JUNE 2019
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ASSOCIATION OF OLD CROWS

JED

The Journal of Electronic Defense

www.crows.org

Making Sense of Cables

Also in this issue:

Survey: Airborne Integrated EW Suites

EW 101: Jamming Track-via-Missile Threats

The new electronic warfare modernized equipment has many parts, some of which are already fielded in the Army, and requires teams in order to be fully effective. Staff Sgt. Brett McCaskill, assigned to 2nd Brigade, 2nd Infantry Division, and Sgt. 1st Class Ryan Beach, with 2nd Armored Brigade Combat Team, 1st Armored Division, are in a team to locate and decipher enemy frequencies from an unknown location.

U.S. ARMY PHOTO BY STAFF SGT. FELICIA JAGDATT

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the view
from here

REBUILDING EW CULTURE

In late April, I had the opportunity to travel down to Maxwell AFB, AL, to attend the second Electromagnetic Defense Task Force (EDTF) Summit, which was organized by the US Air Force's Air Education Training Command. On the second day of the Summit, participants from the Air Force EW Community gathered in a theater to listen to an unclassified briefing on the Electromagnetic Spectrum Enterprise Capability Collaboration Team (EMS ECCT), which the Air Force conducted in late 2018 and early 2019 under the leadership of Brig Gen David Gaedecke, Director of Cyberspace Operations and Warfighting Integration within the Office of the Secretary of the Air Force.

The briefing covered the EMS ECCT "way forward," which includes three main objectives. The first objective is to establish an EMS Center of Excellence within Headquarters, Air Force, Strategic Plans and Requirements (HAF A5/8). This new EMS organization will be led by General Gaedecke. The second objective is to consolidate Air Force EMS reprogramming under the 53rd Wing at Eglin AFB. The third objective, to instill a culture of EMS awareness within the Air Force, is the most challenging and the most important piece of this strategy.

At the beginning of the briefing, current and former Air Force officers described the nearly three decades of EW atrophy within the Air Force. This deterioration began shortly after the major EW successes in Operation Desert Storm in 1991. The F-4G Wild Weasel was retired and replaced by the single-seat F-16CJ, and the EF-111 Raven was retired with no replacement. At the same time, the Air Force graduated no Electronic Warfare Officers (EWOs) from 1993-1999. When it did get back to training personnel for the EW mission, a new designation, the Combat System Officer (CSO), replaced dedicated EWO training. However, the CSOs received far less EW training than EWOs previously had, and it was left to operational EW squadrons to provide a lot of the basic EWO training. This EWO shortfall traveled up through the Air Force ranks during the 2000s and 2010s, but the EW knowledge gap was concealed by the nature of permissive air operations during the Global War on Terror.

Now that the National Defense Strategy is focusing on near-peer competitors who are rapidly developing EMS strategies, the Air Force is beginning to recognize what it has done to its EW culture over the past 25 years. The EMS ECCT "way forward" is just a beginning, but it represents a good start.

During the EMS ECCT briefing, one of the speakers rhetorically asked the audience, "How do you change culture?" He offered four areas of focus: change EW education, improve EW training, participate in more realistic EW exercises and hold people accountable. These may sound like simple solutions, but reversing EW atrophy is tough work, and it cannot be solved by simply throwing money at the problem. The Air Force has at least identified the problem, and now it must pursue the monumental task of rebuilding its EW culture. – *J. Knowles*

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JUNE

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Charleston, SC
www.crows.org

Resilient Space: Emergent Technologies/Faster Implementation
June 11-13
Bedford, MA
www.patriotsroostaoc.org/Space_Conference

Paris Air Show
June 17-23
Paris
www.siae.fr

Electronic Warfare Technology Conference
June 18-21
Swindon, Wiltshire, UK
www.cranflield.ac.uk

4th Annual Directed Energy Systems Summit
June 26-28
Washington, DC
www.idga.org

SEPTEMBER

8th Annual AOC Pacific Conference
September 9-12
Honolulu, HI
e-mail: Arthur.N.Tulak.ctr@pacom.mil

3rd Electromagnetic Maneuver Warfare Systems Engineering and Acquisition Conference
September 10-12
Dahlgren, VA
www.crows.org

DSEI
September 10-13
London
www.dsei.co.uk

AFA 2019 Air, Space and Cyberspace Conference
September 16-18
National Harbor, MD
www.afa.org

OCTOBER

5th Annual Cyber Electromagnetic Activities (CEMA) Conference
October 8-10
Aberdeen Proving Ground, MD
www.crows.org

AUSA Annual Meeting
October 14-16
Washington, DC
www.ausa.org

Seoul ADEX 2019
October 15-18
Seoul, ROK
www.seouladex.com

56th Annual AOC International Symposium and Convention
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Washington, DC
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NOVEMBER

Dubai Airshow 2019
November 17-21
Dubai, UAE
www.dubaiairshow.aero

Defence & Security 2019
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Bangkok, Thailand
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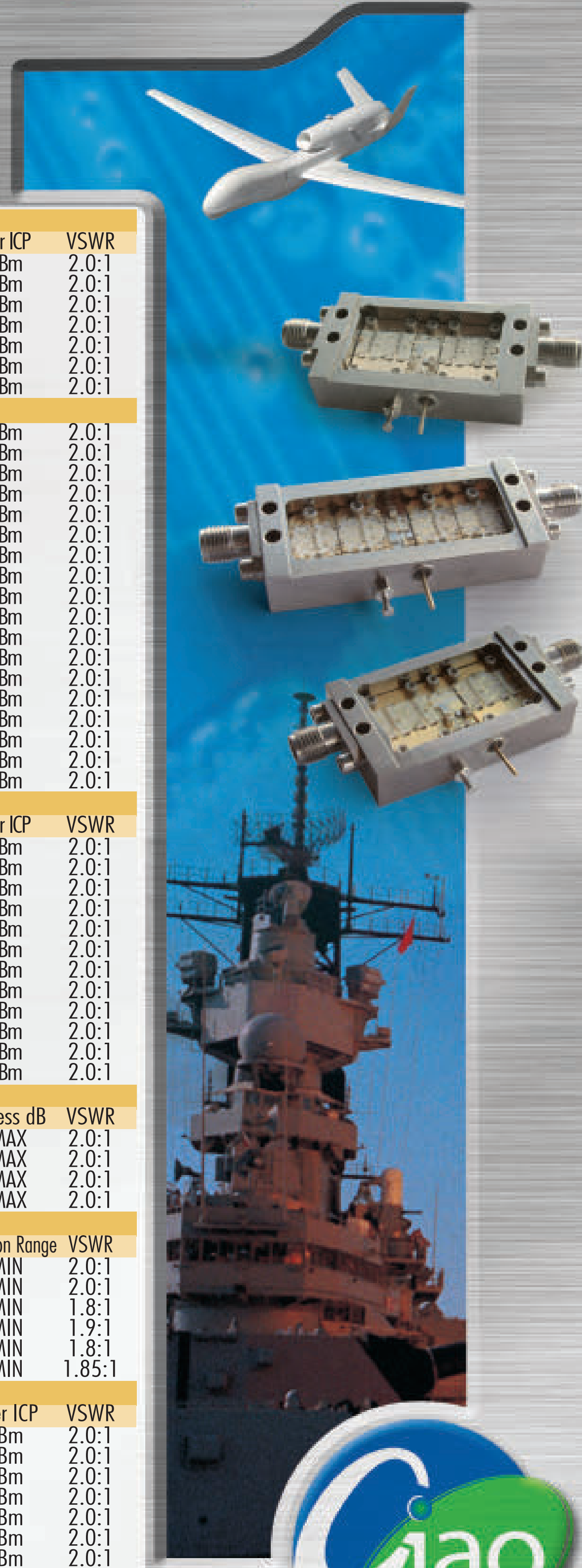

OCTAVE BAND LOW NOISE AMPLIFIERS

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

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

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

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

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

LIMITING AMPLIFIERS

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

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

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

LOW FREQUENCY AMPLIFIERS

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

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Basic EO-IR Concepts
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Airborne Electronic Warfare Systems Integration
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Atlanta, GA
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Basic Electronic Warfare Modeling
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AUGUST

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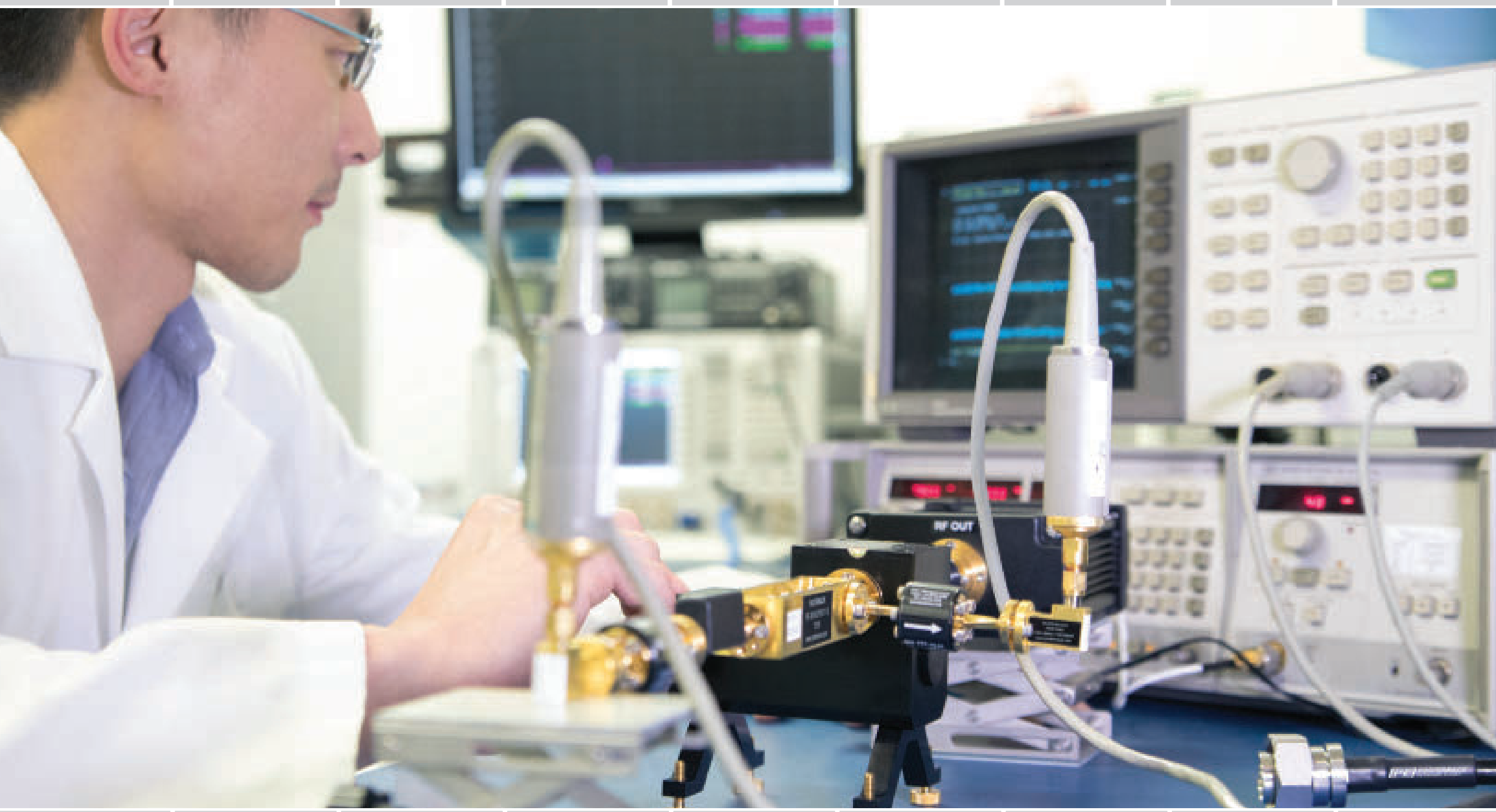
RECOGNIZING TODAY'S THREAT

Having just attended EW Europe last month, I wanted to focus this month on the challenges facing us as we look at the resurgent regional threat (Russia) that has modernized its offensive and defensive weapons systems. They have developed advanced long-range air defense systems, tactical radios, unmanned ISR, signals intelligence and communications electronic warfare (EW) capabilities. Russia has also re-organized and retrained its EW forces and embedded EW units within its larger force structure. We have seen significant use of EW by the Russians to include synchronized signals intelligence, jamming, the use of directed energy weapons, and potentially their most dangerous and effective weapon, Information Operations or Information Warfare.

As the AOC continues to push the advancement of Electromagnetic Spectrum Operations and the Electromagnetic Spectrum/Environment as a warfighting domain, we must realize we are currently at war and will be every day. The cyber threat is real and growing exponentially; we see both military and criminal intent, at times coordinated. Russia's information warfare operations, aiming to weaken adversaries' social cohesion and political systems, is directed at NATO, the United States and the European continent. Governments and individuals are targeted through a variety of instruments using the media and the Internet. Our global use of social networking and thirst for "instant news" provides Russia with the delivery mechanisms for a well-coordinated strategic (disputes between countries), operational (discord within countries) and tactical (disturbance within communities) information campaign with global reach and effect. We use Information Operations and Information Warfare as military terms and military capabilities, but the military is no longer the main point of influence. We – the people, our industrial base, our institutions and our governments – are the true targets.

As we strive to dominate or regain superiority in the Electromagnetic Environment, we must realize that even if we control the EME, even if we can maneuver freely in this warfighting domain, the information/data that is transmitted and received will need to be "authenticated." Do we have a plan in place to vet and verify information and data to establish the "truth?" Do we have a plan in place to counter disinformation that can spread globally in a matter of minutes or hours? We need to expand our vision beyond military targets. We are at war today; we are in an information war, and our societies, our way of life, not the military, are the real targets. – *Muddy Watters*



ONR TO DEVELOP NEW ANTI-SHIP MISSILE DECOY

The Office of Naval Research (Arlington, VA) is planning to develop a new anti-ship missile (ASM) decoy for its surface combatants. The program, known as Long Endurance Advanced Off-board Electronic Warfare Platform (LEAP), calls for development of a ship-launched air vehicle fitted with a 20-lb ASM decoy payload that can communicate with and be operated by a shipboard control station.

According to a solicitation notice, the LEAP program will be split into two parts. Technical Area 1 (TA1) will focus on development of an Autonomous Airborne Carrie (AAC), as well as the shipboard control station and LEAP launcher. TA2 will concentrate on development of the decoy payloads.

The notional requirement for the AAC is an air vehicle that can provide up to one hour of flight, and deliver 600W of power, as well as cooling, to a 20-lb decoy payload. The decoy launcher system must fit within the deck-space footprint designated for EW topside equipment on an *Arleigh Burke*-Class (DDG 51) destroyer and maximize the number of decoys that can be launched. After transitioning from launch to stable and controlled flight, the AAC must perform "ship-relative navigation with air and sea platform awareness with the ability to operate in a Global Positioning System denied environment," according to the program description. AAC development will also address bi-directional communication between the ship and the decoy payload.

ONR will develop the LEAP RF decoy payload under TA2, which aims to provde "...a completely encapsulated, modular RF system capable of maintaining situational awareness in the electromagnetic spectrum, communicate with the host platform, operate autonomously and under direction from the host to transmit Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) signals." The decoy payload will comprise "the compute engine, digital signal processing, RF front end and RF apertures." ONR could eventually develop a family of LEAP decoy payloads to meet the Navy's needs. The cost goal is $100,000-$500,000 per integrated decoy in full-rate production.

Another line of effort under TA2 is to develop concept designs and component technologies for electro-optic/infrared (EO/IR) payloads for the AAC. According to the program description, "It is envisioned that the compact payloads will have components including visible and infrared receivers, internal fine pointing control, control electronics, processor and a local inertial navigation system (INS). It is also desired that the air platform can receive cues over its communication link and provide this information to the payload." As with the decoy payload, the EO/IR payload is envisioned to weigh 20 lb or less and draw its power and cooling from the AAC.

Another aspect of the LEAP program is to investigate the trade space between cost and performance. "ONR sees significant benefits to a lower cost solution in enabling larger numbers of employment as well as more regular training and exercise. However, a more expensive solution may enable more rapid response, as well as more overall capability while reducing overall mission cost." The program will explore trade-offs, such as decoy endurance vs. cost, vehicle reaction time vs. cost, and sophistication of decoy and communication capability vs. cost.

As this issue of *JED* went to press, ONR program officials in the lab's Aerodynamics, Autonomy, Flight Dynamics & Control Department (Code 31) and its Electronic Warfare Department (Code 35) were planning to host an industry day on May 13. ONR plans to issue a formal solicitation under its Long Range Broad Agency Announcement for Navy and Marine Corps Science and Technology (BAA N00014-19-S-B001). LEAP Proposals are due on July 1, and ONR anticipates it will announce contract awards in November. The technical point of contact is David Findlay, PhD, Program Officer, e-mail david.findlay@navy.mil. – *J. Knowles*

USMC DISCUSSES SIGINT PLANS ON CAPITOL HILL

The Association of Old Crows (AOC) hosted its first US Marine Corps (USMC) SIGINT Day on Capitol Hill as part of its Advocacy SIGINT Industry Partnership Project (IPP) on April 11. The SIGINT Day included a panel discussion with USMC leaders followed by an Industry Solutions Forum (ISF).

The panel, "Winning the EMS: Assessing the Future of USMC SIGINT," was hosted by Rep. Paul Cook (CA-8), a retired Marine Corps colonel and a member of the House Armed Services Committee (HASC). Cook opened the discussion by describing the needs of the modern battlefield. According to Cook, the way wars are fought has changed drastically over the years. Today, the USMC and other Services need completely integrated systems and capabilities, which means placing a heavier focus on electronic warfare (EW) and SIGINT.

Cook said that SIGINT used to be something that was far from a part of basic training; it was only talked about "behind closed doors." Now, Cook said, SIGINT and EW capabilities are necessary on a battlefield that's becoming increasingly complex and congested, and should therefore be a part of training and operations throughout the various echelons of each Service.

Panel speakers included Mr. Guy Jordan, Acting Director, Intelligence, USMC; Col Randolph Pugh, Commanding Officer, USMC Intelligence Schools; and Col Dave Burton, Program Manager, Intelligence Systems, Marine Corps Systems Command. The speakers addressed how EW and SIGINT capabilities are being integrated into USMC operations and training, and what needs to change to combat evolving threats.

Jordan discussed the Marine Corp's operational goals, stating that the Service is updating its future ISR plan to place greater emphasis on tactical SIGINT capabilities and improved operations. According to Jordan, the SIGINT and EW mission has been brought forward with the help of the National Defense Strategy (NDS), as well as the creation of the Deputy Commandant for Information (DCI) position, occupied by Lt Gen Lori Reynolds. Reynolds has created an Electromagnetic Spectrum Operations Community of Interest to improve planning and policy for SIGINT and EW operations, Jordan said.

Burton also noted the importance of the DCI, saying that with the advent of the DCI comes the development of a singular community of SIGINT and EW, which will effect organizational changes in the acquisitions process and positively impact the execution of the EW and SIGINT mission.

Pugh spoke to the "human aspect" of the EW and SIGINT mission, particularly focusing on changes that will need to be implemented in today's training programs to improve readiness and effectiveness of EMS warfighters. According to Pugh, past developments and processes are a solid foundation for current and future needs thanks to the 2600 MOS cryptologic community of SIGINT warfighters, but the way new recruits are trained needs to change.

Pugh said the Marine Corps needs to work on making sure recruits understand the technology and how it functions within the EMS, as well as teaching appropriate tactical responses to EW and SIGINT threats. Training should include billet-based training, a persistent learning environment, and experience both jamming enemy systems and having systems jammed through simulation training, Pugh said.

One of the greatest challenges to advancements in EMS training, however, are the squadron commanders themselves, according to Pugh. He said, "Our most pressing concern is that commanders don't care." Because commanders don't fully understand what it's like to operate in today's GPS-denied or PNT-denied environment, they grudgingly devote resources to EW and SIGINT without understanding why these capabilities are so important.

Pugh believes the key to showing commanders the importance of effective EMS operations is demonstrating adversaries' capabilities. The Marine Corps should take a new direction when training commanders, incorporating training sessions where commanders face EW Red Team threats that simulate the effects of EMS attack squadrons, according to Pugh.

Burton also spoke to the challenge of making meaningful changes to EMS Operations, stating that military, government and industry need to recognize that peer and near peer adversaries present different challenges, and the Forces must be able to adapt to both. According to Burton, industry should focus more on developing technology that combats "frequency hoppers," and ensure the warfighter has the ability to operate at high frequency ranges and variable bandwidths, and to simultaneously jam enemy systems and communicate.

The Industry Solutions Forum (ISF) followed the panel discussion, where government, military and industry representatives could discuss current EW and SIGINT needs and share some of the latest technology relevant to the EW and SIGINT mission. – H. Swedeen

IN BRIEF

The US Army announced that it will issue a new set of research topics via its Other Transaction Authority Agreement (OTA) with the **National Spectrum Consortium (NSC)**. The topics are:

SARDP 12, Spectrum Aggregation Technologies: The objective of this effort is to develop and demonstrate a prototype Aeronautical Mobile Telemetry (AMT) transceiver capable of sensing the local RF spectrum environment and aggregating non-contiguous blocks of spectrum in the 6425-6525 MHz based on user defined and ad-hoc policies and real time telemetry channel conditions.

SARDP 26, Reconfigurable Small Unmanned Communications: The objective of this effort is to develop and integrate performance enhancements for small unmanned communications systems. The initial target system for integration of the technology developed under this effort will be Small Unmanned Aircraft (Group 1).

SARDP 29, Spectrum Access Manager: The objective of this effort is to develop and demonstrate a prototype spectrum management and planning tool which provides critical data relating to link availability for a given flight path to support efficient RF spectrum planning by re-binning the spectrum allocations at an identified test range.

SARDP 30, Operational Spectrum Comprehension, Analytics, and Response (OSCAR): The objective of this effort is to develop and demonstrate a spectrum automation solution that supports spectrum access for large force exercises and other spectrum-intensive scenarios.

SARDP 31, Multiband Control Channel for ACTS (MICCA): The objective of this effort is to develop a standardized control channel architecture that provides radio frequency (RF) operating parameters and priorities to dynamic spectrum access (DSA) enabled systems. MICCA is intended to be used for the air combat training system (ACTS), but can be used generally to provide spectrum allocation information to any enabled spectrum dependent system.

SARDP 32, Risk-Informed Spectrum Access: The objective of this effort is to develop risk-informed spectrum access technologies to enhance spectrum sharing behaviors based on situational uncertainty and risk thresholds. Technologies to be developed under this project include formal risk assessment methods and models, which will result in standardized and efficient algorithms for quantifying situational uncertainty for spectrum users and planners, to enable increased user density and/or spectrum-dependent system capability in a given bandwidth and geographic extent.

The topics will be posted for Consortium members on the NSC Web site at www.nationalspectrumconsortium.org.

CSBA RELEASES REPORT ON THE FUTURE OF AIR POWER

Authored by Mark Gunzinger, Carl Rehberg, Jacob Cohn, Timothy A. Walton and Lukas Autenried, a new report from the Center for Strategic and Budgetary Assessments (CSBA) (Washington, D.C.) titled, "An Air Force for an Era of Great Power Competition," specifies a number of recommendations for the US Air Force in terms of its building of and effectively implementing an adequate inventory of aircraft for potential conflicts in the coming decades.

The 2018 National Defense Authorization Act (NDAA) required a report from the Air Force detailing its plans and expectations for its future aircraft inventory. The CSBA report provides a recommendation for this inventory as well as proposing an accompanying force-planning construct that would require the Air Force to size and shape its future force to "sustain strategic deterrence, defend the US homeland, and be prepared to defeat major acts of aggression by China and Russia as part of the Joint Force."

According to the report, this recommended future inventory would be "modestly larger" than today's force, driven by an expected shift toward preparing to deter and defeat great power aggression rather than conducting counter-terrorism operations and defeating lesser regional aggressors. As such, the aircraft inventory will need to be "more lethal, resilient, and better able to operate in contested and highly-contested environments compared to today's force."

A Stitch In Time?

CSBA's study methodology included a mix of independent research, workshops as well as a high-level wargame that played scenarios for major conflicts with China and Russia set in the year 2035 to enable assessments of technologies and capabilities that could join the force by that time. The wargame culminated in a "Strategic Choices Exercise" that tasked four teams with assessing how quickly the Air Force may be able to develop the recommended future force given different funding profiles over a ten-year period (FY 2020–2029).

The CSBA report presents recommended aircraft inventories for both the year 2030 and for an unspecified outyear in line with the report's recommended force planning construct. This is because, although the CSBA report, per the 2018 NDAA requirement, does indeed provide a recommended aircraft inventory for 2030, it also recommends that the Air Force actually work to develop and field the full required capability over the next fifteen to twenty years rather than by 2030. "Attempting to significantly increase the size of the Air Force's aircraft inventory to reach an objective force by 2030 would require it to procure primarily aircraft that are in production now or are about to enter production. This could reduce funding to develop new weapon systems and create significant gaps in capabilities that would be needed beyond 2030." Instead, the report recommends that the 2030 inventory be considered as a "waypoint on the path toward the force of 2035 and beyond." The complete report includes detailed listings by aircraft type of the recommended force numbers for each timeframe, and the ultimate approach taken to achieving those target goals; however, the recommended aircraft numbers discussed in this article represent only the report's recommendations relative to its future "force structure that is consistent with the recommended force planning construct for 2035 and beyond."

More Strike

Overall, the CSBA report notes that the Air Force's current 55 fighter squadron equivalents are roughly half the number of fighter squadrons it had 30 years ago, and although it still maintains the largest bomber force in the world, it is a smaller force than it maintained during most of the Cold War. The emergence of advanced integrated air defense systems (IADS) has also significantly diminished the Air Force's ability to strike globally, it says.

In contrast, CSBA's recommended future force would have a total of 266 primary mission aircraft inventory (PMAI) bombers and 1,329 PMAI fighters, which translates to 24 bomber and 65 fighter squadron equivalents. "Converted to total aircraft inventory (TAI), the future force would have 383 bombers (assuming B-2 bombers remain in the inventory), and 2,107 fighters."

More Stealth

The report focuses on a number of specific areas where force structure modification will be required. Among these is the need for more stealth aircraft. As cited in the report, today, approximately 17 percent of the Air Force's bomber and fighter inventory consists of stealth aircraft that are capable of maneuvering freely in contested areas created by modern surface-to-air and air-to-air threats. In the recommended future force, however, approximately 68 percent of the Service's fighters and bombers would be stealth aircraft.

More Range

The future force will also require a more balanced mix of short-range combat aircraft with small payloads and long-range penetrating bombers with large payloads. According to the report, "In 2019, approximately 79 percent of the Air Force's total potential daily conventional munitions delivery capacity is provided by fighters that have less than 1,000 mi unrefueled combat radius, and only the 16 stealth B-2 PMAI aircraft in the Air Force's bomber force are capable of striking over long ranges and into contested environments." In contrast, the recommended future force would have a little over 400 PMAI long-range combat aircraft that could penetrate highly-contested environments and deliver large quantities of weapons. This would substantially increase the number of targets the Air Force could attack nearly simultaneously over the large areas covered by Chinese and Russian anti-access and area-denial (A2/AD) threats.

Stand-in Jamming Aircraft

Of particular interest and importance to *JED* readers, the report recommends that the Air Force develop and field a family of capabilities to maintain America's air superiority advantage as well as a multi-domain system-of-systems to provide airborne battle management and command and control (BMC2) to joint air forces conducting dispersed operations over large areas. Among these needed future capabilities is a "Penetrating Counter Air (PCA) aircraft that has greater range, mission endurance and larger payload capacity than contemporary fighter aircraft. The PCA aircraft would be capable of conducting stand-in (penetrating) electronic warfare missions to help suppress threats and create the degree of air superiority required for other penetrating aircraft and weapons to survive and perform their missions."

Greater Numbers/More Dispersed Tanker Platforms

The report also points out that the Air Force is currently operating the smallest and oldest air-refueling tanker force in its history and, according to the United States Transportation Command, "the combination of high average age and high levels of sustained demand for air refueling support is reaching a breakpoint." The recommended future aircraft inventory would provide for a larger, modernized force of air refueling aircraft. In addition to the KC-46A aircraft that are now joining the force, the report suggests that the future tanker inventory could include smaller unmanned platforms or theater tankers that could operate from more airfields and penetrate for some distance into lower-risk areas of contested environments. "These capabilities would improve the Air Force's ability to air refuel joint air forces operating from highly dispersed postures in the Indo-Pacific region and Europe."

Ultimately, the CSBA report recognizes that the ultimate mix of capabilities recommended in its unspecified-outyear future force would be a major departure from the Air Force's current aircraft inventory. However, it notes that, "The preponderance of the Air Force's combat, ISR, and BMC2 aircraft cannot penetrate and persist in the contested and highly contested environments that would characterize major engagements against China or Russia in the future. This shortfall would dramatically hinder the Air Force's ability to conduct multi-domain operations. The (proposed aircraft) inventory. which should be complemented by the development of new operating concepts for global strike, close air support, counter-air, electronic warfare, and other operations that span the spectrum of conflict, would shift the Air Force's future force structure toward a mix that is better capable of deterring and defeating great power aggression."
– J. Haystead

world report

REPORT FROM EW LIVE REAL-WORLD TECHNOLOGY DEMONSTRATION

Undeterred by real-world weather conditions, the "2019 EW Live" electronic warfare (EW) equipment exhibition and live demonstration event was held from April 9-11, in Tartu, Estonia. Estonia is directly south of Finland (across the Gulf of Finland); with the Vainameri (Baltic) Sea bordering it to the west, Latvia to the south, and Russia to the east. So, while it may not be one of the most generally-familiar countries in the world, in terms of its location in the new Eastern Europe, it's definitely in a strategic location.

Relative to this, and pointing out Estonia's position as one of the world's most digitally-advanced societies, and in particular, its focus on the rapid development of its IT and cyber sector, Major General Indrek Sirel, Deputy Commander, Estonian Defence Forces, opened EW Live exhibition, noting that, the openng of the Cyber Security Exercises and Training Centre CR14 and the NATO Cyber Range Capability, was held the previous day in Talinn, Estonia, the country's capital. "The digital world doesn't recognize national borders," he stated, "and it's very important that we share our knowledge and experience, and that we merge them together, so that we are stronger when it comes to confronting future threats."

The 2019 EW Live event built upon the experience and success of the inaugural event, which was held in the fall of 2017 in Tartu. Sponsored by the Republic of Estonia Ministry of Defence and the Estonian Defence Industry Association, and organized by Tangent Link (Slough, UK), EW Live is unique in that it features live demonstrations of EW and SIGINT equipment and systems in an actual field environment.

With the theme, "Delivering Knowledge Through Demonstration," the 2019 event provided a "live COMINT & ELINT threat spectrum setting presenting the threat context to current and new types of EW operational equipment."

Unlike most industry trade events, EW Live is organized around "delegations" of attendees representing individual countries. This year, there were more than 280 attendees representing 23 countries and organizations, including (in no particular order) Estonia, Turkey, Latvia, Hungary, Singapore, Poland, Indonesia, Croatia, Czech Republic, France, Italy, Switzerland, Germany, Spain, Algeria, Morocco, South Africa, Bahrain, Saudi Arabia, Lithuania, Finland, Norway, Sweden, Taiwan, the USA, Canada, the UAE, the UK and NATO. *JED* was the official media partner and attended classroom and field demonstrations as a mixed-nation delegation representing the AOC.

The event was held at the Tartu Airport with the industry exhibition stands in the facility's main hangar, while the live demonstrations were set up in the area outside the hangar, in classroom space provided by the co-located Estonian Aviation Academy, and at remote tented and heated areas sited within the boundaries of the Tartu airfield.

In addition, a highlight of this year's event included two days of live counter-drone technology demonstrations. Due to concerns over openly radiating jamming signals aimed at the drone's WiFi control links and GPS receivers, these were held at the Estonian MOD Defence League's Utsali Shooting Range in Kirma, Estonia (approximately 20 minutes from Tartu Airport). In total, the event's nearly-30 participating companies conducted more than 230 live demonstrations over the three-day experience. Participating companies included Allen-Vanguard, AP-Flyer, Battlespace Simulations, Chemring Technology Solutions, COMINT Consulting, Communications Audit, CRFS, Decodio, Exfo Homeland Security, Glenair, Hidrolab, Invsible Interdiction, IZT, L3 TRL Technology, National Instruments, Novator Solutions, Patria, Procitec, Plath, Rohde & Schwarz, Saab Grintek Defence, Sagax Communications, Sesofusion, Tehnoturg-T Raadiosidekeskus, Teledyne Defence & Space, and Textron Systems Electronic Systems.

Speaking at the welcoming reception hosted at the Estonian National Museum on the evening of the first day of the show, Mr. Kusti Salm, National Armaments Director, Director of Defence Investments Department, Estonian Ministry of Defence, stated that the event "provides a live electromagnetic environment where EW subject matter experts have the opportunity to personally witness and test the best electronic warfare products and equipment currently available on the market, including new counter-UAS technology, based on real-life scenarios. It emphasizes to the international EW community the importance of the sharing electronic spectrum knowledge and operational experience in the context of the 21st century battlefield, and allows us all to meet with experts in their field to further our collective knowledge." *– J. Haystead*

MBDA UNVEILS SPEAR-EW STAND-IN JAMMER

The UK arm of European missile manufacturer MBDA (Stevenage, UK) has revealed the ongoing development of an air-launched stand-in jamming/electronic warfare (EW) decoy variant of its SPEAR stand-off miniature precision-strike missile.

Designed to meet the UK's Selective Precision Effects At Range Capability 3 (SPEAR Cap 3) requirement, the SPEAR weapon system is being developed under a four-year, £411 million contract awarded by the Ministry of Defence in March 2016. SPEAR Cap 3 calls for an intermediate range (>100 km) all-weather precision weapon to prosecute fixed, mobile and re-locatable targets in complex, hostile environments bound by restrictive Rules of Engagement.

The SPEAR technical solution is a sub-100-kg weapon featuring a Pratt & Whitney TJ-150-3 turbojet engine, dorsal flip-out wing surfaces, mid-course guidance via a combined GPS/inertial navigation subsystem (with a two-way datalink

enabling mid-course updates, re-targeting and mission abort functions) and a multi-mode (millimetric wave radar/semi-active laser) seeker. A "tuneable" multi-effects warhead, combining precursor and penetrator charges, is fitted to address different target sets.

MBDA has engineered SPEAR to meet the specific internal weapon carriage constraints of the F-35 Lightning II, with the weapon being sized for quad loadout in the F-35B internal weapons bay using a four-pack launcher. An alternative triple launcher is being developed for external carriage on fast jet aircraft such as the Eurofighter Typhoon and the Saab JAS-39 Gripen.

SPEAR is being integrated onto the F-35B as part of the F-35 Block 4 upgrade program. In March 2019, it was announced that BAE Systems had received initial funding from Lockheed Martin, as F-35 prime contractor, to begin integration efforts for both SPEAR and MBDA's Meteor beyond visual range air-to-air missile.

Development of the derivative SPEAR-EW, believed to be using a mix of internal R&D resources and MoD funding, was first publicly acknowledged by MBDA in April 2019. While retaining the outer mold line and mass properties of the baseline missile, the SPEAR-EW variant dispenses with the seeker package and warhead to accommodate additional fuel and an EW payload to enable suppression of enemy air defenses (SEAD).

Intended to act as a SEAD "force multiplier," SPEAR-EW is designed to take an EW payload deep into the missile engagement zone to jam threat radars and provide screening for other strike platforms. According to MBDA, the current development effort is focused on two key areas: first, understanding the maximum limits of range and loiter time; second, the performance and characteristics of the sovereign EW payload, which has been developed by Leonardo (Luton, UK).

For years, the UK MoD and the Royal Air Force have been exploring the potential of stand-in jamming as a candidate technology for SEAD. Studies have considered a range of SEAD options against the increasing threat to air platforms arising from advanced mobile "double-digit" surface-to-air missile systems, advances in digital radar processing and the emergence of new passive detection systems.

One part of this effort was a Stand-in Jammer Capability Concept Demonstrator (CCD) program, delivered by the UK Defence Science and Technology Laboratory and Leonardo. The CCD demonstrated the maturity of this sovereign Stand-In Jammer payload and proved its viability as a near-term option to meet future SEAD requirements. The UK subsequently conducted integration of this sovereign jamming payload with a Raytheon MALD-V vehicle at Raytheon UK's Harlow facility. – *R. Scott*

MASS OMNI-TRAP DECOY GAINS RANGE

Rheinmetall Defence has introduced an extended range version of the Omnitrap multi-spectral decoy associated with its Multi-Ammunition Softkill System (MASS) shipborne expendable countermeasures suite.

Launched to market in 2002, MASS has become the market-leading shipborne decoy system with over 220 launchers sold to date. A typical MASS configuration comprises between one and six stabilized trainable launchers, each of which can fire 32 spin-stabilized 81mm Omni-Trap multi-spectral decoy rounds. Mortar-launched, the baseline Omni-Trap is designed to deploy its payload – comprising radio frequency (RF) chaff, infrared and electro-optical obscurants – to a range of approximately 100 m for seduction purposes.

The new rocket-powered extended-range Omni-Trap round is designed to offer additional range in countermeasures deployment. The primary motivation is to provide greater tactical flexibility for the protection of large radar cross section ships while also allowing for the use of the MASS system in a "close distraction" mode.

It is understood that Germany and Canada have already procured quantities of the extended range round for their MASS systems. Rheinmetall will maintain both Omni-Trap decoy types in production, although it plans to standardise on the rocket-powered version over the long term.

In a further development, Rheinmetall has developed a new millimetric waveband (mmW)/infrared round, which incorporates chaff cut to counter mmW seekers in the Ka-band region.

Rheinmetall has also introduced a new air-deployed RF offboard corner reflector round for MASS. Developed in conjunction with Irvin GQ, the ADS103 is a rocket-powered round (fired from a tube mounted atop the main launcher assembly) which deploys an inflatable corner reflector suspended beneath a parachute. – *R. Scott*

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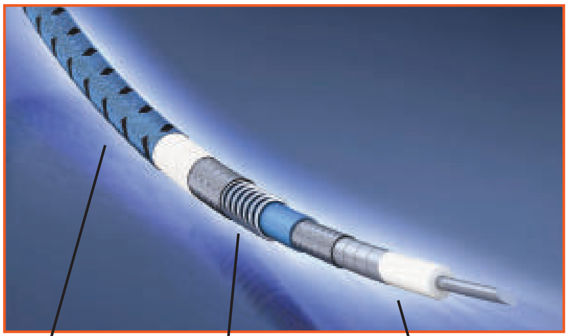

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Reliable Connectivity: Cables and Connectors V

By Barry Manz

PHOTO COURTESY OF DOD

The military has never been easy on microwave flexible cables and connectors. They're routinely subject to levels of abuse unmatched by few if any other applications, from being handled by people who don't recognize their fragility (and consider them excellent for pulling equipment carts), run over by trucks, immersed in chemicals and fuels of all types (and salt water), exposed to huge temperature swings, and many more forms of torture. The higher the frequency, the more fragile cables and connectors become. And, at millimeter-wave frequencies, they're truly delicate. But that's where DOD is headed, and the industry is, as always, coming up with solutions.

Coaxial cables and connectors are remarkable feats of electrical, electromagnetic and mechanical engineering designed to accommodate the vagaries of electromagnetic energy. They must have the lowest possible insertion loss and VSWR, high phase and amplitude stability, the ability to maintain their performance over wide temperature ranges with high resistance to ingress of external signals, and other capabilities.

TOUGH ENVIRONMENTS

The types of cables and connectors available to microwave designers have grown over the years in response to the needs of the defense and commercial markets, and today, there are more than two dozen cable designations that span the range from DC to 67 GHz and connectors that deliver mode-free performance to 145 GHz. There are flexible and semi-flexible cables, hand-formable cables, and various permutations of each one using patented or otherwise proprietary materials and fabrication techniques.

The airborne environment is possibly the most challenging for cable manufacturers because they must satisfy a long

enture into New Regions

list of very demanding specifications, all of which are required to ensure the safety of the pilot and the aircraft. "It's more difficult to manufacture and protect these cables in military and aerospace environments," says Chris Ericksen, product specialist for RF and microwave cable at W. L. Gore, "and we start with the base coax structure and add layers to protect it while maintaining the impedance of the cable in the face of changing environmental conditions and the environment it lives in. We've added layers to our GORE-FLIGHT cables that provide a vapor barrier, a cross-protection layer, as well as jacketing abrasion resistance."

SEMI-RIGID AND FLEXIBLE CABLES

In addition to the various types of flexible cables, there are semi-rigid cables that have been a mainstay for defense systems longer than any other type of transmission medium but waveguide. There are arguably billions of semi-rigid cables throughout the DOD inventory, for connecting microwave components and integrated microwave assemblies, as well as for use with test equipment. Even though semi-rigid cables are comparatively difficult to work with (basically "shape-once only"), they have several unique benefits that set them apart. Semi-rigid cable performance is very close to that of a pure transmission line, as their solid metal outer conductor provides uniformity between itself and the center conductor and dielectric.

PHOTO COURTESY OF DOD

PHOTO COURTESY OF DOD

They can achieve almost 100% shielding effectiveness, retaining the electric and magnetic fields inside, which reduces radiation loss and keeps signals from exiting or entering. Semi-rigid cables also have very high amplitude and phase stability, and compared to flexible cables, have lower insertion loss and lower VSWR. Given the choice, few people would volunteer to use semi-rigid cables if a flexible or semi-flexible type could serve without sacrificing performance or increasing the cost too much.

As for flexible cables, the trend is toward focusing on packaging and the needs of specific applications, according to Gore. "All the capability that the industry needs right now we've had for a long time," says Paul Pino, principal electrical engineer at the company. "It's more of a packaging challenge that we're up against right now, such as ruggedness and techniques that allow the cable to remain lightweight and flexible and still endure a large amount of rough handling, especially during installation in an airframe."

DAMAGE CONTROL

Although it's unlikely that anyone has ever conducted such a study, it's reasonable to assume that most of the damage to microwave cables and connectors comes not from the environment but the people who use them. However, one survey cited by W. L. Gore showed that more than 75% of microwave cable assemblies are replaced frequently, that 36% were replaced once a year, and 20% were replaced at least twice a year. About 29% of respondents cited cable damage during installation as the primary cause of failure.

The damage is rarely intentional but end-users, unlike their creators, know little about microwave cables and connectors, which is fine in the consumer world, where cables and connectors are commodities, generally inexpensive and expendable. But in defense, aerospace and other mission-critical applications, failure is not only costly but potentially catastrophic.

Not surprisingly, any microwave cable manufacturer will readily admit that one of its greatest challenges is educating their customers about the "care and feeding" of their products. And, while DOD is not the only offender, it's surely in the top tier. "One of the really big challenges we face in the military is how work gets done," says Pino. "In the 1970s, a single person was usually responsible for a system, who became an expert, and understood not only how a circuit works but the interconnects as well, and how they impact the system's operation. This doesn't exist as much to-

day because those people have retired, so there isn't much awareness about cables or knowledge that a failure can cause an aircraft to be lost."

It's obviously not reasonable to expect everyone in the military who might encounter high-frequency cables and connectors to understand how they work. However, a case can be made that they should know that they need to be handled with care, not only because mishandling can have disastrous results, but because they are expensive to buy and extremely costly to replace once installed.

Consider, for example, an EW or communications system in a fighter aircraft that experiences degraded performance. To solve the problem, the "swaptronics" approach is often employed in which LRUs are removed from the aircraft and replaced if spares are available. If this doesn't work, and there is no damage to the antennas, then cables, connectors, or both must be the culprit.

Verifying this hypothesis requires the ability to find the discontinuity through distance-to-fault detection,

"The 0.8-mm connectors are so small it's almost impossible to see without a microscope, but it's still big enough so we can manipulate it," says Tumbaga.

which is only possible with a vector network analyzer (VNA) or a system like USM-670A Joint Services Electronic Combat Systems Tester (JSECST) that incorporates its capabilities. Also required is someone who has been trained to use the test equipment – possibly the greatest challenge of all. If both can be procured, measurements are made to determine where the discontinuity is located, which is probably at a cable/connector interface. Thus, the logical choice would be to "simply" restore the interface by removing a short length or cable and installing a new connector at its end.

Unfortunately, Murphy's Law dictates that the offending discontinuity may well be buried within the airframe, making it inaccessible without removing panels to reach it. This and repair itself require the skills of a cave explorer, significant technical expertise and surgical precision. With luck, however, it's possible that the cable assembly is terminated using field-replaceable connectors.

This would at least make the repair possible, as microwave cable assemblies are manufactured as a piece to ensure optimum performance at their cable/connector interface. There are also multiple protective layers surrounding the center conductor and very possibly a vapor seal on a flight-grade assembly. Many aircraft (and other platforms) do not have field-replaceable connectors.

This is just one hypothetical scenario in which a cable, a connector or both are the source of a problem, but it illustrates the time and cost required to solve a cable-related problem, as well as why it's essential to recognize that

PHOTO COURTESY OF DOD

microwave interconnects aren't simply commodities, but complex and precision components that can either make or break system performance.

Other scenarios are also not that uncommon, according to Pino. "We've encountered cases where cables have been installed in aircraft, tested before they go in, tested after they go in, and still have to be removed and reinstalled because they could not withstand the rigors of installation."

This situation isn't likely to improve in the future, as systems move into the millimeter-wave region, where components get smaller, more fragile and more expensive. "A TNC connector is a doorknob compared to connectors with a diameter of 0.8-mm and 1-mm," says Pino. "They are very fragile and are eventually going to be used in the field where people have no idea what a microwave cable is or what you need to do to keep it working properly."

One solution, developed by Rosenberger, Spinner, Rohde & Schwarz and Germany's national metrology institute, is the 1.35-mm (RPC-1.35) connector, which in size lies between the 1.85-mm and 1-mm connectors. Their efforts were undertaken to accommodate the auto industry's need for connectors that operate to 60 or 90 GHz in anticipation of sensors for autonomous vehicles.

Their goal is to provide a connector that is large enough to handle (with care) and is also larger than the tiny 1-mm connector that operates well into the millimeter-wave region. It should have a lifetime of at least 3,000 mat-

ing cycles and uses a threaded coupling to prevent unlocking. The 1.35-mm interface is currently in the standardization process for IEC 61169-65 and IEEE P-287), which cover connectors up to 110 GHz.

CONNECTOR EVOLUTION

Most microwave connector types have been available for years and often decades, and improvements mostly concern increasing performance levels and reducing cost. There are three broad categories of microwave connectors: production, instrument and metrology. The production-grade of connectors include general-purpose or field connectors for components and cables and are the most commonly used in field-service applications and other use cases, where their loose tolerances and minimum performance levels are acceptable. They are also the least expensive.

Instrument-grade connectors are precision types generally used as the ports on test equipment and in low-cost calibration kits. They have tight tolerances, very good performance and long operating lifetimes. This makes them well suited for measurement applications in which they are mated and unmated many times over their operating lives. Instrument-grade connectors are also relatively inexpensive, especially compared to the highest grade, the metrology-grade connector.

Metrology-grade connectors are used on calibration standards that require the highest possible levels of performance so they can be used for ensuring compliance with the National Institute of Standards and Technology (NIST) and other national standards bodies. Even though these connectors and adapters have precision slotless contacts and extremely high dimensional tolerances, they can still be mated and unmated many times, a testament to their precision tolerances and design features. Metrology-grade connectors can only be used with each other because mating them with lower-grade connectors or adapters can damage them, or worse. Even tiny amounts of dust and debris can make them unusable for metrology applications.

Most of the development work on precision higher-frequency connectors in the last few decades has been conducted by the test and measurement community along with manufacturers of complementary products that support them. The C83.2 and IEEE P287 connector committees working in the 1960s and then later from the 1980s to today established a forward-looking approach for precision connector development.

Initially, their goal was to revise the existing IEEE Standard 287 to make it more representative of current trends and future needs, as well as standardizing laboratory and general-purpose precision connectors to reduce the growing list of connector variants. Their efforts even extended to 110 GHz, which today seems somewhat clairvoyant as both instruments, connectors and adapters are now available for this frequency.

THE INCREDIBLE SHRINKING CONNECTOR

The SMA, the world's most widely-used microwave connector, was the

continued on page 38

SYMPOSIUM AGENDA

"Building the EMS Enterprise"

The 2019 International Symposium and Convention will survey the EMS Enterprise across *Organization, Technology, Readiness,* and *Support* equities necessary to achieve EMS superiority. Distinguished senior military leaders and subject matter experts will discuss how the dynamic threat environment is fueling new opportunities in technology and operational concepts for US and Coalition forces. Breakout sessions will explore developments in multi-function systems, command and control, collaborative EW technology, and more, to show how EMS superiority provides decisive operational advantage—ultimately preparing the warfighter for victory.

Symposium Sessions

Below is a sample of some symposium sessions that are on the agenda this year. You can learn more about themes, session chairs, and agenda descriptions at **56.crows.org**

- State of the EMS Enterprise
- Threat-Based Intel in EMS Ops
- Multi-Functional EMS Technologies
- Managing the Electromagnetic Battle
- Readiness in the EMS
- High-Energy EM Weapons Update
- C2 of Allied EM Operations
- Core Enabling Technologies
- Senior Visions for MDO in the EMS

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SPEAKER SPOTLIGHT

James A. Faist, SES
Director, Adv Capability,
OUSD Research & Engineering

Honorable Alan R. Shaffer
Deputy Under Secretary of Defense
for Acquisition and Sustainment

Lt Gen Robert Elder, USAF (Ret'd)
AOC Senior Advisory Board

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basis for many millimeter-wave connector types and most higher-frequency connectors have at least something in common with the SMA. The earliest millimeter-wave connectors were the BRM/OSM/SMA types that appeared in 1958, and later the BRMM/OSSM/SSMA family introduced in 1960. They extended mode-free operating frequencies to 18 to 24 GHz and 26 to 34 GHz, respectively.

The next advance was the MPC2 connector developed by Maury Microwave, which operated to 40 GHz but could not mate with other connector types. To remedy this, the company developed a 2.92-mm air interface connector (the MPC3) that was compatible with the SMA and mode-free to 40 GHz. Unfortunately, little or no commercial instrumentation with such a high measurement range was available at the time, but the design nevertheless played a major role in connector development afterward, when test equipment manufacturers increased their measurement frequencies.

Kevlin Microwave released an SSMA-compatible air interface connector, the KMC-SM, that operated mode-free to 40 GHz and was followed by the 3.5-mm connector developed at Hewlett-Packard in the 1970s. This connector was later marketed by Amphenol as the APC 3.5 that is mode-free to 26.5 GHz. The 2.92-mm connector was resurrected as the K connector by Wiltron (now Anritsu) to provide connectors and adapters required for the company's then-new scalar network analyzer that had a measurement range up to 40 GHz. The K connector is SMA compatible and is mode-free to 46 GHz. After this, HP, Amphenol, and Omni-Spectra (acquired by MACOM) introduced the 2.4-mm connector that reaches 50 GHz, this time lead by Julius Botka and Paul Watson at HP.

The 2.4-mm connector was a significant contribution to the microwave industry. It satisfied the needs of all three connector grades – production, instrumentation, and metrology – and created an interface that made it possible to be improved over time. Botka and his team expanded this concept to create the 1.85-mm connector that is mode-free to 72 GHz. From a test equipment viewpoint, it was actually Wiltron rather than HP that first introduced it commercially, in order to meet the needs of a new 60-GHz network analyzer, calling it the V connector.

Millimeter-wave connectors exceeded the 100-GHz benchmark in 1989 with the 1-mm connector credited to Watson at HP. It is mode-free to 110 GHz and was mechanically innovative, pushing the tolerance limits of fabrication technology because of its tiny dimensions. Another major development, credited to Omni-Spectra, is the blind-mate connector that allows an entire, multi-connector subsystem to be connected to another without the need for intervening cable.

Blind-mate connectors are self-aligning and guide themselves properly into position. They are a staple of rack-and-panel and module-to-module environments, allowing multiple RF connectors to be simultaneously connected. Blind-mate connectors include the OSP (22 GHz), OSSP (28 GHz) OS-50P (40 GHz), as

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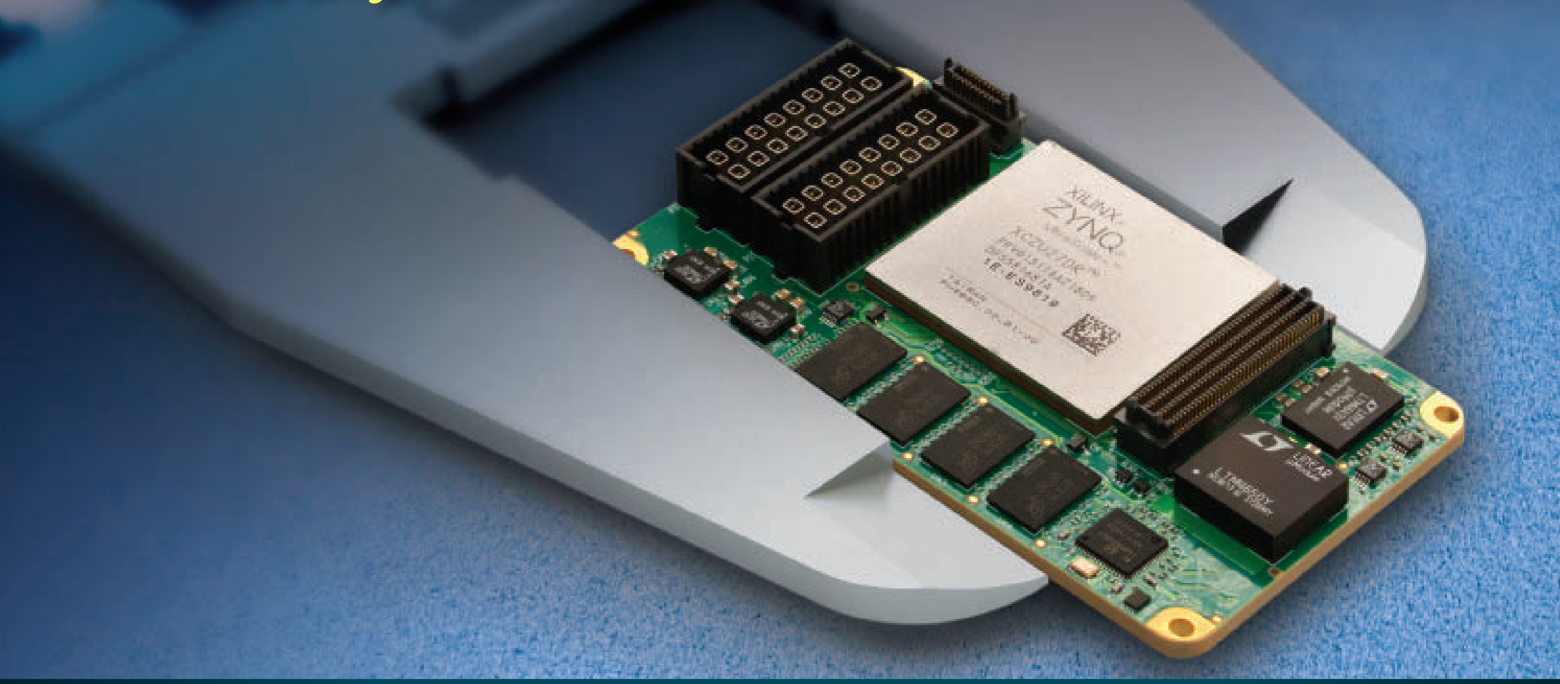

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well as SMP (a.k.a. GPO), and mini-SMP (a.k.a. SMPM). Their mode-free operating range has increased to 65 GHz over the years.

Having reached 110 GHz with a truly tiny connector body, the question for test equipment manufacturers was how they would meet the connector challenges posed by VNA's with even higher measurement frequencies when they inevitably became available. Remarkably, that question has been answered by the 0.8-mm connector developed by Anritsu that is mode-free to 145 GHz and was created for use with the company's latest VNA. The 0.8-mm connector has an air dielectric front-side interface, like K and V connectors, with the center conductor supported by a proprietary, low-loss support bead on one end and a PTFE bead on the other. As the support bead is made of high-temperature material, it can survive exposure up to 200° C for short periods.

"The design challenge for the 0.8-mm interface required that we change quite a few things," says Charles Tumbaga, field marketing engineer at Anritsu. "We had to develop a proprietary bead to achieve good impedance matching, which wasn't such a problem for previous connectors but with the 0.8-mm connector, it was necessary in order to achieve impedance control within 3%." "The 0.8 mm connector is actually mode free higher than 145 GHz," he continues, "but we can currently only show traceability to 145 GHz because we can only source it in a coaxial form. However, it has a theoretical limit of 170 GHz. When we developed the connector, we also had to develop the cables and adapters for calibration."

As the only company offering 0.8-mm connectors, it's not surprising that Anritsu makes all the components within its own facilities. The company has its own machine shop on site in Morgan Hill, CA, that can achieve extraordinarily precise tolerances and for components such as adapters, the company relies on its own thin-film facility as well. Even the semi-rigid cables required for use with the connectors are designed and manufactured in-house.

Bill Oldfield, one of the most innovative forces behind high-frequency connector development, who worked for years at Wiltron and later at Anritsu, stated in a conference paper that it should be possible to create even smaller connectors than the 0.8-millimeter that was a result of his efforts. He proposed 0.6-mm and even 0.4-mm connector interfaces, and although Oldfield has passed away, his concept lives on, at least in theory. "As the connector size gets smaller, even a little bit of dirt on the interface makes all the difference in the world, especially above 110 GHz," says Tumbaga. "The 0.8-mm connectors are so small it's almost impossible to see without a microscope, but it's still big enough so we can manipulate it," he explains.

"However," he says, "although the smaller connectors could theoretically be built, I don't really think it's practical because even dirt too small to see can effect repeatability, and mating and unmating them would have to be done with incredible precision to keep them aligned to provide concen-

tricity, without which repeatability disappears."

Such connectors would presumably be usable to hundreds of gigahertz. And while DOD has its sights on terahertz imaging and other applications, it's inconceivable that connectors like this could be fabricated let alone handled by mere mortals. It's also likely that at frequencies approaching light wavelengths, highly-integrated semiconductor devices that incorporate functionality from baseband to the output frequency would eliminate the need for any type of interconnect.

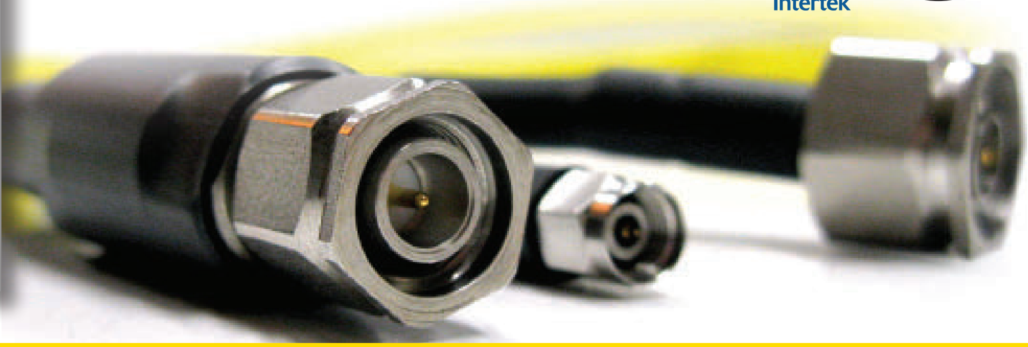
There is nevertheless lots of spectrum between 145 GHz and 300 GHz, where the lightwave region begins, and at least at the lower end of this range, both DOD and the wireless industry have their sights on using it, eventually. This obviously requires instruments that can measure at these frequencies. Although this is already possible using frequency extenders with existing VNAs, all the test fixturing is in waveguide and is apparently likely to remain that way. There are indeed waveguide designations into the terahertz range (WR-051), but even a WR-3 waveguide that covers 220 to 330 GHz has internal dimensions of 0.8 x 0.4 mm.

FUTURE DEVELOPMENTS

In addition to enhancing the performance of its cable and its applications, Gore is looking further out to the possible use of different materials combinations, although current material sets meet any challenges the company sees in the near future. Erickson said, "When you move to exotic materials, such as carbon fiber composites, to save weight, for example, they're very intriguing but cost prohibitive and would require different ways to attach connectors to them, which is a challenge the military may or may not accept. It's not yet possible to achieve the conductivity you get today with standard-quality metals."

Connector manufacturers have a considerably different challenge as the state-of-the-art is determined mostly by applications that require test equipment with higher measurement frequencies. Unfortunately, from a pragmatic perspective it appears that high-frequency connectors have been reduced so far in size already that further reductions seem unlikely, as mere mortals couldn't even see them. Nevertheless, when DOD, the wireless industry or some other formidable group requires higher performance, it creates the incentive for innovation. Fortunately, neither DOD nor the wireless industry is clamoring for even 0.8-mm connectors at the moment, so it will be a long time before they'll need to address the issue.

PHOTO COURTESY OF DOD



TECHNOLOGY SURVEY
A SAMPLING OF AIRBORNE INTEGRATED EW SUITES

By John Knowles

Ask any group of electronic warfare system engineers which was the first "integrated" airborne EW suite, and you are likely to receive a variety of answers. We often use the term, "integrated EW suite," but the definition is vague enough, in a technical sense, to leave a lot of room for argument as to which was the first one. However, it is safe to say that integrated airborne EW suites have been flying on strike aircraft since the 1980s, and they have evolved considerably since that time.

For the purposes of this month's survey, we are defining an integrated EW suite at its most fundamental level: an automated computer network comprising at least one type of threat warning sensor, a suite controller/manager and a countermeasures system. Integrated EW suites can take many forms. On a helicopter, it can be as simple as a missile warning system, an EW controller and a countermeasures dispenser. Or they can be far more complex – sensing and delivering countermeasures across many areas of the Electromagnetic Spectrum.

The aim of any integrated EW suite is to take a huge tactical workload off the aircrew and provide a decision-making advantage in an engagement. Today, EW suites can collect data from different types of onboard sensors (radar warning receiver, missile warning system and laser warning system), rapidly fuse these inputs into a single multispectral picture, make a tactical decision that is passed through an advanced EW management function and deliver a combination of precise countermeasures effects, such as jamming, active RF decoys, chaff or infrared decoys.

Integrated EW suites are fitted on many types of aircraft. Fighters and strike aircraft, which often operate in challenging RF threat environments with multiple pop-up surface-to-air missile (SAM) threats, typically need integrated EW suites to handle demanding threat situations that can arise. For the first time in nearly 30 years, Western air forces have focused fighter EW requirements on IR-guided air-to-air missiles, which is driving a need to integrate passive missile warning and new IR countermeasures capabilities onto strike aircraft. Transport aircraft, which can face IR MANPADS during take-off and landing, often use IR self-protection suites that include directed infrared countermeasures (DIRCM) systems. Today, with the proliferation of long-range threats such as the S-400, transport aircraft are paying more attention to radar-guided threats than in the past. Helicopters rely on multispectral EW suites that cover radar-, IR- and laser-guided threats. As you will see in the survey table, some companies are now marketing integrated EW suites for UAVs.

THE SURVEY

This month's survey includes 26 airborne integrated EW suites from 15 companies. Most EW suites are made by the major EW systems houses that manufacture threat warning systems and jammers. Some suites are designed for a specific aircraft model (this is particularly true of fighter aircraft, which have limited available space for internally mounted EW suites), while others (particularly podded suites) can be fitted to multiple aircraft types.

In the survey table, the first column describes the name or model number of the EW suite. The second column lists the type of threats – RF or IR/EO – the EW suite detects and defeats. The third column indicates the EW suite's warning systems, followed in the next column by the frequencies or IR bands that these sensors cover. The fifth column describes the EW suite controller or suite management system. Some suite controllers are discrete systems, and others are part of the receiver processing unit. The next two columns describe the suite's countermeasures system(s) and the frequencies covered.

The eighth column indicates if the suite is configured for internal installation on the aircraft or if it is configured in a pod or weapons pylon. Some users prefer internal EW suites because pods take up a weapons station and because internal installations can optimize antenna locations. Pods, however, provide flexibility by enabling a smaller number of EW suites to be procured and rotated to deploying units. If the EW suite is being retrofitted throughout an existing aircraft fleet, pods also typically require less platform integration work.

The ninth column shows which types of aircraft each EW suite is designed for. The next two columns describe the suite's weight and power requirement.

NEXT MONTH

In the July issue of *JED,* we will look at communications intelligence (COMINT) receivers. To request a survey questionnaire, please e-mail JEDEditor@naylor.com.

AIRBORNE INTEGRATED EW SUITES

EW Suite Name/ Model	Suite Type	Warning Sensors/Systems	Warning Sensor Operational Frequency Coverage	Suite Controller	Countermeasures Systems
ASELSAN; Ankara, Turkey; +90 (312) 592 10 00; aselsan.com.tr					
ASELSAN HEWS (Helicopter EW Self Protection Suite)	RF, UV, EO/IR	ASELSAN RWR, ASELSAN LWS, AN/AAR-60 (MILDS)	RWR: C-J, LWR: Band I, II, III , IV MWS: Solar Blind UV	Suite Central Processing Unit	ASELSAN RF Jammer, OZISIK CMDS
Self Protection Electronic Warfare System-II (SPEWS-II)	RWR, ECM	AN/ALQ-178 (V)5+	RWR: C-J,	Integrated RWR and ECM Suite	AN/ALQ-178 (V)5+
BAE Systems, Inc.; Nashua, NH, USA; +1 603-885-4321; www.baesystems.com					
Eagle Passive Active Warning Survivability System (EPAWSS)	*	*	*	*	*
AN/ASQ-239 F-35 Electronic Warfare / Countermeasure System	*	*	*	*	*
Elbit Systems EW and SIGINT - Elisra; Holon, Israel; +972-77-293-5229; www.elbitsystems.com/elisra					
All In One	RF, EO/IR	SPS-65V5 (RWR, LWS) PAWS (MWS)	RWR:0.5-18 GHz;24-40GHz; LWS:bands I, II, III, optional IV; MWS:IR	Embedded in SPS-65V5	CMDS embedded as part of SPS-65V5, Light SPEAR™ (radar jammer), MDS (DIRCM)
ALL-in-SMALL™	RF, EO/IR	SPS-65-PAWS-V5.5 (RWR, LWS and MWS)	RWR:0.5-18 GHz;24-40GHz; LWS:bands I, II, III, optional IV; MWS:IR	Embedded in SPS-65V5	CMDS embedded as part of SPS-65V5.5, Light SPEAR™ (radar jammer), MDS (DIRCM)
ELETTRONICA Group - ELT Roma; Rome, Italy; +39 06 41541; www.elt-roma.com					
Integrated EW Suite	RF, EO/IR	VIRGILIUS family, Off-The-Shelf MWS (UV/IR)	RWR: 0.5-40 GHz; MWS: Band I, II and IV	ELT-950 Advanced EW Management System	RF Jammer: VIRGILIUS family; IR Jammer: ELT-600; Expendable Active Decoy: SPARK (DRFM based)

Countermeasures Freq. Coverage	Configuration	Platform	Weight (Lb or kg)	PWR (W)	Features
RF Jammer: H-J	Internal	Rotary Wing, Transport, Business Jet	155 kg	3030W	MWS: Detection of all approaching missiles and missile exhaust plumes in "Solar Blind" UV Band; CMDS: Automatic, Semi-Automatic, Manual and Bypass operating modes; Simultaneous and sequential dispensing; RWR: High sensitivity, multi-channel digital receivers; RF Jammer: Solid-state AESA amplifier architecture, integrated receiver/TG with digital RF memory (DRFM); LWS: Detection, identification and classification of laser designator, laser beam rider and range finder.
H-J	Internal	Fighter	*	*	Internally mounted self-protection system specifically designed for F-16 Block 50C aircraft; provides intelligent control of chaff/ flare dispenser systems for enhanced and coordinated ECM response. Multi-receiver structure (superhet receiver, wideband receiver and digital receiver); simultaneous multiple threat jamming.
*	*	Fighter	*	*	Fitted on F-15
*	*	Fighter	*	*	Fitted on F-35 Lightning II
RF Jammer: Full band	Internal or Pod	Rotary-Wing, Transport/ Business Jet/ Large Aircraft	SPS-65-PAWS-V5 Processor - EWC, RWR, LWS, MWS and CMDS (One LRU) - 7 kg, RWR: Spiral Antennas (4) - 0.2 kg per unit, LWS: Sensors (4-6) - 1.0 kg per unit; CMDS dispensers (2-24) - 2.8 kg per unit; IR Sensors (3-6) - 3.4 kg per unit; Light SPEAR Processor - 11 kg; RF Jammer T/R Low Band - 0.5 kg per unit; RF Jammer T/R High Band - 0.25 kg per unit; DIRCM - 19 kg	SPS-65-PAWS-V5 Processor RWR, LWS, CMDS and MWS (One LRU) - 220W; LWS Sensors (4-6) - 15W per unit; CMDS Dispensers (2-24) - 3W per unit; MWS Sensors (3-6) - 45W per unit; Light SPEAR - 250W; RF Jammer T/R Low Band - 100W per unit; RF Jammer T/R High Band - 45W kg per unit; DIRCM - <1000W	RWR: Advanced wide band and narrow band digital receivers; MWS: IR Based MWS, IR Centric™; RF Jammer: Digital Receiver and RF Memory (DRFM) embedded into a single compact LRU; advanced Suite features: ESM, multispectral threat geolocation, Net-Centric EW applications.
RF Jammer: Full band	Internal or Pod	Rotary-Wing, Transport/ Business Jet/ Large Aircraft	SPS-65-PAWS-V5.5 Processor - EWC, RWR, LWS, MWS and CMDS (One LRU) - 9 kg, RWR: Spiral Antennas (4) - 0.2 kg per unit, LWS: Sensors (4-6) - 1.0 kg per unit; CMDS dispensers (2-24) - 2.8 kg per unit; IR Sensors (3-6) - 3.4 kg per unit; Light SPEAR Processor - 11 kg; RF Jammer T/R Low Band - 0.5 kg per unit; RF Jammer T/R High Band - 0.25 kg per unit; DIRCM - 19 kg	SPS-65-PAWS-V5.5 Processor RWR, LWS, CMDS and MWS (One LRU) - 300W; LWS Sensors (4-6) - 15W per unit; CMDS Dispensers (2-24) - 3W per unit; MWS Sensors (3-6) - 45W per unit; Light SPEAR - 250W; RF Jammer T/R Low Band - 100W per unit; RF Jammer T/R High Band - 45W kg per unit; DIRCM - <1000W	RWR: Advanced wide band and narrow band digital receivers; MWS: IR Based MWS, IR Centric™; RF Jammer: Digital Receiver and RF Memory (DRFM) embedded into a single compact LRU; advanced Suite features: ESM, multispectral threat geolocation, Net-Centric EW applications.
RF jammer: 2-18 GHz, DIRCM: Band I, II and IV	Internal or Pod	Fighter, Transport, Rotary-Wing	config dep.	config dep.	Completely integrated suite, the EW Manager ELT950 uses AI technology and functionally integrates sensors and countermeasures, including smart cooperation among active and passive effectors and on-board/off-board countermeasures. Versatile solution, adaptable to different platforms via SW, already installed on several platforms in diverse configurations. RF Jammer based on real AESA architecture, GaN technology. IR Jammer based on QCL technology.

AIRBORNE INTEGRATED EW SUITES

EW Suite Name/ Model	Suite Type	Warning Sensors/Systems	Warning Sensor Operational Frequency Coverage	Suite Controller	Countermeasures Systems
ELTA Systems Ltd.; Ashdod, Israel; +972-8-857-2312; www.iai.co.il					
EL/L-8247/8 RWJS (Radar Warning and Jamming System)	RF	ELTA ESM	*	*	ELTA ECM
EL/L-8260/2 INEWS SPS (Integrated EW Self-Protection Suite)	RF, EO/IR	ELTA RWR, LWR, pulse Doppler MWS	*	*	CMDS
Harris Corporation; Clifton, NJ, USA; www.harris.com					
AN/ALQ-211 A(V)4 Advanced Airborne Integrated Defensive EW Suite (Advanced AIDEWS)	RF	AN/ALQ-211 A(V)4 RWR	C - J Band	AN/ALQ-211 A(V)4 RWR	AN/ALQ-211 A(V)4 Jammer
Hensoldt Sensors GmbH; Taufkirchen, Germany; +49.89.51518-0; www.hensoldt.net					
HENSOLDT AMPS-MLR (Airborne Missile Protection System with Missile Warning System MWS, Laser Warning System LWS and Radar Warning System RWS)	UV/RF/EO	HENSOLDT MILDS (Missile Launch Detection System) Block 2 HFI (Hostile Fire Indication) [AN/AAR-60] MWS; HENSOLDT ALTAS-2QB (Advanced Laser Threat Alerting System - 2 Quadrants with Beamrider Detector) LWS; Full digital RWR: HENSOLDT Kalætron RWR; Digital IFM RWR: ELT160	MILDS Block 2 HFI: UV; ALTAS-2QB: 0,5 - 1,65 µm; Kalætron RWR-S 1 - 18 GHz; Kalætron RWR-M 0.5 - 40 GHz; Kalætron RWR-L 0.5 - 40 GHz; ELT160: 2 - 40 GHz	AMPS Control and Display Unit (ACDU)	ACDS (Advanced Countermeasure Dispensing System) - chaff/flare
AMPS-MD (Airborne Missile Protection System with Missile Warning System MWS and Directed InfraRed Counter Measure DIRCM)	UV/Laser/EO	HENSOLDT MILDS (Missile Launch Detection System) Block 2 HFI (Hostile Fire Indication) [AN/AAR-60] MWS	MILDS Block 2 HFI: UV	AMPS Control and Display Unit (ACDU)	MIYSIS DIRCM, optional ACDS
AMPS-M(V) (Airborne Missile Protection System with Missile Warning System MWS and optional Missile Approach Confirmation Sensor MACS)	UV/RF/EO	HENSOLDT MILDS (Missile Launch Detection System) Block 2 HFI (Hostile Fire Indication) [AN/AAR-60] MWS	MILDS Block 2 HFI: UV; opt. confirmation sensor MACS: pulse Doppler radar	AMPS Control and Display Unit (ACDU)	ACDS
Indra; Madrid, Spain; +34 91 627 10 00; www.indracompany.com					
SIMBA	RF, EO/IR	RWR, MWS, LWS	RWR: E-J Band	*	CMDS

Countermeasures Freq. Coverage	Configuration	Platform	Weight (Lb or kg)	PWR (W)	Features
*	*	Fighter, Rotary-Wing	17-30 kg	*	Central Unit incorporates ESM and ECM functions; common EMS receiver and antenas for ESM and jammng functions.
*	*	Rotary-Wing	*	*	Autonomous multi-spectral threat environment analysis and identification by integrating and fusing the data from the RWR, LWR and MAWS.
E - J Band	Internal	Fighter, Transport	186 lb	4.3 kW	Stand-alone RWR/TG option in small form factor; interfaces with ALQ-213; AESA interoperability interface; ability to address next gen threats with significant processing/ growth provisions; digital technology DRFM architecture; 3U COTS format for long-term sustainability; internal installation, AN/ALQ-211 A(V)4, and configurable for pod installation, AN/ ALQ-211 A(V)9.
*	Internal or Pod	Fighter, Transport/ Business Jet/ Large Aircraft, Rotary-Wing, UAV	config dep., with minimum config. At 41.5 kg	config dep.	Solar blind MWS; Hostile Fire Indication for tracer ammunition; laser warner including laser range finder, laser target designators and laser beam rider detection capability; full digital radar warning receiver with excellent multisignal capability, digitalization close to antenna (avoiding RF cables).
Band 2 and 4	Internal or Pod	Fighter, Transport/ Business Jet/ Large Aircraft, Rotary-Wing, UAV	config. Dep., with minimum config at 31.9 kg	config dep.	Solar blind MWS; Hostile Fire Indication for tracer ammunition; flexible system configuration with 1, 2 or 3 DIRCM turrets and optional 0-16 Chaff- & Flare Dispensers. DIRCM: short time to energy on target (TEOT), very high beam-pointing accuracy; individual jam-code configuration, 100% customer control allows complex jam codes; high laser power in relevant bands; low beam divergency.
*	Internal or Pod	Fighter, Transport/ Business Jet/ Large Aircraft, Rotary-Wing, UAV	config. Dep., with minimum config at 15.3 kg	config dep.	Solar blind MWS; Hostile Fire Indication for tracer ammunition; very low false alarm rate close to 0 in 100 flight hours; probability of declaration close to 100%; velocity and distance information of a threatening missile available; lower invest compared to a DIRCM solution. Option: HENSOLDT MACS (Missile Approach Confirmation Sensor) MWS.
*	*	Fighter, Transport, Rotary-Wing	config dep.	*	A control center receives and processes alerts from radar signals, missile launches or laser-guided weapons, providing information to the pilot and reacting to alerts identified as dangerous by dispensing flares.

AIRBORNE INTEGRATED EW SUITES

EW Suite Name/ Model	Suite Type	Warning Sensors/Systems	Warning Sensor Operational Frequency Coverage	Suite Controller	Countermeasures Systems
Leonardo MW Ltd.; Basildon, Essex, UK; 44 (0) 1268 522822; www.leonardocompany.com					
Praetorian Defense Aids Subsystem	RF, EO/IR	RWR, MWS	*	*	RF jammer, towed decoy, CMDS
BriteEye Integrated Radio Frequency Defensive Aids Suite (RF DAS)	RF	Seer Advanced RWR	C to K Band	EW Controller	CMDS and BriteCloud RF Decoy
Helicopter Integrated Defensive Aids Suites (HIDAS)	RF, EO/IR	RWR, MWS, LWS	*	Defensive Aids System Controller	CMDS
My-konsult System AB; Gelbgjutarevägen, Sweden; www.mykonsult.com					
Advanced EW Suite	RF	RWR	RWR: 0.5-18 GHz, optional Ka band	Astor IV EW Management System	Astor IV EA and training system
Northrop Grumman; Rolling Meadows, IL, USA; www.northropgrumman.com					
Falcon Edge Integrated EW Suite	RF	ESM	*	*	RF jammer, towed decoy, CMDS
Guardian	EO/IR	MWS	*	*	DIRCM
Raytheon; Dallas, TX, USA; www.raytheon.com					
Advanced Countermeasures Electronic System (ACES)	RF	RWR	*	*	ALQ-187(V)2, ALE-47 CMDS
Saab Grintek Defence Pty Ltd; Centurion, South Africa; +27 12 492 4400; www.saabgroup.com					
IDAS-3	RF, EO/IR	RWR-300: radar warning function; MAW-300: missile approach warning function; LWS-310: laser warning function	RWR: 0.7 to 40 GHz with option of 0.5 to 40 GHz; MAW: Sun-blind UV spectral range; LWS: 0.5 to 1.7 µm	Defensive Aids Controller, part of the central processing unit.	BOP-L series of countermeasures dispensing systems.
Terma A/S; Lystrup, Denmark; +45 87 43 60 00; www.Terma.com					
MASE	RF, EO/IR	ALR-69DK(V)2, ALQ-162(V)6 (NGC), AAR-54(V) (NGC)	*	ALQ-213(V) EWMU	ACMDS
C-130	RF, EO/IR, EO/UV	ALR-69(V) Class IV, AAR-54(V) (NGC), AAR-60(V)2 MILDS-F (Hensoldt)	*	ALQ-213(V) EWMU	ACMDS
F-16	RF, EO/UV	ALR-69(V) Class IV, ALQ-131 (NGC), ALQ-162(V)6 (NGC), AAR-60(V)2 MILDS-F (Hensoldt)	*	ALQ-213(V) EWMU	ACMDS
Thales; Paris France; www.thalesgroup.com					
SPECTRA	RF, EO/IR	RWR, MWS, LWS	*	*	RF jammer, CMDS

Countermeasures Freq. Coverage	Configuration	Platform	Weight (Lb or kg)	PWR (W)	Features
*	Internal	Fighter	*	*	Fitted on Eurofighter Typhoon
*	*	Fighter, Transport, UAS	*	200W	Cue, code and rapidly release BriteCloud and other expendables.
*	Internal	Rotary-Wing	*	*	DIRCM and RF jammer optional.
RF jammer: 2-18 GHz, optional Ka.	Internal or Pod	Fighter, Transport, Rotary-Wing	Pod: 150-195 kg metal or carbon fibre	Minimum 200W	Dual cooperating and modified ALQ-503 pods covering C – J, KA and GPS bands; RWR with Library and PRI data bank; separate band generators with dual DRFMs, SOR plus PRI Predictor and multi trackers; semi-automatic or automatic multi-modes; multi-threat capable.
*	Internal	Fighter	*	*	Fitted on F-16E/F Block 60.
*	Pod	Transport, Rotary-Wing	550 lb	2,800W	Podded variant of NG family of DIRCM solutions.
*	*	Fighter	*	*	Developed for F-16 users.
*	Internal or Pod	Rotary-Wing, Transport, Fighter	48 kg depending on configuration (Excl chaff and flare payload and cabling).	340W depending on configuration	Fully integrated user data files, recording files and ground support software system for library compilation and post flight analysis. Third Party IR Based MAW, DIRCM and dispenser systems have been integrated and can be offered.
*	Internal and Pod	Rotary-Wing	*	*	Modular/open system architecture supporting adaptability for aircraft, subsystem configurations and coherence to standards (e.g. FACE, NDAS); System architecture and capabilities optimized for coordinated responses and sensor fusionautomated threat response, embedded training, smart dispensing and consolidated situational awareness.
*	Internal and Pod	Transport	*	*	Modular/open system architecture supporting adaptability for aircraft, subsystem configurations and coherence to standards (e.g. FACE, NDAS); System architecture and capabilities optimized for coordinated responses and sensor fusionautomated threat response, embedded training, smart dispensing and consolidated situational awareness.
*	Internal, Pod and Pylon	Fighter	*	*	Modular/open system architecture supporting adaptability for aircraft, subsystem configurations and coherence to standards (e.g. FACE, NDAS); System architecture and capabilities optimized for coordinated responses and sensor fusionautomated threat response, embedded training, smart dispensing and consolidated situational awareness.
*	Internal	Fighter	*	*	Integrated EW suite for the Rafale multi-role combat aircraft. MWS and dispensers supplied by MBDA.

SURVEY KEY – AIRBORNE INTEGRATED EW SUITES

EW SUITE NAME/MODEL

Product name or model number.

SUITE TYPE

Types of threats the EW suite detects and defeats (RF, EO/IR).

WARNING SENSORS/SYSTEMS

Types or models of threat warning sensors or systems.

- ESM = electronic support measures
- LWS = laser warning system/sensor
- MWS = missile warning system/sensor
- RWR = radar warning receiver

WARNING SENSOR OPERATIONAL FREQUENCY COVERAGE

Indicates the operating frequency range of the warning sensor or system.

SUITE CONTROLLER

Indicates the name of the suite's controller.

COUNTERMEASURES SYSTEM

Indicates the type of countermeasures system(s) provided by the EW suite.

- CMDS = countermeasures dispenser system (chaff/flare)
- DIRCM = directed infrared countermeasures system
- DRFM = digital RF memory

COUNTERMEASURES FREQUENCY COVERAGE

Indicates the operating frequency range of the suite's RF and IR jammers.

CONFIGURATION

Indicates if the EW suite is configured for internal installation on the aircraft or carried externally in a pod or pylon.

PLATFORM

Indicates why types of airborne platforms the EW suite is designed to protect.

- UAS = unmanned aerial system

WEIGHT

Weight in lb or kg.

POWER

Indicates the power consumed by the EW suite in Watts.

FEATURES

Additional features.

OTHER ABBREVIATIONS USED

- config. dep. = configuration dependent
- COTS = commercial off-the-shelf
- ECM = electronic countermeasure
- opt = optional
- UV = ultraviolet

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

JULY 2019 PRODUCT SURVEY: COMINT RECEIVERS

This survey will cover communications intelligence (COMINT) receivers. Please e-mail JEDEditor@naylor.com, to request a survey questionnaire.

New EA Techniques Part 5

Jamming Track-via-Missile Threats (Cont.)

By Dave Adamy

Last month, we discussed jamming track-via-missile (TVM) threats with self-protection jammers. We ended with the jamming-to-signal ratio that can be achieved as a function of the jammer capabilities and the jamming geometry. Now, we will discuss the burn-through-range equations. We will also include an example calculation of jamming effectiveness against a modern long-range TVM missile system.

Remember that there are three jamming signals: against the radar, against the missile receiver and against the data link (which is a digital signal at a different frequency) as shown in **Figure 1.**

Figure 2 shows the jamming links for which burn-through ranges will be calculated.

SELF-PROTECTION BURN-THROUGH RANGE FOR JAMMING THE RADAR

Last month, we established that the jamming-to-signal ratio for self-protection jamming of the radar receiver in a TVM guided missile system is:

$$J/S = ERP_J - ERP_S + 71 + 20 \log R - 10 \log RCS$$

Where: *J/S* is the jamming to signal ratio in dB,

ERP_J is the effective radiated power of the jammer (the dB sum of the jammer transmitter power and the gain of the jamming antenna in the direction of the radar in dBm)

ERP_S is the effective radiated power of the jammed radar in dBm,

R is the range from the radar to the target (and jammer) in km, and

RCS is the radar cross section of the target in m².

For the burn-through range, we need to specify the minimum effective jamming-to-signal ratio (J/S Req). This depends on the jamming technique. Solving the J/S equation for range at burn through gives:

$$20 \log R_{BT} = ERP_S - ERP_J - 71 + 10 \log RCS + J/S\ Req$$

Where: R_{BT} is the range from the radar to the target at burnthrough in km.

Now, we determine the burn-through range from the range term with the formula:

$$RBT = \text{Anti-log}\ \{(20 \log R_{BT}) / 20\}$$

SELF-PROTECTION BURN-THROUGH RANGE FOR JAMMING THE MISSILE RECEIVER

From last month: The jamming to signal ratio for the jamming signal used against the missile receiver is:

$$J/S = ERP_J - ERP_S + 71 + 20 \log(R_{MT}) - 10 \log RCS_B$$

Where: J/S is the jamming to signal ratio in dB,

ERPJ is the effective radiated power of the jammer (toward the missile) in dBm,

ERPS is the effective radiated power of the radar in dBm,

RMT is the range from the missile to the target in km, and

RCSB is the bi-static radar cross section of the target in m².

Solving this J/S equation for range at burn-through gives:

$$20 \log R_{MTBT} = ERP_S - ERP_J - 71 + 10 \log RCS_B + J/S\ Req$$

Where: R_{MTBT} is the range from the missile to the target at burn-through.

Now, we determine the burn-through range from the range term with the formula:

$$R_{MTBT} = \text{Anti-log}\ \{(20 \log R_{MTBT}) / 20\}$$

SELF-PROTECTION BURN-THROUGH RANGE FOR JAMMING THE DATA LINK

For the jamming signal used against the data link, the J/S ratio is:

$$J/S = ERP_{JL} - ERP_L - 20 \log(R_{JR}) + 20 \log(R_{MR})$$

Where: J/S is the jamming-to-signal ratio in dB,

ERPJL is the effective radiated power of the jammer against the data link in dBm,

ERP_L is the effective radiated power of

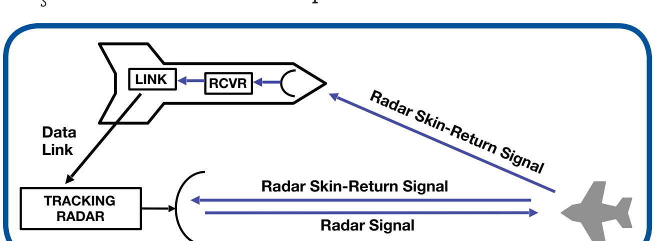


Figure 1: A missile system using TVM guidance.

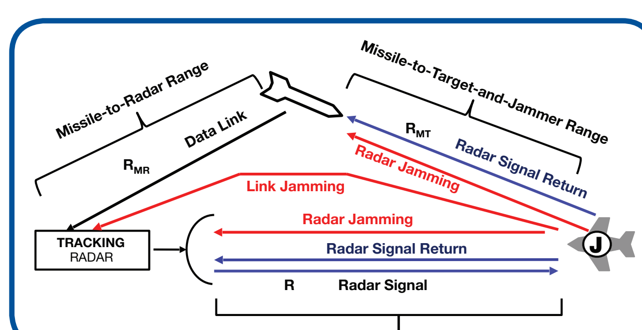


Figure 2: For self-protection jamming against a threat with a track-via-missile feature, the jammer must jam the tracking radar and also jam the missile receiver and/or the data link from the missile to the radar.

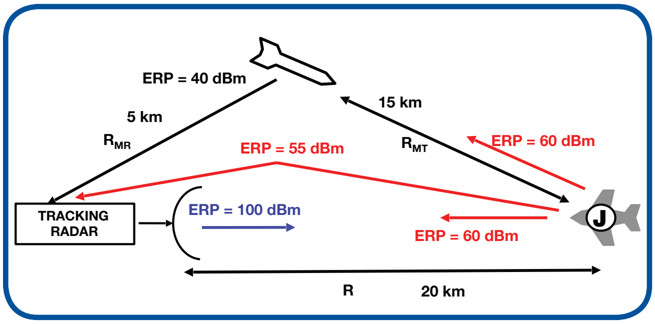


Figure 3: This is the geometry for the burn-through-range calculation example. This is for a missile system using TVM guidance, jammed by a self-protection jammer.

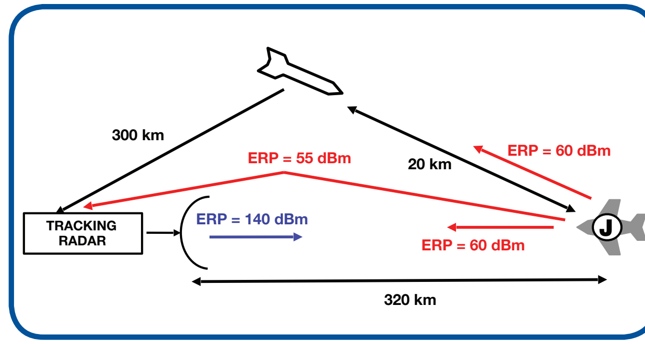


Figure 4: This is the geometry for a long-range TVM missile system example. The target is protected by a self-protection jammer.

the data link transmitter in dBm,
RJR is the range from the radar to the jammer, and
RMR is the range from the missile to the radar in km.

Solving this J/S equation for range at burn through gives:

$$20 \log R_{MRBT} = ERP_L - ERP_{JL} - 20\log(R_{JR}) + J/S\ Req$$

Where: R_{MRBT} is the range term for the link propagation distance at which the jammer is no longer effective (i.e., the "burn-through range").

Now, we determine the burn-through range from the range term with the formula:

$$R_{MRBT} = \text{Anti-log}\ \{(20 \log R_{MRBT}) / 20\}$$

AN ENGAGEMENT EXAMPLE

As the engagement proceeds, the missile moves toward the target and the distance between the radar and the missile increases as shown in **Figure 3.** The ERP(s) and RCS (s) remain the same as they were in last month's column.

- The ERP of the radar is 100 dBm.
- The ERP of the data link is 40 dBm.
- the ERP(s) of the jammer are:
  - toward the data link receiver: 55 dBm and
  - toward the main tracking radar and the missile receiver: 60 dB.
- The radar cross section of the target is:
  - toward the tracking radar: 10 square meters and
  - toward the missile receiver (i.e., the bistatic RCS): 8 square meters.

To calculate the burn-through range, we need to establish the minimum effective jamming-to-signal ratio, which will vary with the jamming technique used. For this example, we will assign the value of 2 dB.

The burn-through range term for the radar against the jammer is:

$$20 \log R_{BT} = ERP_S - ERP_J - 71 + 10 \log RCS + J/S\ Req = 100 - 60 - 71 + 10 + 2 = -19$$

Now, we determine the burn-through range from the range term with the formula:

$$R_{BT} = \text{Anti-log}\ \{(20 \log R_{BT}) / 20\} = \text{antilog}\{-19/20\} = 112 \text{ meters}$$

The burn-through range term for the radar using the signal received through the missile receiver is:

$$20 \log R_{MTBT} = ERP_S - ERP_J - 71 + 10 \log RCS_B + J/S\ Req = 100 - 60 - 71 + 8 + 2 = -21$$

Now, we determine the burn-through range from the range term with the formula:

$$R_{MTBT} = \text{Anti-log}\ \{(20 \log R_{MTBT}) / 20\} = \text{antilog}\{-21/20\} = 89 \text{ meters}$$

The burn-through range of the data link against the jammer is:

20 log RMRBT = ERPL – ERPJL -20log (RJR) + J/S Req = 40 – 55 +14 + 2 = 1

RMRBT = Anti-log {(20 log RMTBT) / 20} = antilog{1 /20} = 1122 meters

This shows that both the radar and either the receiver on the missile or the data link must be jammed to protect the target.

TVM GUIDANCE FOR LONGER RANGE MISSILE SYSTEMS

The TVM technique becomes more interesting for new-generation, longer range missiles as shown in **Figure 4.** Consider the following missile system and geometry against the same jammer we have been considering:

The ERP of the tracking radar = 140 dBm

The missile is 300 km from the radar and 20 km from the target (which is equipped with a self-protection jammer)

The J/S against the tracking radar is:

$$J/S = ERP_J - ERP_S + 71 + 20 \log R - 10 \log RCS = 60 - 140 + 71 + 50 - 10 = 31 \text{ dB}$$

(very effective jamming)

But with TVM and the jammer aimed at the missile receiver

$$J/S = 71 + ERP_J - ERP_S + 20 \log(R_{MT}z) - 10 \log RCS_B = 60 - 140 + 71 + 26 - 9 = 8 \text{ dB}$$

(much less effective jamming)

Now consider jamming the data link

$$J/S = ERP_{JL} - ERP_L - 20 \log(R_{JR}) + 20 \log(R_{MR}) = 55 - 40 - 26 + 49.5 = 38.5 \text{ dB}$$

(very effective jamming)

This shows that it is more effective to jam the data link than the missile receiver to protect a target against a long-range missile far from its radar.

WHAT'S NEXT

Sorry, column scheduling error by the author! Because of the complexity of the TVM subject, we are going to have to spend a third column on jamming TVM threats. Next month, we will finally get around to jamming a TVM threat with a remote jammer (stand-off or stand-in). For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

HIGH-POWER RF SWITCH

Aethercomm has introduced a high-power, symmetrical 500W RF Switch, the SSHPS 0.005-0.050-500, which operates between 5 and 50 MHz, and offers 50 dB typical isolation and a 6-8 µsec maximum switching speed. This RF switch operates from +28 Vdc supply with 550mA maximum current draw and is intended for electronic warfare (EW) applications requiring higher power output and isolation, and low insertion loss. *Aethercomm Inc.; Carlsbad, CA, USA; +1 760-208-6002; www.aethercomm.com.*

COMPACT PULSED MICROWAVE POWER MODULE (MPM)

dB Control has released a compact pulsed microwave power module (MPM) weighing 18 lbs with dimensions of 7 x 3 x 18 in. The dB-3774B operates from 6 to 18 GHz and offers 1kW peak power. Intended for radar jamming applications, this MPM features a conduction-cooled mini traveling wave tube (TWT) for power amplification and a solid-state driver amplifier for RF gain. *dB Control; Fremont, CA, USA; +1 510-656-2325; www.dBcontrol.com.*

RF/MICROWAVE SIGNAL GENERATORS

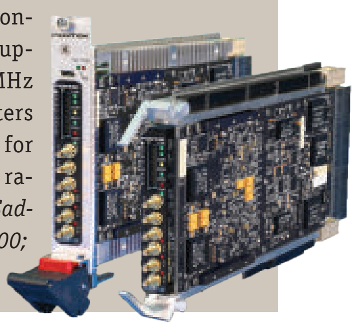
Berkeley Nucleonics has added three new RF/Microwave Signal Generators to its Model 855B Series, including 2-Channel, 4-Channel and 8-Channel signal generators. The signal generators are intended for radar simulation, quantum computing, electronic warfare (EW) and defense systems, and beamforming applications. The new models offer -80 to 25 dBm on each output with an operational frequency of 300 kHz-40 GHz and switching speeds down to 25µsec. *Berkeley Nucleonics Corporation; San Rafael, CA, USA; + 1 800-234-7858; www.berkeleynucleonics.com.*

DIRECTIONAL COUPLER

KRYTAR has released a new directional coupler operating in the 10-110 GHz frequency range with a flat nominal coupling of 10 dB across the full 100-GHz bandwidth. The Model 1100110010 coupler has test and measurement applications, as well as uses in power monitoring and leveling for EW systems, antenna beamforming systems, electromagnetic-compatibility (EMC) testing, radar systems and wireless communication. The new coupler offers frequency sensitivity of ±1.25 dB from 10-90 GHz and ±1.80 dB from 90-110 GHz, and directivity of at least 10 dB from 10-55 GHz and at least 7 dB from 55-110 GHz. *KRYTAR, Inc.; Sunnyvale, CA, USA; +1 877-734-5999; www.krytar.com.*

3U VPX BOARD

Pentek has announced an addition to its Jade family of 3U VPX boards, the Model 54851, based on the Xilinx Kintex Ultrascale FPGA. The new model features two 500-MHz 12-bit analog-to-digital converters (ADCs) with two multiband digital downconverters (DDCs) and one digital upconverter (DUC), and two 800-MHz 16-bit digital-to-analog converters (DACs). This model is intended for RF I/O for communications and radar systems. *Pentek, Inc.; Upper Saddle River, NJ, USA; +1 201-818-5900; www.pentek.com.*



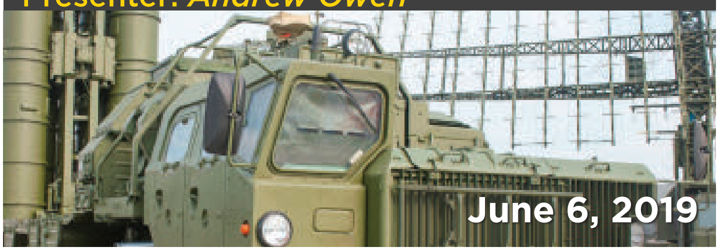
ANALOG-TO-DIGITAL CONVERTER

Analog Devices has introduced the AD9175 dual, 16-bit digital-to-analog converter (DAC), intended for radar and jamming systems, automatic test equipment and wireless communication. This DAC offers sample rates up to 12.6 GSPS and features an 8-lane, 15.4-Gbps JESD204B data input port to support single-band and multiband RF applications. The AD9175 features three data input channels per RF DAC datapath, and supports a maximum 3.08 GSPS complex input data rate at 11-bit resolution and up to 1.23 GSPS at 16-bit resolution. *Analog Devices, Inc.; Norwood, MA, USA; +1 800-262-5643; www.analog.com*

2019 AOC Virtual Series

AOC Virtual Series has been a tremendous asset providing the AOC's audience with learning, advocacy, and the exchange of information. Register today to hear from subject-matter experts on all things EW!

ELINT & RESM, Getting the Facts Straight
Presenter: *Andrew Owen*



June 6, 2019

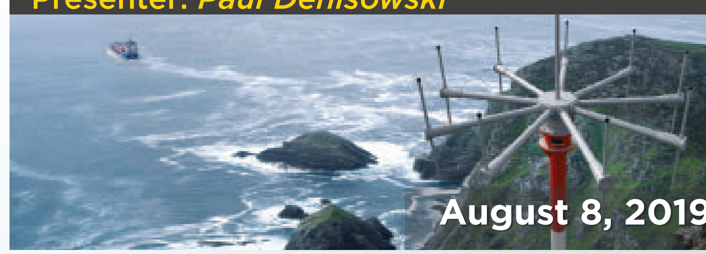
Space EW 2.0
Presenter: *Dave Adamy*

June 20, 2019

Understanding Tracking Radars
Presenter: *Kyle Davidson*

July 11, 2019

An Introduction to RDF Methodologies
Presenter: *Paul Denisowski*



August 8, 2019

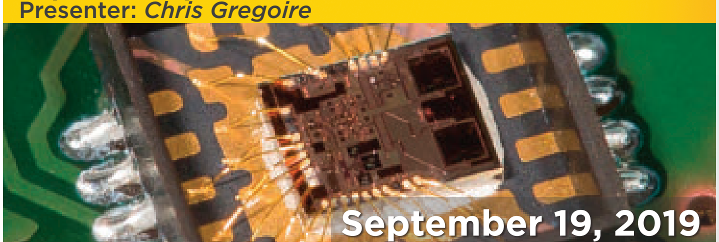
Evolving to the Next Generation of Multifunctional EW - Part II
Presenter: *Matthew Orr*

August 22, 2019

Intro to Machine Learning for EW
Presenter: *Kyle Davidson*

September 5, 2019

Achieving SWAP-C Benefits in EW Systems using Positive Gain Slope MMIC Amplifiers
Presenter: *Chris Gregoire*



September 19, 2019

RAF 100 Group and its EW Legacy
Presenter: *Thomas Withington*

October 3, 2019

For more upcoming AOC Virtual Series Webinars, visit crows.org

ASSOCIATION OF OLD CROWS

ASSOCIATION OF OLD CROWS *news*

NAWCWD HOSTS 48TH ANNUAL COLLABORATIVE EW SYMPOSIUM

By Kimberly Brown, NAWCWD Public Affairs

U.S. NAVY PHOTO BY KIMBERLY BROWN

Naval Air Warfare Center Weapons Division hosted more than 650 industry and government electronic warfare (EW) leaders from the United States for the 48th Annual Collaborative Electronic Warfare Symposium held April 2-4 at Naval Base Ventura County, Point Mugu, California.

The annual symposium, hosted by NAWCWD under a co-sponsorship agreement with the Association of Old Crows (AOC), focuses on collaboration in the world of EW. Briefs are held at the classified level, allowing attendees to have more in-depth discussions than they could have in a regular meeting environment.

"This was once again a great opportunity for professionals across the entire EW community – military, government civilian, industry – to get together, hear interesting presentations and see firsthand EW capabilities in the various NAWCWD Point Mugu labs," said John Dailey, president of the Point Mugu AOC chapter.

Key leaders from the U.S. Navy, U.S. Marine Corps, Royal Australian Air Force, and the Office of the Secretary of Defense joined academic and industry leaders at Naval Base Ventura County, the home of NAWCWD's EW capabilities, for the three-day event.

"Without a venue like this, a lot of these other people wouldn't get together," said Brian Ziegler, the symposium's conference chair. "The symposium brings people out of the woodwork from government and industry to learn and collaborate together."

Ziegler also noted that the event allows leaders in the field to learn about what other teams are doing, including work they may be able to help with or benefit from but weren't aware of previously. "It's all these little things that are kind of intangible but are enabled through this collaborative approach," he said.

This year's event featured keynote addresses by U.S. Navy RADM Steve Parode, director of the Warfare Integration Directorate for the Office of the Chief of Naval Operations; Dr. William G. Conley, director for Electronic Warfare for the Office of the Undersecretary of Defense, Acquisition and Sustainment; and Air Commodore Terry Van Haren, Royal Australian Air Force Washington attaché.

"Having our Australian counterparts here again this year was so important," said Ziegler. "Our collaboration and continuing partnership with our Australian counterparts is only going to continue to grow."

In addition to keynote addresses, several focused discussion sessions allowed participants a more interactive format to explore better ways to collaborate in the field of EW. Topics included EW enablers, collaborative electronic attack and the warfighter perspective.

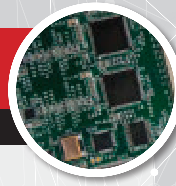
Attendees also toured EW laboratories and static displays, including the U.S. Navy's last EA-6B Prowler. Also on display was an MH-60R from the "Scorpions" of Helicopter Maritime Strike Squadron 49, an E-2C Hawkeye from the "Sun Kings" of Carrier Airborne Early Warning Squadron 116, and an MQ-8B Fire Scout from Vertical Takeoff Unmanned Aerial Vehicle Maintenance Detachment Point Mugu.

AOC DC CAPITOL CLUB CHAPTER HOSTS 2ND ANNUAL CHERRY BLOSSOM CRUISE

The Association of Old Crows D.C. Capitol Club Chapter hosted its 2nd Annual Cherry Blossom lunch cruise on April 9. The networking event included a lunch buffet and a narrated tour of the monuments. This sold-out event was attended by academia, industry and government, as well as local STEM partners who shared new opportunities for STEM outreach with local K-12 students.

FEATURED LIVE COURSES

DRFM Technology and Design for Electromagnetic Maneuver Warfare



Dr. Phillip Pace

Mondays & Wednesdays
13:00 – 16:00 EDT | June 3 – 26
This course examines both the design of the DRFM as well as the technologies and strategies used to create superior false target decoys.

Airborne Expendables/UAS Capabilities and Potential

Dr. Patrick Ford

Mondays & Wednesdays
13:00 – 16:00 EDT | August 19 – 28
This course provides attendees with a strong foundation in expendables/sUAS, from basic airframe classes and capabilities, to EW potential, to the current FAA airframe and pilot certification/flight approval process.

21st Century Electronic Warfare, Systems, Technology, and Techniques

Dr. Clayton Stewart

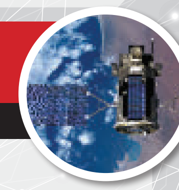
Mondays, Wednesdays, & Fridays
13:00 – 17:00 EST | February 3 – 21, 2020
This course offers a comprehensive overview of modern electronic (EW) warfare systems, technology, and techniques.

Introduction to Radar Systems

Kyle Davidson

Mondays, Wednesdays, & Fridays
13:00 – 16:00 EDT | July 29 – August 9
This course introduces the audience to radar systems in a military context, with a focus on search and tracking radars associated with modern day threats.

SPACE EW



Dave Adamy

Mondays, Wednesdays, & Fridays
13:00 – 16:00 EDT | September 4 – 20
In the eight sessions of this course, we will cover the nature of EW in space and go on to work practical EW problems appropriate to the space environment.

Intermediate Electronic Warfare
EW EUROPE 2020

Dr. Clayton Stewart

Friday & Saturday | **08:00 – 17:00 BST**
June 19 – 20, 2020 | Liverpool, UK
We will begin with a historical perspective and introduce use of radar, integrated air defense system, early EA functions and conclude with an overview of modern EA, ES, and EP.

= Web Course, no travel required!

56 AOC INTERNATIONAL SYMPOSIUM & CONVENTION
WASHINGTON D.C.

Fundamental Principles of Electronic Warfare
Dave Adamy
Saturday & Sunday
08:00 – 17:00 EDT | October 26 – 27

Advanced Principles of Electronic Warfare
Dave Adamy
Thursday & Friday
08:00 – 17:00 EDT | October 31 – November 1

Machine Learning for Electronic Warfare
Kyle Davidson
Saturday & Sunday
08:00 – 17:00 EDT | October 26 – 27

Electronic Countermeasures—Theory and Design
Kyle Davidson
Thursday & Friday
08:00 – 17:00 EDT | October 31 – November 1

FOR COURSE LISTINGS AND MORE VISIT **CROWS.ORG**

44TH ANNUAL DIXIE CROW TECHNICAL SYMPOSIUM

The Dixie Crow Chapter of the Association of Old Crows hosted its 44th annual symposium in Warner Robins at the Museum of Aviation, Robins AFB, Georgia, from 24-27 March. This year's theme, "Dominate the Electromagnetic Spectrum (EMS) in Contested Environments through the use of Agile, Resilient Systems and Architectures," highlighted the importance of Electronic Warfare (EW) systems and the vital role Command and Control, Intelligence, Surveillance and Reconnaissance (C2ISR) plays in protecting our warfighters on today's battlefield.

Keynote speaker BG Neil S. Hersey, Deputy Commanding General – Cyber and Commandant of US Army Cyber School, Fort Gordon, Georgia, kicked off the week's events with over 1450 attendees.

The 6th Annual Crow's N.E.S.T. (Novel Experiments with Science & Technology) drew in 350 local students from local schools and Bleckley and Pulaski Counties. N.E.S.T. technology demonstrations were collaborative efforts by local military, government civil service, academia, defense industry, students and volunteers designed to inspire students to pursue STEM careers.

The event was capped off by the Annual Banquet on 27 March, held in the Nugteren Exhibit Hangar at the Museum of Aviation, where attendees welcomed back guest speaker Lt Gen Bradley A. Heithold, US Air Force (ret).

Proceeds from this event fund the Dixie Crow Chapter's annual $52,000 Education Foundation Scholarship Program Budget. Since its founding in 1979, the Education Foundation has provided $1,156,091 to more than 700 Individuals pursuing degrees in STEM-related disciplines.

Mark your calendars for the 45th Annual Dixie Crow Symposium, 22-25 March, 2020.

PALMETTO ROOST HONORS ALL-FEMALE BACHELOR OF SCIENCE IN CYBERSECURITY CLASS OF 2019

At the April 17 Charleston Southern University Awards Day, the Palmetto Roost, Lowcountry AOC chapter, presented awards to three members of the first graduating class for a Bachelor of Science in Cybersecurity: Caliyah Kappel, Stefhany Mejia-Rocha and Ashley Ward.

The Palmetto Roost was instrumental in the financial and curricular development of this academic program. Students in the Cybersecurity program complete four critical courses in Network Penetration and Hacking, Cyber Defense, Principles and Practices of Cybersecurity, and Network Security. They also leave with their CompTIA Security+ certification.


5th Annual
Cyber Electromagnetic Activity (CEMA)
ASSOCIATION OF OLD CROWS
8-10 OCTOBER 2019
Aberdeen Proving Ground, MD

AOC Industry and Institute/University Members

SUSTAINING

BAE Systems
Ball Aerospace & Technologies Group
Bharat Electronics LTD
The Boeing Company
CACI
Chemring Group Plc
Collins Aerospace
DRS Defense Solutions
Electronic Warfare Associates
General Atomics
General Dynamics
Harris Corp.
Huntington Ingalls Industries
Keysight Technologies
Leonardo MW Ltd.
Lockheed Martin Mission Systems and Training (MST)
Mercury Systems
Northrop Grumman Corporation
Raytheon Company
Rockwell Collins
Rohde & Schwarz USA
Saab

MILITARY UNITS

30 Cdo IX Gp RM
453 EW Squadron Research
51 Sqn, Royal Air Force
Air Command Denmark
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