matter experts. Selected concepts will be awarded a $4,000 prize and an invitation to participate in the next phase. In the Phase II – "xTechSearch Technology Pitches" phase, contestants will give in-person, "venture-capital-style" presentations of their technology and proposed proof-of-concept demonstrations. Finalists will receive a $10,000 prize and an invitation to attend Phase III: "AUSA Innovators' Corner," where up to twenty-five finalists will be featured at the AUSA Global Force meeting. Up to twelve Phase III prize winners will be announced at the event, with each receiving a $120,000 prize and an opportunity to demonstrate their proof-of-concept in the Phase IV "xTechSearch Capstone Demonstration," which is to be conducted at the AUSA Annual Meeting, October 2019, in Washington DC. The single grand-prize winner will be awarded an additional $250,000 prize.

The solicitation number is: W911NF-19-S-0003. The primary point of contact is Nikolaos Georgakopoulos. Phone: 919-541-0817. Email: nikolaos.georgakopoulos.civ@mail.mil. – *J. Haystead*

ARMY SEEKS PRIME CONTRACTOR FOR SIGINT/EW PLATFORM DEVELOPMENT, PRODUCTION AND SUPPORT

The US Army Program Manager Electronic Warfare and Cyber (PM EW&C) is seeking sources for Technical Enhancements/Additional Production of Mobile Ground Tactical Signals Intelligence (SIGINT) and Electronic Warfare (EW) Systems/Capabilities. A single prime contractor is sought to produce, test, train, field and support ten ground-tactical SIGINT systems in accordance with the capabilities provided by an existing configuration based on two platforms – a SIGINT sensor and a Modular Integration Kit (MIK) support platform, which are primarily hosts for integrated COTS/GOTS Intel capabilities capable of multiple modes of employment (dismounted, vehicle-based, man-pack). Program requirements call for no more than 1 year from contract award to system delivery and potential fielding immediately thereafter in accordance with Army fielding schedule/requirements.

The prime contractor will also develop, test, integrate/retrofit/field, provide training, and support additional/enhanced capabilities for new/previously delivered/fielded ground tactical SIGINT systems, including improved/

more efficient signal processing, expanded performance ranges and exploitation of emerging Signals of Interest (SOI's). The timeline from development to completion of fielding/training cycles is no more than 18 months after the contract award.

In addition, the prime contractor will also develop, produce, test, train, deploy and support ground tactical SIGINT and/or EW systems in accordance with the capabilities provided by an existing configuration, as well as enable the development of additional/enhanced capabilities. The current configuration provides mobile Electronic Support/Electronic Attack (ES/EA) capabilities in a single platform to provide situational awareness and non-kinetic effects or a "call" for kinetic effects (fires) in a robust and dynamic Electromagnetic Spectrum (EMS) environment. Development to completion of fielding/training cycles are no more than 18 months from contract award.

The solicitation number is: W56KGY18R0314. The point of contact is: Amber M. Lowe, (443) 861-4796, e-mail amber.m.lowe3.civ@mail.mil. – *J. Haystead*

IN BRIEF

Raytheon Co. (El Segundo, CA), and Jariet Technologies Inc. (Redondo Beach, CA) have been awarded respective $11.5 million and $5.4 million competitive, cost-plus-fixed-fee research and development (R&D) contracts from the Air Force Research Laboratory, Sensors Directorate (Wright Patterson AFB, OH), as part of the Defense Advanced Research Projects Agency's (DARPA) Millimeter-Wave Digital Arrays (MIDAS) program. In Raytheon's contract announcement, DARPA said the company will explore innovations in digital tile architecture and integrated, scalable apertures with groundbreaking transmit and receive components. Work will be performed in El Segundo, CA, and is expected to be completed by Nov. 4, 2020.

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Lockheed Martin Corp. (Orlando, FL), has been awarded a sole-source $172.2 million fixed-price, incentive-fee contract by the US Air Force Life Cycle Management Center (Eglin AFB, FL), for Lot 2 production of the Long Range Anti-Ship Missile (LRASM) program. The contract covers production of 50 LRASMs. Work will be performed in Orlando, FL, and is expected to be completed by December 2021.

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Raytheon Canada Ltd. (Ottawa, ONT), has won a pair of contracts valued at $30 million (combined) from the Canadian Government to develop, deliver and install an over-the-horizon (OTH) radar in the country's polar region "to determine what effects, if any, the Aurora Borealis has on target detection along the Canadian north," according to a company press release. The Polar Over-The-Horizon Radar (POTHR) program, encompasses two sites, – one for the transmitter and another for the receiver. **D-TA Ltd.** (Ottawa, ONT), Raytheon's major subcontractor, will provide a 1024-channel OTHR receiver, and a 256-channel OTHR transmitter for the system. The radar will operate

across the 3- to 30-MHz range at a resolution of one megahertz. The contract runs through March 2020. Depending on the test results from this radar program, the Canadian Government could opt to buy additional radars.

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Teledyne Microwave Solutions (Rancho Cordova, CA) has been awarded a $7.5 million sole-source, firm-fixed-price contract from the Naval Supply Systems Command Weapon Systems Support (NAVSUP) (Philadelphia, PA) for repair of Traveling Wave Tubes (TWTs) used on ALQ-99 Tactical Jamming Systems in support of EA-18G "Growler" aircraft. Work will be performed at Teledyne's production facility in Rancho Cordova, California, and is expected to be completed by November 2021.

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Naval Air Systems Command (NAVAIR), Advanced Tactical Airborne Protection Systems (PMA 272), has issued a Broad Agency Announcement (BAA) for the demonstration of existing technologies for a Dual-Band Decoy (DBD). According to the announcement, the Navy is looking to develop an expanded/wideband-RF, towed, self-protection decoy to counter current and emerging RF threats. Of specific interest are "technologies that can be leveraged and applied where significant size, weight, power and cooling constraints exist, such as those associated with the current ALE-50 and ALE-55 form factor and interface limitations, as installed on the F/A-18E/F aircraft." The solicitation number is: N0001918R0086. The point of contact is Shannon Buckalew, (301) 757-5552, e-mail shannon.buckalew@navy.mil.

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The **US Army Rapid Capabilities Office (RCO)** is seeking sources and information relative to providing dismounted Electronic Warfare (EW) capabilities to Brigade Combat Teams (BCT) in response to the Cyber Electromagnetic Activities (CEMA) Operational Need Statement (ONS). According to the RFI, "The primary capability focus areas for this effort include Counter-Unmanned Aircraft Systems (C-UAS) and Offensive Electronic Warfare (Electronic Attack and Electronic Surveillance). Threshold performance requirements have not yet been set and will be informed by industry's response to this Request for Information (RFI)." The government anticipates releasing a solicitation in early Q2FY19. The RCO plans a competitive demonstration in the summer of 2019 as part of the contract award process. The solicitation number is: W56JSR-19-R-ARC01. The point of contact is Darbye T. Brooks, (443) 395-1569, e-mail darbye.t.brooks.civ@mail.mil.

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The US Air Force has announced plans to sponsor the **Strategic Development Planning & Experimentation (SDPE) Strategy Interchange Meetings** February 19-22 at the General Jacob E. Smart Conference Center, Joint Base Andrews, MD. This event, which will be classified at the Collateral Secret Level, is intended to inform industry of the Air Force strategic direction, priorities and challenges

in many technical areas relevant to current and future Air Force capabilities, technology roadmaps, and future acquisition funding streams. Topic areas for the meeting include: 1) Air Force Capability Development Updates (Enterprise Capability Collaboration Teams & Design Teams and/or Air Force Weapons Integration Capabilities Updates); 2) SDPE Experimentation Campaigns (Directed Energy Weapons Experimentation Campaign, Hawkeye Experimentation Campaign and Global Lightning (Commercial Space Internet) Campaign); 3) Pathfinder Activities Artificial Intelligence (AI) Experiment – how can AI and machine learning be utilized in an operational condition to improve autonomy efforts and increase mission effectiveness; Positioning, Navigation and Timing (PNT) Experiments – exploring open PNT architectures, complimentary technologies utility, and increasing cockpit situational awareness; and Personnel Recovery Experiment – exploring the ability to support personnel recovery in contested environment). The event will also include several "Watch List" topics, including: a. Adaptive Basing; b. Communications - (C4I Design Team); c. Counter-Directed Energy Weapons (DEW); d. Light ISR (Intelligence, Surveillance and Reconnaissance)/Attack; and e. Electronic Warfare/Electromagnetic Spectrum (EW/EMS) Experimentation. Additional information is available at the Defense Innovation Marketplace SDPE SIMs webpage, https://defenseinnovationmarketplace.dtic.mil/technology-interchange-meetings/sdpe/.

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The **Special Electronic Mission Aircraft (SEMA) Directorate** of the Fixed-Wing Project Office within the US Army's Program Executive Office for Aviation has issued a Request for Information (RFI) for an "emerging potential requirement" for a High-Altitude Airborne ISR capability. The notional requirement is for an aircraft that can fly above 35,000 feet, operate in an Anti Access/Area Denial (A2/AD) environment and provide coverage for at least 8 hours. The aircraft will carry communications intelligence (COMINT) and electronic intelligence (ELINT) payloads, as well as aircraft survivability equipment that will enable it to operate in high-threat environments. According to the RFI, "It is the intent of Program Managers of the Fixed Wing and the Sensors Aerial Intelligence Project Offices to conduct individual conference calls as necessary. The USG may conduct a Technology Demonstration to evaluate the capability of a potential solution." Responses to the RFI are due on January 11. The point of contact is Carol Matthews, e-mail carol.h.matthews.civ@mail.mil.

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The Air Force Life Cycle Management Center's (AFLCMC's) Command, Control, Communications, Intelligence and Networks (C3I&N) Program Executive Office (PEO), **Kill Chain Integration Branch** (Hanscom AFB, MA) has announced plans to issue a two-step Broad Agency Announcement (BAA) The areas of interest include: ISR state of-the-art advancement; enhancing situational awareness; mobile networking and communications equipment; improvements to existing Air Force and DOD infrastructure; USAF cryptographic operations advancement; geospatial analysis of social media; exploitation of enemy threat systems; increasing data utility and accessibility; exploitation of the battlespace; Anti-Access/Anti Denial environments (communication and Position, Navigation and Timing); 5th to 4th Generation communications, and machine learning and artificial intelligence. The solicitation number is FA8726-19-S-0001. The contracting point of contact is Shawn Walles, (781) 225-0515, e-mail shawn.walles@us.af.mil.

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The Air Force Research Laboratory, Information Directorate, Information Exploitation and Operations Division, **Cyber Operations Branch (AFRL/RIGB)** has issued a two-step BAA (FA8750-19-S-7002) titled "Cyber/SIGINT Collection, Processing Techniques and Enablers." According to the BAA, "The overall technical objective of this BAA is two-fold. The first component of the objective is in the area of ISR information extraction for SIGINT issues, including new and innovative methods and processing techniques that will provide decision-makers with ISR information in as near real-time as possible. SIGINT technologies process information on various communications mediums, operate in environments in low signal-to-noise ratio areas and conduct operations against uncooperative targets where the noise types and channel conditions are frequently varying from message to message. As time is critical and ISR mission analysts' workload is high, the automation of the SIGINT collection, processing and exploitation capabilities in both tasking and training is a major goal. The SIGINT research and development is grouped into three broad technology areas: Information Extraction, Signal Processing, and Automation Enhancements." The second part of the this objective is "to research unique and innovative techniques and algorithms that provide the identification, collection, processing, and exploitation of electronic communication signals in a moderate to dense co-channel environment with potentially significant Doppler effects. The goals for this component are to develop methods for the detection, identification, characterization, and geolocation of emerging communications and low radiated power level signals of interest; advance digital signal processing software methodologies to provide new and existing systems and waveforms; develop new and innovative software and hardware architectures for standoff collection systems; develop and integrate these capabilities into information operations and collection systems; and develop the ability to characterize cognitive, software-defined radios from either airborne or ground-based platforms operating in dense signal environments." The Air Force anticipates $99.9 million in funding for this BAA over three years and expects to award multiple contracts valued between $250,000 and $4.5 million. The deadline for proposals is January 29. The point of contact is Douglas Smith, AFRL/RIGB, (315) 330-3474, douglas.smith.44@us.af.mil.

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The US Army's Communications-Electronics Research Development and

Engineering Command (CERDEC), **Space and Terrestrial Communications Directorate,** has recently issued a call for White Papers related to communications decoys. Under the 2018 Broad Agency Announcement (BAA-18-R-STCD), the Directorate issued White Paper Call 005 titled "Spectrum Obfuscation." According to the problem statement, "The adversary may use the large radio frequency (RF) footprint of the Army's Mission Command Network to find and fix targets. CERDEC is developing the capability to obfuscate the RF environment with radio decoys. The RF decoys will impair the adversary's observe, orient, decide, act loop by forcing the adversary to discriminate between real and decoy RF signals." The Army is seeking information to support its Wideband Alluring Signal Projection (WASP) project, which "aims to emulate the RF communications systems typically found at battalion and brigade level command posts. The WASP will emulate duty cycles and RF behavior typically associated with mission command nodes. The WASP mitigates the operational security and affordability risks of using current radios as decoys. Through emulating only the key over-the-air waveform features, the WASP will not require cryptography. CERDEC envisions the WASP integrated on an autonomous vehicle or hand emplaced with additional decoy modalities (i.e., tents, generators, inflatable vehicles, etc.). CERDEC is seeking innovative research approaches to emulate the RF communications systems typically found in battalion and brigade command posts." The topic point of contact is Alex Chang, e-mail kauteng.a.chang.civ@mail.mil.

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The US Army's Threat System Management Office (TSMO) has awarded a $499,122 contract to **EWA Warrior Services LLC** (Herndon, VA) for work under the "Quantum Technologies for Threat Military Applications" project. Under the OTA contract, the company will support the TSMO's efforts to conduct "a comprehensive evaluation of current adversarial, non-adversarial, and commercial capabilities utilizing quantum technologies as a strategic means of delivering or supporting operationalized effects (e.g., Cyber, Electronic Warfare, Anti-Access Area Denial, etc.) against US Military and Coalition forces. The evaluation is intended to show how current and future threat capabilities can be enhanced or materialized through next-generation quantum technologies. "The award description goes on to state, "This effort will consist of two phases. Phase I, as the base of the prototype project will consist of extensive global market research with a final report expected to be classified at the TS level. Phase I closeout will consist of a recommended functional area (domain) for Phase II hardware/software prototyping. Phase II will consist of prototype development targeted at TRL 7. The overall duration of the effort is estimated to be 36 months, with 12 months for Phase I and 24 months for Phase II."

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The United States Air Force Research Laboratory Sensors Directorate, Multi-Domain Sensing Autonomy Division (AFRL/RYA) has announced plans to enter into a sole-source contract with the **New Mexico Institution of Mining and Technology** (NMIMT) (Socorro, NM). According to the announcement, "The objective of this effort entitled, 'Cyber-Physical Research and Testing for Distributive Sensing', is to conduct research and development in a relevant and realistic cyber and electronic warfare (EW) environment for the employment of assets for cyber-kinetic combat effects and Multi-Domain Operations (MDO). This effort will establish or maintain the existing capabilities at the Playas Research and Training Center (PTRC) in Playas, New Mexico. This is needed in order to expand current capabilities and meet test range requirements in support of AFRL Sensors Directorate research goals in understanding sensing effects across multiple domains (air, space, cyber, and ground) to include internet of things (IoT) and distributed sensing with traditional and ad hoc configurations. There is a definite and urgent need for a cyber-kinetic infrastructure to facilitate development, testing, and evaluation of operational cyber, EW, and non-kinetic capabilities in support of national military objectives." The AFRL announcement also stated, "Of particular importance to AFRL/RYA is the research and development of the physics and phenomenology in regards to the interface between the physical world (i.e., objects and the environment) and the cyber realm (i.e., networked devices). This specifically includes techniques by which objects and events can be sensed or manipulated via transducers and kinetic actuators on cyber-connected devices. This must also address challenges associated with adversarial or natural denial or degradation of the sensing/manipulation channel, as well as opportunities gained with geometric and spectral diversity of distributed and multi-phenomenology employments." The NMINT was selected because it could provide the facilities needed for this research. "There are limited test and training opportunities for employment of cyber and EW effects since current military operating ranges are overscheduled or unavailable, and do not possess credible cyber system capabilities to support regular use by cyber and EW customers. Only the deployment of relevant technology and networks in realistic and representative environments, free from physical or electronic interference, can assure the accurate development of operational cyber capabilities. An open-air test and training environment where researchers and operators can replicate combat conditions and perform simultaneous operations, cyber-enabled kinetic operations, or physically-enabled cyber operations is a necessity." The PTRC provides six "other than American" test and training venues – four feature buildings constructed of pressed earth (the building material of one third of the world) and two others representing nomadic yurt villages. According to the contract terms, NMIMT will "establish or maintain existing facilities to expand current capabilities and develop an environment that will eventually serve as an operational range for DOD cyber-kinetic and multi-domain operations. The facilities and capabilities will include wired and open-air communications and network infrastructure, representative worldwide physical infrastructure, and specialized facilities to support test, training, and operations."

world report

NEW COMBAT AIRCRAFT STUDY ADVOCATES FOR UCAVs – NOTES CONTINUING IMPORTANCE OF EW

In a new study published by the Royal United Services Institute (RUSI) (London, UK) titled "Next Generation Combat Aircraft Threat Outlook and Potential Solutions," author Justin Bronk, Research Fellow for Airpower and Military Technology at RUSI, makes the case that the next generation of threats facing future NATO combat aircraft (beyond 5th-generation) may not be best met solely with new manned aircraft platforms. Instead, he says, "A mix of next-generation manned combat aircraft, limited to a modest level of technological ambition beyond the capabilities offered by current fifth-generation fighters, like the F-35 and F-22, coupled with a stable of regularly-evolving unmanned combat aerial vehicles (UCAVs), in low-rate production," may be a better approach, offering "both a way to rapidly expand NATO airpower if a crisis appeared imminent, and in a worst-case scenario at least offer a latent capability to replace losses and draw the worst attrition away from scarce manned assets in a high-intensity conflict."

In conjunction, Bronk observes that, although "stealth characteristics will remain valuable, other elements of the survivability equation," such as electronic warfare, "may well regain some of their traditional importance." The study is based on research and discussion with combat-air-capabilities planners in the US, the UK, France, Germany, Italy, Spain, Norway, Sweden, Denmark, Poland, and other European countries. As one case in point, Bronk points to Sweden's decision to design its next-generation Gripen E aircraft around an internal EW suite, an approach intended to blind enemy sensors to the aircraft's presence, rather than trying to make the aircraft itself hard to detect. He adds that "one advantage of EW over airframe-shape-based stealth is that it can be regularly and relatively cheaply upgraded and updated in response to known threat developments."

At the outset, Bronk emphasizes that his paper does not examine whether a new generation of combat aircraft is the optimal or correct answer to future defense challenges, but rather looks at "what shape these efforts might take; sheds light on some of the challenges and drivers; and suggests some potential options for force optimization." He begins by stating that there are three key features of future high-intensity conflict that are likely to shape the requirements of next-generation combat-air systems: an increasing density, variety, and resolution of sensors, coupled with powerful post-processing analysis techniques making it harder to enter contested airspace undetected; cutting-edge surface-to-air missile systems and sensors proliferating from Russia and China to countries currently considered to be sub-peer opponents; and the fact that crucial enablers for combat aircraft, such as large prepared airfields/aircraft carriers, aerial refueling tankers, etc., on which sustained operations depend, will be at risk from much longer distances than ever before.

In particular, Bronk says, "Russia is currently, and will likely remain for several decades, the source of the most capable ground-based air defense systems, as well as EW capabilities which can significantly degrade NATO networks and sensors. However, China is emerging as the more potentially worrying source of future combat aircraft which might pose a threat to Western types." In addition, he also observes, that "attrition from combat losses in the air and, potentially due to direct attacks on bases, is likely to be a significant feature in any future high-intensity conflict." As such, he says Western defense planners must prepare for the potential impact of a return to significant combat attrition, and the need for "combat mass."

Bronk says, UCAVs offer a number of key advantages in high-intensity conflict scenarios, including expendability, comparative simplicity of manufacture, and combat endurance. "Since UCAVs don't have to be flown regularly and in large numbers to maintain an aircrew cadre, they can be produced in relatively small numbers and regularly upgraded and iteratively improved as the threat picture changes over time, while still representing a potent combat asset." He does, however, also note that "there could be political and legal sensitivities around their development in peacetime, since for use in high-intensity warfighting, they must be capable of automatic threat recognition, targeting, and lethal-weapons release if datalinks are jammed."

According to Bronk, efforts to produce new manned combat aircraft would benefit greatly, from being coupled to a European UCAV program to produce prototypes and low-volume production aircraft which could be tested, evaluated, and iteratively developed on a much shorter cycle than large manned combat-aircraft program. "Politically, it ought to be easier to align the various national procurement cycles, budgets, operational requirements, and industrial workshare ambitions across the European countries discussed with a more flexible, evolving and low-volume production UCAV consortium than large-scale manned-fighter-fleet replacement efforts." – *J. Haystead*

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Mr. Jay Kistler, SES
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Director, EW and Countermeasures,
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Deception and Denial at Sea:

By Richard Scott

Ever since radar emerged as a primary means for surveillance, targeting and weapon guidance in the maritime arena, so navies have sought methods and means by which to disrupt or deceive potentially hostile radio frequency (RF) sensors. This specific subset of naval electronic warfare, historically referred to as electronic countermeasures (ECM) but latterly re-cast as electronic attack (EA), has two main objectives: first, to deny or disrupt radar picture compilation so as to degrade the ability of an adversary to make informed tactical decisions; second, to deceive or decoy the RF guidance and terminal homing systems used by the overwhelming majority of the world's anti-ship cruise missiles (ASCMs).

Expendable RF countermeasures, such as chaff, corner reflectors and active offboard decoys, are an important part of the soft-kill armory. Such devices are popular owing to their relatively low cost, and the fact that they offer the inherent attraction of angular deception. Their principal drawbacks are limited endurance, the challenge of ensuring spectral realism, and the need for very accurate positioning in time and space in order to present a credible alternative target in the RF seeker field-of-view.

The other side of the RF-countermeasures coin is the onboard jammer, which seeks to degrade and disrupt hostile radars by emitting signals designed to obscure or confuse the return echo received by the victim radar. While early jammers were largely limited to noise techniques and relatively simple deception modes, current generation shipborne EA systems embody a rich repertoire of modes embracing both smart noise and advanced deception techniques.

Recent technology trends include the introduction of high effective radiated power phased array transmitters capable of ultra-fast beam switching to provide wide coverage in azimuth against multiple threats, the embrace of solid-state power amplifiers, and the adoption of digital radio frequency memory (DRFM) devices that are capable of much higher integrity capture and regeneration of received pulses compared to previous analog frequency memory loops, and offering a much improved capability against advanced radar types. In addition, gallium nitride (GaN)-powered jammers will soon enter service with some navies. GaN technology allows higher efficiency in power generation with consequent benefits in terms of size, weight and power.

Novel ECM techniques are being explored to counter, for example, monopulse seekers and inverse synthetic aperture radars. There is also a trend to extend frequency coverage – historically tending to the H-J bands (6-18 GHz) portion of the electromagnetic spectrum – into the millimetric region (mmW) to counter the emergence of mmW threat seekers in the Ka-band region.

SEWIP BLOCK 3

Under the overarching umbrella of the Surface Electronic Warfare Improvement Program (SEWIP), the US Navy is introducing a series of incremental upgrades, through a modular open systems approach, to improve the performance of the legacy AN/SLQ-32 shipboard EW system. Originally developed by Raytheon, and fielded from the late 1970s onwards, SLQ-32 is a family of shipborne EW outfits providing detection, analysis, threat warning and, in the (V)3, (V)4 and (V)5 variants, protection from ASCM threats.

The next instantiation of SEWIP, known as Block 3, is integrating advanced EA functionality into the upgraded AN/SLQ-32 suite. Following an exhaustive competition, the Naval Sea Systems Command (NAVSEA) in February 2015 selected Northrop Grumman to perform SEWIP Block 3 design and development ahead of a rival bid from Lockheed Martin (partnered by Raytheon).

SEWIP Block 3 is designed to deliver a common EA capability to DDG-51 destroyers, aircraft carriers and amphibious assault ships fitted with the AN/SLQ-32(V)3 and AN/SLQ-32(V)4 systems, and also selected new-construction platforms. The embodiment will introduce an integrated EA capability encompassing a new transmitter, array and associated jamming techniques.

Block 3 also encompasses a government software development effort for a Soft Kill Coordination System (SKCS) to provide direction and scheduling for both onboard and offboard "soft-kill" effectors. The Applied Physics Laboratory of Johns Hopkins University is leading engineering design, algorithm development and prototyping for the SKCS.

Northrop Grumman's SEWIP Block 3 technical solution adopts an active electronically scanned array based on GaN transmit/receive modules, and capitalizes on technology previously matured and de-risked under the ONR's Integrated Topside (InTop) program; InTop demonstrated an integrated EW/IO/Comms prototype that addressed critical technologies required for SEWIP Block 3.

The SEWIP Block 1B3 (high gain/high sense adjunct), Block 2 (upgraded ES antenna/digital receiver) and Block 3 units will in aggregate comprise the AN/SLQ-32(V)7 system. General Dynamics is subcontractor to Northrop Grumman, leading on human systems integration and training tasks. In this role, General Dynamics supports the design, analysis, interface updates, and design support activities for the SEWIP Block 3 hardware, the integration of Blocks 2 and 3, and operator and maintainer software.

It had originally been intended that AN/SLQ-32(V)7 would be delivered in two different configurations – Large Radar Cross Section (LRCS) and Small Radar Cross Section (SRCS) – based on the size

Naval Jammers Get Smarter

of the ship. However, the requirement for the LRCS variant has now been eliminated since it has been determined that the SRCS system can meet operational requirements for all US Navy ship types slated to receive the Block 3 system.

In October 2015, NAVSEA awarded Northrop Grumman a $91.7 million target cost plus fee contract to complete the SEWIP Block 3 Engineering and Manufacturing Development (EMD) phase. Under this award, the company is tasked to mature the SEWIP Block 3 system design; finalize integration, modeling and test plans; and produce two production-representative EDMs for laboratory and field testing.

However, by the end of 2015 Northrop Grumman had informed NAVSEA's Program Executive Office for Integrated Warfare Systems (PEO IWS 2.0) that it would not be able to complete the EMD phase for the original target cost. As a result, in May 2016, Northrop Grumman and PEO IWS 2.0 began revising the original EMD phase statement of work to control the cost increase. The company's cost estimates continued to escalate, and in March 2017, Northrop Grumman submitted a revised proposal incorporating an increased proposed cost of to complete a revised EMD phase.

Northrop Grumman's original development contract included fixed-price production options for FY2017 and FY2018, which were bid in a competitive environment prior to the start of system development. The program will procure FY 2017 and FY 2018 units at these contract prices

In August 2017, NAVSEA exercised a $2.5 million contract option to purchase long lead-time materials for initial production. At the end of the following month, NAVSEA issued a contract modification that partially terminated the EMD phase and thereby eliminated a number of deliverables (including the LRCS variant, environmental qualification testing and maintainability demonstrations).

Delays to the EMD program have impacted the schedule for SEWIP Block 3 introduction to service. According to FY 2019 budget documentation, technical evaluation and initial operational evaluation and test are scheduled for FY 2021. A Full Rate Production decision review is programmed for the second quarter of FY 2022.

As well as providing an advanced ship-based EA capability, the AN//SLQ-32(V)7 system and its embedded SKCS functionality will provide a means to cue and control a planned helicopter-borne Active Offboard Electronic Warfare (AOEW) Active Mission Payload (AMP) offboard EA system via Link 16. AOEW AMP effects will be coordinated by SLQ-32/SKCS in conjunction with other soft-kill RF countermeasures during the engagement.

Lockheed Martin is under contract to develop and deliver the AMP, designated AN/ALQ-248. The system, which will be integrated on MH-60R and MH-60S multi-mission helicopters, is a self-contained pod hosting both high sensitivity receiver and EA subsystems. The system is designed to be able to operate independently, or in coordination (using Link 16 messages) with the AN/SLQ-32(V)6/7 systems.

The USN plans to achieve an initial operational capability with the AN/ALQ-248 payload in 2021. Cobham Integrated Electronic Solutions is Lockheed Martin's partner and major subcontractor for the AN/ALQ-248 pod.

In advance of the delivery of the full SEWIP Block 3 capability, the US Navy has pursued on a "gap-filler" EA program that introduces EA technology derived from NRL's Transportable Electronic Warfare Module (TEWM) to address separate Urgent Operational Needs Statements (UONS) raised by the US 6th Fleet and the 7th Fleet. Conceived by NRL's Tactical Electronic Warfare division as a modular, portable and platform-agnostic testbed incorporating an ES receiver integrated with a wideband DRFM-based EA capability, TEWM has previously demonstrated noise jamming and high-resolution false targets with realistic amplitude and Doppler modulation, providing a capability to engage multiple threats simultaneously, and generate multi-component waveforms that combine false targets with obscuration jamming.

An artist's rendering of the SEWIP Block 3 sponson installation (between the radar arrays) on a DDG-51 destroyer. NORTHROP GRUMMAN

Under a so-called TEWM "Speed To Fleet" (TEWM STF) initiative, the AN/SLQ-62 system has been developed to meet a classified 6th Fleet Urgent Operational Need (UON). TEWM STF systems engineering has been performed by NRL and NSWC Crane Division. A capability enhancement upgrade for AN/SLQ-62 was developed in FY 2017.

Another TEWM exploitation, identified as the SEWIP Block 3T program, has introduced the AN/SLQ-59 system to address a 7th Fleet UON. Harris (then Exelis) was in 2013 contracted by NRL to undertake "production and install activities" in support of SEWIP Block 3T. The company in January 2015 showed an image of a mmW EA system at the Surface Navy Association annual symposium; it is unclear whether this system forms part of either TEWM installation.

A number of Pacific Fleet DDG-51 guided missile destroyers have been observed fitted with the AN/SLQ-59 system (receiving a dual-mount antenna group affixed to the bridge wings port and starboard). Another variant of AN/SLQ-59 has also been fitted to CG-47 cruisers (this configuration features two separate single-mount antennas fitted on sponsons either side of the forward superstructure).

VIRGILIUS

Italian EW house ELT Roma (part of Elettronica Group) has long been in the vanguard of naval EA technology, and is today claiming a world lead for its Virgilius jammer with regard to both architecture and techniques. In particular, Virgilius is claimed by the company to embody the state-of-the-art with regard to solid-state active array and multi-bit amplitude-phase DRFM technology, and thereby deliver sufficiently accurate amplitude and phase control of the radiated ECM signals to enable the implementation of complex wavefront distortion or "cross-eye" techniques.

Virgilius draws on Elettronica's experience from its existing product pedigree, notably the previous generation Nettuno 4100 jammer, and an extensive program of research and development that has exploited prior experience in the airborne EW arena (where the company had introduced DRFM exciters and active phased array transmitters into the efensive aids subsystem developed for the Eurofighter Typhoon).

Shipborne jammers have traditionally used travelling-wave tube (TWT) power amplifiers, with signals radiated through single-beam antennas. However, Elettronica (working with the Italian Ministry of Defence and the Italian Navy) in the early 1990s started the engineering development of a new-generation shipborne EA system – to become Nettuno 4100 – based on solid-state technology. In doing so, it set out a series of key objectives: to be effective in countering all modern radars (both search and tracking, including coded, coherent and monopulse types); a capability to defeat multiple simultaneous threats, in different RF bands, approaching along different axes; wide field-of-view electronic beam steering in elevation (up to 50 deg) as well as azimuth; and excellent availability, reliability and maintainability.

The exploitation of DRFM technology formed one part of the company's approach, providing the means to generate very high fidelity replicas of complex signal types (including complex/coded/coherent waveforms). Elettronica's first DRFM, developed in the mid-1990s, was a 2-bit device originally used for the ELT-553 airborne self-protection jammer. The company has subsequently gone on to develop a new-generation multi-bit DRFM using Field Programmable Gate Array (FPGA) technology, with signal control both in amplitude and phase.

It is, however, the maturation of solid-state technology for high power shipborne EA applications that Elettronica regards as its most celebrated achievement. While acknowledging that there was much initial scepticism regarding the ability of solid-state devices to match the ERP achieved by TWT-based jammers, the company claims that its solid-state architecture has fully demonstrated the required power while, for the same ERP class, also yielding reduced weight, smaller size, and more efficient power consumption.

Two prototype Nettuno 4100 units (each featuring a single antenna array) were built and extensively tested on an Italian Navy frigate. These systems were used to demonstrate overall system functionality, the ability to track radar threats with the specified accuracy in both azimuth and elevation (while at the same time compensating electronically for ship motions), verify the predicted "on target" ERP level, and demonstrate the implementation of the Cross Eye ECM technique.

Subsequently, production-standard Nettuno 4100 systems have been delivered for the Italian Navy's new aircraft car-

A Nettuno 4100 antenna head on board the French Horizon air-defence frigate FS Chevalier Paul. RICHARD SCOTT/NAVYPIX

rier Cavour, and as part of the Electronic Warfare System (EWS) for the Franco-Italian Horizon and FREMM frigate programs. The Horizon and FREMM orders were fulfilled as part of the SIGEN consortium with Thales France.

The move to individual elements in the array provides for very narrow beam radiation and programmable-beam reception. In the case of the Horizon ships, each vessel has a dual-face antenna head fitted forward (offset to port) and starboard (offset to starboard) to ensure full 360 degree coverage. In this case, each array face covers a 180 deg field-of-view in azimuth for both signal reception and ECM transmission.

To meet the specific needs of smaller ships, ELT Roma is now developing Virgilius as a new lightweight, compact H-J band shipborne jammer (with a mmW adjunct in development). Virgilius adopts a suitably scaled GaN-based solid-state phased array architecture, and integrates a digital receiver and DRFM into the same response channel. One feature highlighted by ELT Roma is dual polarization both during reception and transmission to ensure effectiveness in the fact of the latest generation counter-countermeasures techniques.

ELT Roma has for some time been leading the advocacy for the cross-eye jamming technique, which provides the ability to counter monopulse radars. Cross-eye is an angle deception technique that requires carefully coordinated transmissions, of nearly equal strength, from two physically separated jamming sources so that the victim radar receives the returned signals out of phase and with a specific amplitude imbalance. This effects "wavefront distortion," and so displaces the tracking radar aiming point

The challenge for the realization of cross-eye is its complex execution. However, ELT Roma argues that the architecture embodied its latest solid-state jamming systems now makes the implementation of Cross-Eye a practical proposition. Specifically, ELT Roma points to the use of the same antennas to receive and transmit (ensuring perfectly coincident centers of phase), the excellent matching and control (both in phase and amplitude) afforded by solid-state active phased array transmitters, and the adoption of multi-bit DRFM technology (to enable high-fidelity signal replication and accurate phase/time control).

Having initially performed airborne trials to demonstrate the cross-eye technique, ELT Roma (working with the Italian Ministry of Defence and the Italian Navy) in 1993 conducted a first live shipborne trial. A follow-on field trial was performed in 2000, this being described as being "conducted in realistic combat-like radar engagements, using 'full-feature' cross-eye systems." A further test campaign was performed in 2005 with a later generation of jammers.

Following these tests, the company now claims that its cross-eye approach to have been demonstrated as an effective, robust and reliable technique to effect angular deception of monopulse radars. Accordingly, the company now offers this functionality across its jammer portfolio.

SHARK ATTACK

The Digital Shark ECM system produced by Israel's Rafael Advanced Defense Systems is the latest evolution of the company's Shark product line, which dates back to the Shark/RAN-1101 system, and associated RAN-1010 and RAN-1020 multi-beam array transmitters (MBATs), first brought to market in the late 1980s. The Shark suite has also been sold as an integral part of Rafael's export-oriented SEWS/RAN-1110 integrated EW suite.

In its original instantiation, Shark/RAN-1110 was based on a conventional analog architecture, and the MBATs based on multiple mini-TWTs. Now, however, Rafael has significantly upgraded the architecture to the so-called Digital Shark standard with the infusion of digital receiver technology and an advanced DRFM-based techniques generator.

The company has also migrated the MBAT subsystem from its original TWT-driven configuration to a full solid-state transmitter architecture. In this case, the transmitter technology has been pulled through the airborne Sky Shield escort jammer previously supplied by Rafael to the Brazilian Air Force for its AMX fighters.

Digital Shark features a solid-state dual-axis MBAT, which can rapidly steer the jamming beam in both azimuth and elevation. The antenna can be stabilized or unstabilized, the difference being that the non-stabilized MBAT has a wider beamwidth in elevation.

Combining high power and ultra-fast beam switching to counter multiple threats, Digital Shark is scalable according to platform type (the company offers the option of a single MBAT covering 360 deg in azimuth or dual transmitters each covering a 180 deg sector). The digital techniques generator is capable of producing a range of coherent and non-coherent techniques, including range gate pull-off/pull-in, velocity gate pull-off/pull-in, noise, false target generation and combined responses, with the DRFM providing for fast coherent and accurate frequency set-on.

Elbit-Elisra, Israel's other naval EW house, has traditionally enjoyed the monopoly on EW equipment supply to the Israel Navy. This includes the supply of the NS-9005 series of active jamming systems.

Building on the iterative development of NS-9005, and the cross-fertilisation of technology building blocks from its airborne EW portfolio, Elbit-Elisra is now offering an advanced shipborne ECM subsystem as part of its export-oriented Aqua Marine integrated EW suite. The company has developed its own coherent DRFM digital techniques generator offering a wide range of jamming responses. Another feature of Aqua Marine is the capability for surveillance and high ERP jamming in both the I/J-band and mmW frequencies.

THE SCORPION'S STING

While many of its peers are moving to solid-state phased array EA systems, the EW business of Thales UK is continuing to promote a more conventional jammer – in the shape of Scorpion 2 – in the belief that it remains appropriate to the need of many navies with more limited budgets. The company highlights the system's small footprint, ease of integration, advanced techniques generator and high ERP (achieved through the combination of a TWT-based transmitter and stabilized, steerable dish antenna).

The EA subsystem supplied by Rafael for the Indian Navy's Rajput-class destroyer upgrade includes both I/J-band and mmW transmitters.

RICHARD SCOTT/NAVYPIX

Covering the 7.5- to 18-GHz frequency range, Scorpion 2 can be installed in either single- or dual-head configurations according to platform size and role. Integrated with, and typically cued by, the ship's ESM, the system features its own receiver and tracking antenna. Threats are processed via the DRFM-based techniques generator, which provides for the high-fidelity replay of received radar characteristics. Alongside the primary steerable transmitter unit, an additional wide beam horn is provided to give a wide area protection capability.

A further developed Scorpion 3 variant, which would integrate solid-state power amplifiers is still in the company's future roadmap. However, a launch remains conditional on favorable market trends.

RIGEL

The last two decades have seen Spain invest in the development of a significant EW knowledge and industrial base, the latter largely vested in Indra. One product of this investment is Indra's Rigel family of EW systems, which includes a DRFM-based EA component covering the 6- to 18-GHz frequency band.

According to Indra, Rigel EA configurations can be built up on the basis of either mechanical or electronically-steered transmitters. A narrow-band receiver subsystem provides high accuracy elevation and DF measurement to provide for preci-

sion tracking of the emitter, so optimizing radiation efficiency and maximizing ERP on target.

A range of advanced jamming/deception techniques is available. The system can provide up to 11 types of jamming modulation, including spot noise, barrage noise, noise cover pulse, Range Gate Pull Off/Velocity Gate Pull Off, Range Gate Pull In/Velocity Gate Pull In, and Angle Gate Pull Off/Angle Gate Pull In.

STEAMING AHEAD

The naval EW market is responding to new longer-range ASCM threats by introducing EA systems that feature sophisticated DRFMs and GaN-powered active arrays. These developments, combined with advances in offboard countermeasures, will enable ships and their crews to operate in complex threat environments, such as littoral waters, with greater confidence.

Defeating the EO/IR threat

Recognizing the emergence of a electro-optic/infrared (EO/IR)-guided threats in the maritime arena, particularly littoral environments, a number of R&D efforts have been instigated to develop directed EO/IR countermeasures systems.

The US Navy's SEWIP roadmap has identified a future Block 4 upgrade intended to introduce EO/IR countermeasures capabilities into the AN/SLQ-32(V) system. While there is as yet no firm program for implementation, the Office of Naval Research's Combined EO/IR Surveillance and Response System (CESARS) Future Naval Capabilities effort, being led by the Naval Research Laboratory (NRL), is informing SEWIP Block 4 requirements and de-risking enabling technologies.

CESARS embraces two distinct functional components: the Shipboard Panoramic EO/IR Cueing and Surveillance System (SPECSS); and Multispectral EO/IR Countermeasures for Advanced Threats (MEIRCAT). SPECSS is designed to perform 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. multi-band capability against multiple targets in a single engagement is a MEIRCAT requirement.

CESARS is comprised of five distinct subsystems: SPECSS camera; SPECSS processing; MEIRCAT high resolution cameras (Product 1); MEIRCAT laser sources (Product 2) and MEIRCAT beam control, pointing and processing (Product 3). NRL's objective is to develop a TRL 6 maturity level system suitable for limited testing onboard a naval vessel.

L-3 Cincinnati Electronics was in February 2016 awarded a $8.9 million contract by the NRL for work associated with the SPECSS function of CESARS. Under this activity, L-3 is to design, develop and test both mid-wave IR and visible spectrum panoramic imagers. A second SPECSS contract, valued at $3.9 million, was placed with BAE Systems Information and Electronic Systems Integration in April 2016.

Three contracts have been let by NRL in support of the MEIRCAT portion of CESARS. 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.

Elettronica in October 2018 disclosed that it was privately funding the development and demonstration of a shipborne EO/IR countermeasures system and leveraging technology from the EURODIRQM DIRCM system being co-developed with Indra. Two engineering demonstrator systems have already been the subject of successful at-sea trials, the company told *JED*.

EURODIRQM is based on European-sourced Quantum Cascade Laser (QCL) technology. According to Elettronica, QCL technology allows for a range of operating frequencies to adapt to specific maritime weather conditions. The company adds that QCL energy is generated directly in the band of interest, so optimizing power consumption.

At-sea development and demonstration activities running since 2015 have focused on data gathering in different weather and clutter conditions in order to characterize performance in the maritime domain. Elettronica expects to have a fully engineered product – scalable to suit different platform types – available by the end of 2020.

The UK in 2009 established a 30-month technology demonstrator program, known as ELOPE, to prototype a shipborne electro-optical countermeasures system. The testbed system, developed by Thales UK and evaluated on land and at sea during 2011, used multi-band laser effectors to accurately track and defeat incoming EO/IR-guided threats.

In terms of configuration, the system consisted of a stabilized panoramic pointing and tracking head located on the countermeasure enclosure, with the main EO module suspended beneath the head inside the enclosure. In operation the system is designed to take external cues and EO threat prioritization data from the host ship's sensor suite (such as radar or infrared search and track).

The track is then handed off to the ELOPE system's own thermal and visual band cameras to perform search and track. Once each target is located, a laser rangefinder is used to give accurate range data, fine aimpoint tracking is achieved, and the directed laser countermeasure engaged.

ELOPE had at one stage been viewed as a potential element of the UK's nascent MIDAS (Maritime Integrated Defensive Aids Suite) soft-kill suite. However, budget pressures have over time forced the downscaling of the MIDAS effort, and it is understood that ELOPE has not progressed beyond the prototype stage. – *R. Scott*

EMS and the "D-word" – DOD and Services Still Waffling on EMS as a Domain

By John Haystead

Editor's note: This is the first installment of a new column in JED dedicated to elevating the discussion of the EM Domain. The aim of this column is to examine the EM Domain from many perspectives and to provide a holistic discussion of this topic. The JED editorial staff believes the EM Domain question is clearly the most important issue facing the EW and SIGINT community because it underpins most of what we do (or don't do) in the future with regard to EMS DOTMLPF-P. This column will primarily be written by the JED staff, but we also believe it is important that this discussion is conducted as a debate. As such, we welcome contributions from others, and we will publish them if they advance the discussion.

In the US, the long ongoing discussion/debate regarding the establishment of the EMS as a Warfighting Domain appears to have been deliberately moved to the backburner by the Services and the DOD overall, but it also appears that this approach is extremely difficult, if not impossible, to actually execute. That was certainly the case at the 55th Annual AOC International Symposium and Convention, as speaker after speaker tried mightily (often to the amusement of the audience) to avoid the use of the term, "EMS Domain," while clearly speaking of it as just that. Instead, a plethora of other descriptors were employed, as well as discussions of the EMS as an element of a grander "information domain."

The tone for the EMS Domain discussion during the symposium may have been set during the opening-day panel session, chaired by Dr. William Conley, Director of Electronic Warfare, OUSD(A&S)/A/Platform and Weapon Portfolio Management (P&WPM), as well as Executive Secretary for the DOD's Electronic Warfare Executive Committee (EW EXCOM). While he spoke of the importance of cross-domain synergy, Dr. Conley did not list the EMS among them. And, in fact, in speaking with *JED* for an article published in the December issue of the magazine, Dr. Conley specifically stated that, "The DOD, through the EW EXCOM, is not advancing anything that would recognize the EMS-as-a-Warfighting-Domain agenda," although noting that there is not yet a public statement "as to why we've decided to take this course of action to date."

The first presenter among the opening panel took the subject on directly, if not completely clearly. Jake Schaffner, Senior Advisor for Technical and Mission Convergence, USD(I), said that, "One thing that we're following fairly closely, because it causes us a lot of grief, is this discussion of the EMS as a domain. The reason is that when you're inside the Intel community and you look at what's happening, whether it's an EW activity, a cyber activity, in some cases a space-control activity, or SIGINT for my community, at the bits level, they sort of look identical. A lot of our more sophisticated EW activities are nothing more than a form of cyber operations that are conducted over RF. So, for the Intel side of the house, saying this is cyber, and it's not EW and it's not space control, really doesn't make sense, because for us, what we're analyzing is essentially all the same stuff and we're producing products that have to go to different people but they all look the same, so why do we have distinctions of domain and distinctions in the standup of individual forces?"

The unclear part of this view is that it doesn't seem to address the fact that cyberspace is in fact already established as a domain, the EMS is currently considered as just 'something-other-than-a-domain,' and Intel or information operations is, as per the name, operations. The statement that "A lot of our more sophisticated EW activities are nothing more than a form of cyber operations that are conducted over RF," in fact appears to state the case that the EMS is in fact a discreet warfighting environment, or domain.

Up next, Col Charles Cosnowski, USAF, Director Joint EW Center (JEWC) said, "I don't really care if you call the EMS a domain, I just want you to consider it a 'maneuver space.'" As his metaphor for the viewpoint, Cosnowski said, "Just like you think of the land component or the sea component, if you have things that are going to hinder you from using certain aspects of that component, such as a mountain that prevents you from going through that way, in the case of the spectrum, there can be a set of frequencies that are being used by someone else preventing you from going through there." He also pointed out that, "The reason the JEWC's Joint EMS Operation Centers (JEMSOCs) are needed is that no one Service controls the EMS, and the JEMSOCs work on how they can use and

share the spectrum across both strategic and tactical levels, as well as denying adversaries access to the spectrum."

On day two of the symposium, Gen Paul Selva, USAF, Vice Chairman of the Joint Chiefs of Staff, got into the topic during his own keynote address, stating that "We can use and leave the spectrum at will," seeming to clearly imply that the EMS is a place – a domain. "In my military incarnation, I always knew the spectrum was out there. That was easy, it was easy to see, and easy to understand, but the EMS has quietly slid into all of our lives. Now it is not only about competing in a warfare sense, but competing economically in the same space."

The final day of the conference featured a senior-level, multi-Service panel moderated by Lt Gen Robert Elder (USAF, Ret.), Strategy and Technology Advisor, Georgia Tech Research Institute, as well as a past AOC President. It was here that General Elder brought the question of the EMS as a domain to the forefront.

Responding directly to whether the EMS should be treated as a domain, MGen Michael Green, USMC, Director for Intelligence, J2, somewhat dodged the question, but did observe that, "Organizationally, we've started to treat this as a warfighting function, not so much a domain in and of itself. In talking about that function, we're talking about achieving effects in the information space, and have created an MEF Information Group that brings all these capabilities under one roof. EW is no longer boutique but an integrated part of planning and operations. EW will become ever more precise in its effects, and we want to ensure that we can achieve these warfighting effects in this arena or whatever you want to call it."

In his response, Brig Gen David Gaedecke, USAF, Director Cyberspace Operations and Warfighting Integration Office of Information Dominance, and also the lead on the Air Force's Enterprise Capability Collaboration Team (ECCT) for EMS said, "It's a topic we've discussed relative to the ECCT work. However, the Air Force hasn't established a formal position on that. There is an absolutely increasing effort, however, in treating it as the operational environment that it is. The challenge is the implications of formally designating the EMS as a domain. It's more important than one Service's declaration, because all of the Services have to operate together. It's something that we have to consider. It's physical and it exists, it's not manmade. Whether we are here or not, the EMS is out there. My driver is not to force a 'yes or no' decision for the Service, but to acknowledge the importance of EMS operations and our ability to conduct those operations today and in the future. We absolutely have to acknowledge it and we have to do it from a multi-domain approach, as well. We have to learn how to operate in it if we are going to do what the NDS tells us to do."

DOD leaders did their best to provide their perspectives on the EMS Domain question. The DOD's position is still far from clear.

US NAVY PHOTO BY MC1 SAMUEL SOUVANNASON

Representing the US Navy, RADM Michael Brookes, Deputy Commander, US Fleet Cyber Command/US 10th Fleet also hedged his bets on the subject saying only that, "There is an intersection of the EMS and traditional SIGINT with cyber and space and the information-wide capabilities in support of electromagnetic warfare. As we look at fleet cyber, we definitely have an interest in all things related to those venues and the intersection, as we see it, of those domains. We view cyber, space and the EMS merging mostly in terms of electromagnetic maneuver warfare. Being able to successfully operate in that environment is key to the future, and information will be the weapon of choice in future, and the domain that we will have to optimize to be successful." It was not clear whether Admiral Brookes was referring here to the EMS as "the domain that will have to be optimized," or to an 'information domain.'

The final panel member, BG Jennifer Buckner, US Army, Director of Cyber G-3/5/7 at Army Headquarters, also took a crack at the question. General Buckner noted that she served as an EW officer in the 82nd Airborne Division, which provided her with "foundational experience and that she is now in a position to further that advocacy for the future fight." Said General Buckner, "The most important way that we're recognizing the EMS is as a form of maneuver – both as an enabling capability, but also a primary warfighting capability. It is captured in our multidomain operational concepts in terms of recognition that we must maintain assured access to, and freedom of maneuver within, the EMS." General Buckner also seemed to speak to a higher-level information space rather than an EMS domain, however. "Our recognition in the Army G3 operations directorate really reflects our mindset and recognition that these are capabilities that are warfighting capabilities in this operational domain – what was previously spread across cyber, EW and information operations. This unites those capabilities so that we can advocate for them in a comprehensive way. There is significant work by our Army cyber enterprise to really look at this domain in a much different way, with an initial focus on building our cyber forces, but now turning our attention to our EW force – fighting in this information space."

To his credit, General Selva did actually acknowledge the 'elephant-in-the-room.' As he said in the concluding remarks of his presentation when thanking the attendees for their advocacy for effectively managing and fighting in the EMS, "If our great-power competitors are outspending us ten-to-one, we have to outsmart them 1,000-to-one. We cannot stand still in this space. If there is a better way to do this, get your voice heard. If you have a better idea about how to compete in this particular *arena of battle* – and you'll notice I'm very carefully not calling it a domain – get your voice heard, pump up the volume. Do not let us stand still, or we will lose."

Next Generation EW Part 15

Upgrades to Acquisition Radars *(cont'd)*

By Dave Adamy

All of the Russian-made acquisition radars are being upgraded to meet the needs of the continuing upgrades to the missile systems. This month, we will discuss three typical modern Russian acquisition radars among the dozens of upgraded radars.

BIG BIRD

The 64N6E radar, with the NATO designation BIG BIRD (see **Figure 1**), is an S-band acquisition radar that is part of the S-300 surface-to-air missile system. Its antenna is a two-sided reflective phased array fed by two horn antennas with 2,700 phase elements on each side. The antenna rotates with a 12-second period and provides two hits on a target per rotation. It can track airborne targets from 20,000 meters down to 60 meters with target velocities up to 10,000 km/hr.

Figure 1: The BIG BIRD radar provides target acquisition for the Russian S-300 missile systems. This image is from a display at the MAKS 2005 Air Show. ALEXANDER SIGACHOV

Open literature states the BIG BIRD's operating frequency at about 2 GHz and the transmitter power to be 0.7 kW. It has a frequency modulated continuous wave (FMCW) modulation with frequency hopping.

From a graphic analysis of open-source pictures of the BIG BIRD radar, the size of the phased array is about 5.75 meters wide and 4.25 meters high. At 2 GHz, the 3-dB beam for an antenna with these dimensions is 2.5° high by 1.9° wide. Elsewhere in open literature, a beam width of 2° is estimated. These beam widths support a calculation of approximately 38 dBm boresight gain. With a 0.7 dB transmitter power, this would make the effective radiated power (ERP) approximately 97 dBm.

BIG BIRD has auxiliary antenna/receiver channels for side lobe suppression. Open literature states that it can provide direction of arrival information on jamming transmitters and has a moving target indicator (MTI) capability.

The target acquisition range of the radar is reported in open literature to be 149 km or 40 km for smaller targets with a maximum detection range of 200 km and a range accuracy of 1,200 meters.

Figure 2: The VOSTOK radar is claimed to have a 72-km range against the F-117 stealth fighter aircraft. The image above is a Vostok-E variant designed for the export market by Belorussian company, KB Radar. KB RADAR

VOSTOK

The VOSTOK E is a two dimensional radar (no elevation measurement) that is a replacement for the P-18 SPOON REST radar. Open literatures states that its operating frequency is 175 MHz. It operates via random frequency hopping across 50 channels, with the ability to skip jammed frequencies. It has three channels for jamming suppression, and is said to reject chaff by 25 to 30 dB. Its range error is stated at 25 meters, its angle error (this is in azimuth) is 1.1° and its velocity error is 1.8 m/sec. Its ability to determine the direction of arrival of jamming signals is said to be ± 1°.

The Vostok-E's antenna is shown in **Figure 2.** A dimensional analysis of this open-source photograph yields dimensions of 15 meters wide by 1.8 meters high. This radar is very consistent with the Russian "Shoot and Scoot" philosophy in that its stated set up and take down times are 6 minutes.

The acquisition range of this radar (again from open literature) is stated to be 255 km against a B-52, 133 km against an F-16 and 72 km against an F-117.

Figure 3: The Protivnik-GE is a multliband 3D radar. This example was displayed at the MAKS 2011 air show. VITALY KUZMIN

PROTIVNIK-GE

The PROTIVNIK-GE 59N6-E radar is an acquisition radar which is part of the S-400 system. It is designed to track aircraft and cruise missiles flying at all altitudes at ranges up to 200 km. This radar also supports interceptors and tracking of low-orbit satellites. The minimum tracking altitude is a function of range. For a 1.5 m^2 target, at 100 meters altitude, the range (stated in open literature) is 40 km; at 1 km altitude, it is 100 km; at 5 km altitude it is 240 km; and at 12 to 80 km altitude, it is 340 km.

From open literature, the radar's features include pulse compression, 10 redundant receiver channels, IFF and excellent side-lobe suppression. The close-in side lobes are stated as -40 dB and back lobes to -53 dB relative to the main beam boresight gain. The transmitter has 500 kW peak power and 12 kW average power.

The 8.5 x 5.5-meter array (shown in **Figure 3**) is mechanically steered in azimuth and electronically steered in elevation. It can provide up to 20 pencil beams. The tracking accuracy is 0.2° in azimuth, 0.17° in elevation and 50 to 100 meters in range. One variation has an active electronically steered array (AESA) capability to steer and track with agile beams. The system has a 22-meter elevation mast.

WHAT'S NEXT

Next month, we will start a new series to discuss the jamming approaches required to counter the new-generation radars we have been talking about during the last several months. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

Views from the 55th Annual AOC Inte

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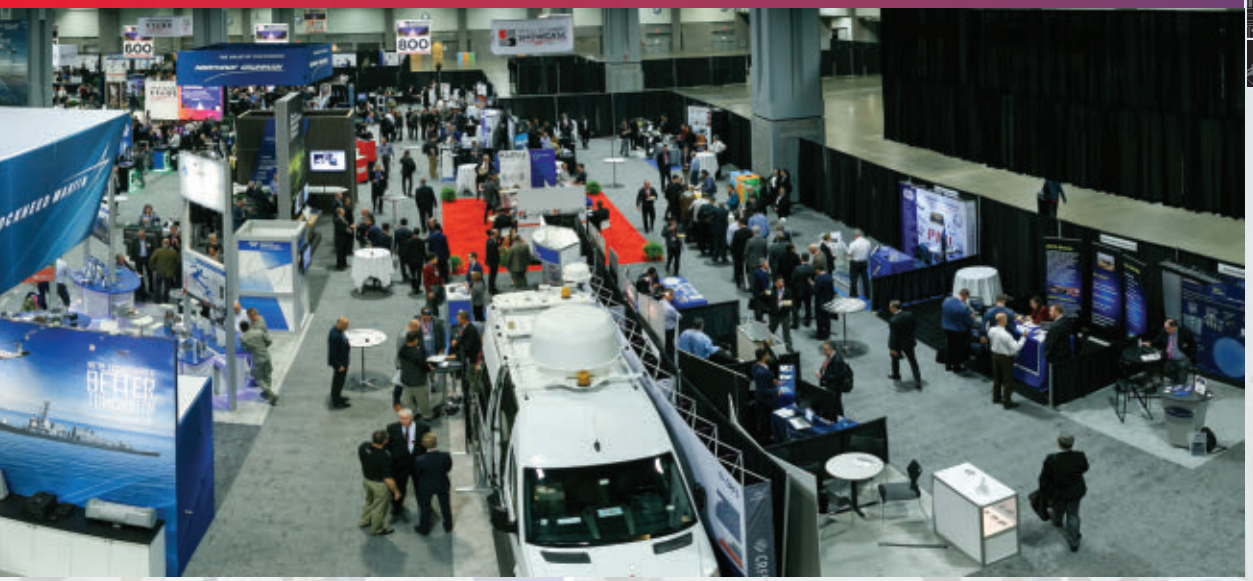
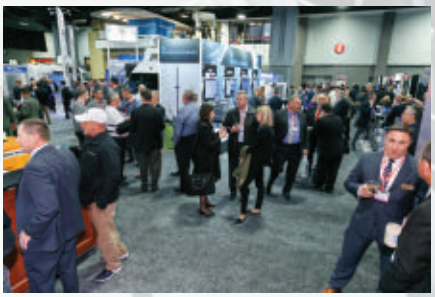
rnational Symposium and Convention





DIXIE CROW SYMPOSIUM 44 CALL FOR PAPERS

The Electronic Warfare and Avionics System Program Office (EWA SPO), AFLCMC/WNY, will sponsor the 2019 Air Force Technical Program on March 26-28, 2019. The program will be held at the Scott Theater (Building 1500), Museum of Aviation, Robins AFB, GA.

The organizers are soliciting topics in support of this year's theme "Dominate the EMS in Contested Environments through the use of Agile, Resilient Systems and Architectures." Papers to support this theme should relate to Electronic Warfare (EW), Intelligence, Surveillance & Reconnaissance (ISR), or Avionics and may include (but are not limited to) technical solutions, initiatives, enablers, techniques, methods, policy/doctrine updates, interoperability, open systems, modeling, architectures and best practices.

Abstracts should be unclassified; however the presentation itself may be classified. Abstracts must include the speaker's name, position title, paper title, organization name, e-mail address, phone number, and applicable security classification of the proposed presentation. Abstracts must be unclassified and less than two pages.

Abstracts, as well as speaker biographies, should be submitted via e-mail not later than 4 February 2019. You must indicate the highest classification level of your presentation (written and verbal). A sample abstract is included at http://www.robins.af.mil/About-Us/AF-Technical-Program. You must use the abstract format provided. Include contact information in your e-mail (if different than the proposed speaker) and forward to: AFLCMC.WNY.AFTechProg@us.af.mil

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BILLY MITCHELL CHAPTER CELEBRATES 50 YEARS

On November 11, Veteran's Day, almost 70 Old Crows from the Billy Mitchell Chapter gathered to celebrate the chapter's 50th anniversary. The BMC was founded on November 14, 1968.

To mark the event, the chapter met at Casa Rio on the San Antonio River Walk to enjoy good food and drinks, as well as fantastic friendships. BMC President John Langford kicked off the festivities by discussing chapter highlights over the past 50 years before handing off to several past BMC presidents to regale the group with their favorite AOC memories.

John Langford welcomes everyone, then watches as Ron Poland, BMC past President, relates his favorite AOC memories to the group.

JORAM SENDER, ISRAELI OLD CROW, PASSES

Col Joram Sender, IAF (Ret.), passed away November 13, 2018. Joram was known to many in the AOC community, widely respected for his support of the Association, and well liked for his honest and straightforward manner.

Joram was born on May 24, 1952 in Haifa, Israel, and passed away at his home in Ramat Hasharon surrounded by his family after a fierce battle with cancer. Between 1970 and 2001 Joram served as a career officer in the Israeli Defense Forces Intelligence Corps. He rose through the ranks rapidly and became a colonel in 1993, serving in various significant positions including overseas as an attaché.

Throughout his service, he was known for his trailblazing and innovative thinking. After retiring from the Israeli military, Joram joined Elbit Systems EW and SIGINT (Elisra) as Senior Director for Business Development and Planning. During his time there, he established the business intelligence unit and led various strategic processes focusing, most recently, on cyber warfare.

Joram was an active participant in the Israeli AOC Chapter and in the international AOC community. He often attended several AOC symposiums per year and was always willing to share new ideas to improve these events while also acting as a strong advocate for industry. His last AOC event was at EW 2018 in Lausanne, Switzerland.

Joram is survived by his loving wife Naomi, three children and eight grandchildren, of whom he was extremely proud.
– J. Clifford and J. Knowles

ASSOCIATION OF OLD CROWS

48th Annual Collaborative EW Symposium

April 2-4, 2019 | REL USA/AUS Pt. Mugu, CA

THEME: Collaboration and Collaborative EW
(US/AUS collaboration, Stand-in/Stand-off/Self-Protect jammer collaboration, Sensor collaboration, Man/Machine Collaboration, blue on blue collaboration/interoperability)

TOPICS:

1. Coherent Electronic Attack: Technology trends and advancements focused at the precise phase and timing requirements to produce sophisticated coherent jam strategies. This includes the cognitive/AI algorithms that can drive system adjustments at the speeds/ precision necessary to produce coherent effects

2. Cooperative Electronic Attack: Technology trends and advancements focused at combining EA systems for increased performance. This includes both offensive and self-protect EA and potential jam strategies that can optimize EA resources between different type EA systems.

3. Collaborative Electronic Attack: Technology trends and advancements focused at generating broader EA effects at the operational level. This includes the optimal allocation of limited EA assets over a longer duration and broader geographic areas than EA support to single target area and short time on target.

4. Collaborative EW enablers to improve EA effectiveness: Non-EA technology trends and advancements that are necessary to produce greater EA effectiveness. Includes networked solutions, interoperability / compatibility concerns, manned / unmanned teaming, assured comms.

5. Warfighter Perspective

SAVE THE DATE APRIL 2-4, 2019

CALL FOR PAPERS:

Abstracts Due: February 1, 2019

Send Unclassified abstracts to Ms. Christine Armstrong at **armstrong@crows.org** and **PT_MUGU_EW_SYMPO.FCT@navy.mil**

Abstracts should be limited to one page of text or 400 words

Registration opens January 2019!

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