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The Journal of Electronic Defense

MARCH 2019
Vol. 42, No. 3



Passive Radar Technology - A Response to Stealth?

Also in this issue:

Survey: Benchtop Spectrum Analyzers

2019 Industry & Institute/University Member Guide

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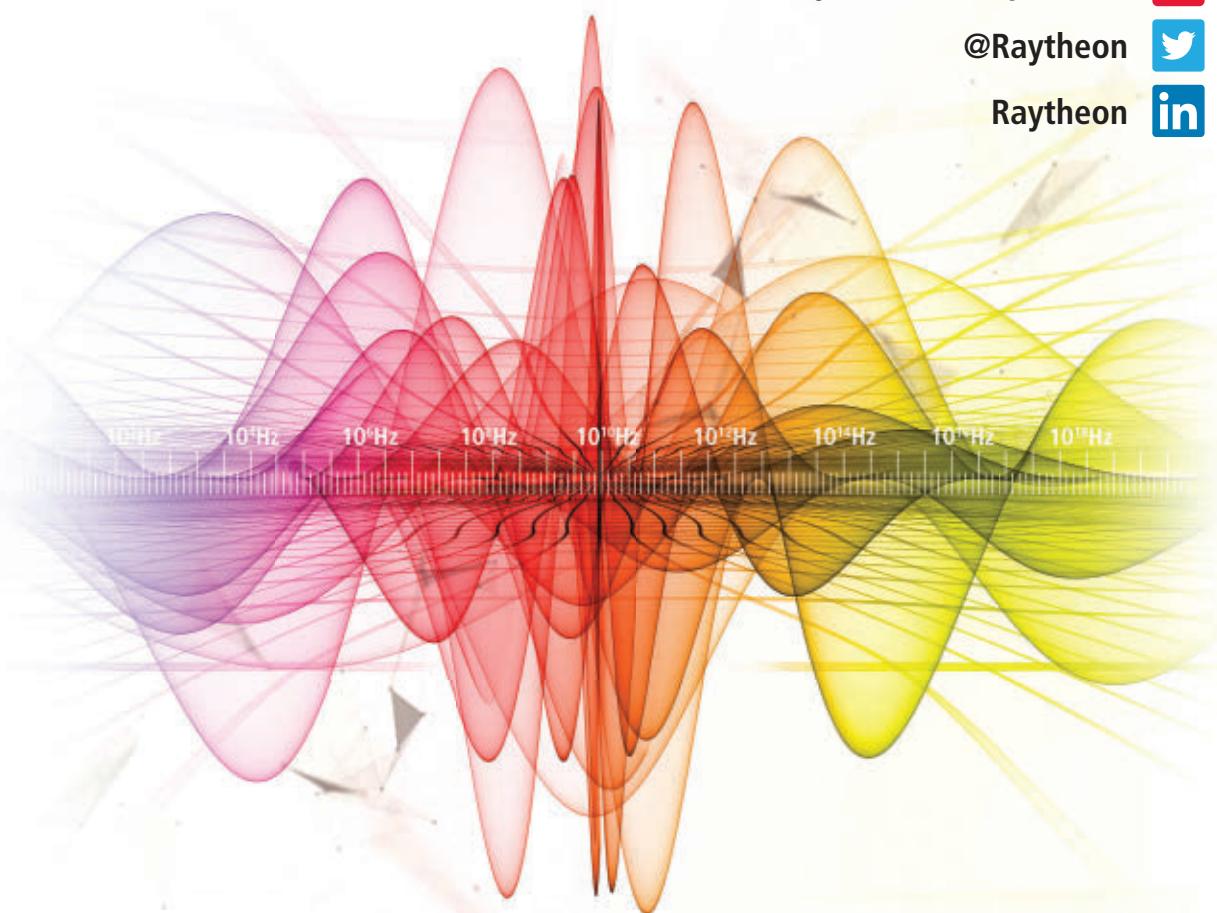
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The Journal of Electronic Defense

March 2019 • Volume 42, Issue 3

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Can Do Easy – United States Marine Corps EA-6B, Bureau # 163045, crewed by USMC Captains Aaron "Bambi" Staggs, electronic countermeasures officer, David "Nicole" Richey, ECMO, and Evan "Fonix" Bottorff, pilot, turns on to runway 18 to make its final take-off ever after getting fuel at Tinker Air Force Base, OK. The jet was one of three Prowlers from the VMAQ-2 Death Jesters that departed for Davis-Monthan AFB, AZ, on November 29. The Prowler will officially be retired during a "Sundown Ceremony" on March 8 at MCAS Cherry Point.

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John Haystead

Passive radars are not new. But the combination of EMS congestion and the wider use of stealth technology is driving new interest in these types of solutions. This month, *JED* takes a look at the state of passive radar technology.

Technology Survey: Benchtop Spectrum Analyzers 33

Barry Manz

Benchtop spectrum analyzers have evolved tremendously over the past 15 years. They feature more functionality and, thanks to evolving ADC technology, much better performance.

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A NEW LIFE FOR USAF EW?

s the US Air Force getting more serious about EW? I cannot blame some of you for expressing skepticism. When I first arrived at *JED* back in 1994, the Air Force was fairly well invested in EW. Its EW enterprise seemed very robust. It had the people, the combat experience, the labs, the test and training ranges, and the equipment, because successive Air Force leaders had focused on it.

Not everything was what it appeared to be, however. In terms of expertise, the Air Force's Electronic Warfare Officer (EWO) "brain drain" had already started back in 1980, when the F-16 achieved Initial Operational Capability. As a single-seat fighter, the F-16 had a fully automated EW system – no EWO needed – and EWO production declined accordingly. During the 1990s, this trend continued. The F-4G Wild Weasel was replaced by F-16CJs (again, no EWO needed), and the fleet of EF-111 Ravens was retired in 1998 without any replacement. By the 2000s, the Air Force was producing just a handful of EWOs each year compared to the 1960s and 1970s, and the EW syllabus was being watered down in favor of developing Combat System Operators (CSOs), which placed the burden of EWO training on operational units. Ironically, all of this happened over the same 30 years that the Air Force became more committed to its distributed offensive battle network and, as a result, strategically dependent on maneuvering in the Electromagnetic Domain.

As I mentioned at the beginning of this column, there have been some recent indications that the Air Force is beginning to evolve its EW thinking. It is re-invigorating its development of EWOs at NAS Pensacola; it has taken a fresh look at its future EW needs via the Electronic Warfare Enterprise Capability Collaboration Team (ECCT) under the guidance of Brig Gen David Gaedecke; and last year it established an Electromagnetic Defense Task Force (EDTF) under Lt Gen Steven Kwast at Air Education and Training Command.

The EDTF, which held its inaugural EDTF summit last year and released its first report in November, is looking outside some of the traditional EW areas and focusing more attention on areas such as EM Domain, quantum technology, high-power electromagnetic (HPEM) technologies, and electromagnetic pulse (EMP) effects. This is not a flash in the pan, by the way: The next EDTF summit is slated for April 29-May 1 at Maxwell AFB.

Taken together, the new EWO program at Pensacola, the EW ECCT and the EDTF are positive developments. Do they signal an EW Renaissance for the Air Force? I'm not ready to make that claim just yet, because the Air Force has spent a long time allowing its EW enterprise to atrophy. First, it has to recognize that it even *has* an EW enterprise. It will take a sustained and concerted effort just to turn the EW enterprise around and then rebuild it to meet today's even more demanding EW needs. It does appear, however, that the Air Force is positioning itself to begin this process. – *J. Knowles*

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The Journal of Electronic Defense
is published for the AOC by

NAYLOR
ASSOCIATION SOLUTIONS
5950 NW 1st Place
Gainesville, FL 32607
Phone: (800) 369-6220 • Fax: (352) 331-3525
www.naylor.com

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Editorial: The articles and editorials appearing in this magazine do not represent an official AOC position, except for the official notices printed in the "Association News" section or unless specifically identified as an AOC position.

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PUBLISHED FEBRUARY 2019/JED-M0319/8109

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calendar conferences & tradeshows

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Washington, DC
www.idga.org

Counter UAS Summit

March 12-14
Washington, DC
www.idga.org

2019 Directed Energy Summit

March 20-21
Washington, DC
www.boozallen.com

Dixie Crow Symposium 44

March 24-27
Warner Robins, GA
www.dixiecrowsymposium.com

AUSA Global Force Symposium and Exposition

March 26-28
Huntsville, MD
www.ausa.org

APRIL

48th Annual Collaborative Electronic Warfare Symposium

April 2-4
Point Mugu, CA
www.crows.org

Annual Directed Energy Science and Technology Symposium

April 8-12
Destin, FL
www.deps.org

2019 Army Aviation Mission Solutions Summit

April 14-16
Nashville, TN
www.quad-a.org

Air University Electromagnetic Defense Task Force (EDTF) Summit

April 29-May 1
Maxwell AFB, AL
Contact: aetc.ccp.protocol@us.af.mil

Directed Energy to DC (DE2DC)

April 29-May 2
Washington, DC
www.deps.org

Security Cooperation Symposium: Interoperability, EW & FMS 2019

April 30-May 2
Atlanta, GA
www.crows.org

MAY

Sea-Air-Space

May 6-8
National Harbor, MD
www.seaairstospace.org

Electronic Warfare Europe 2019

May 13-15
Stockholm, Sweden
www.eweurope.com

11th Annual Electronic Warfare Capability Gaps and Enabling Technologies Conference

May 14-16
Crane, IN
www.crows.org

JUNE

International Microwave Symposium

June 2-7
Boston, MA
www.ims2019.org

10th Annual Cyber & Electronic Warfare Convergence Conference

June 4-6
Charleston, SC
www.crows.org

Paris Air Show

June 17-23
Paris
www.siae.fr 

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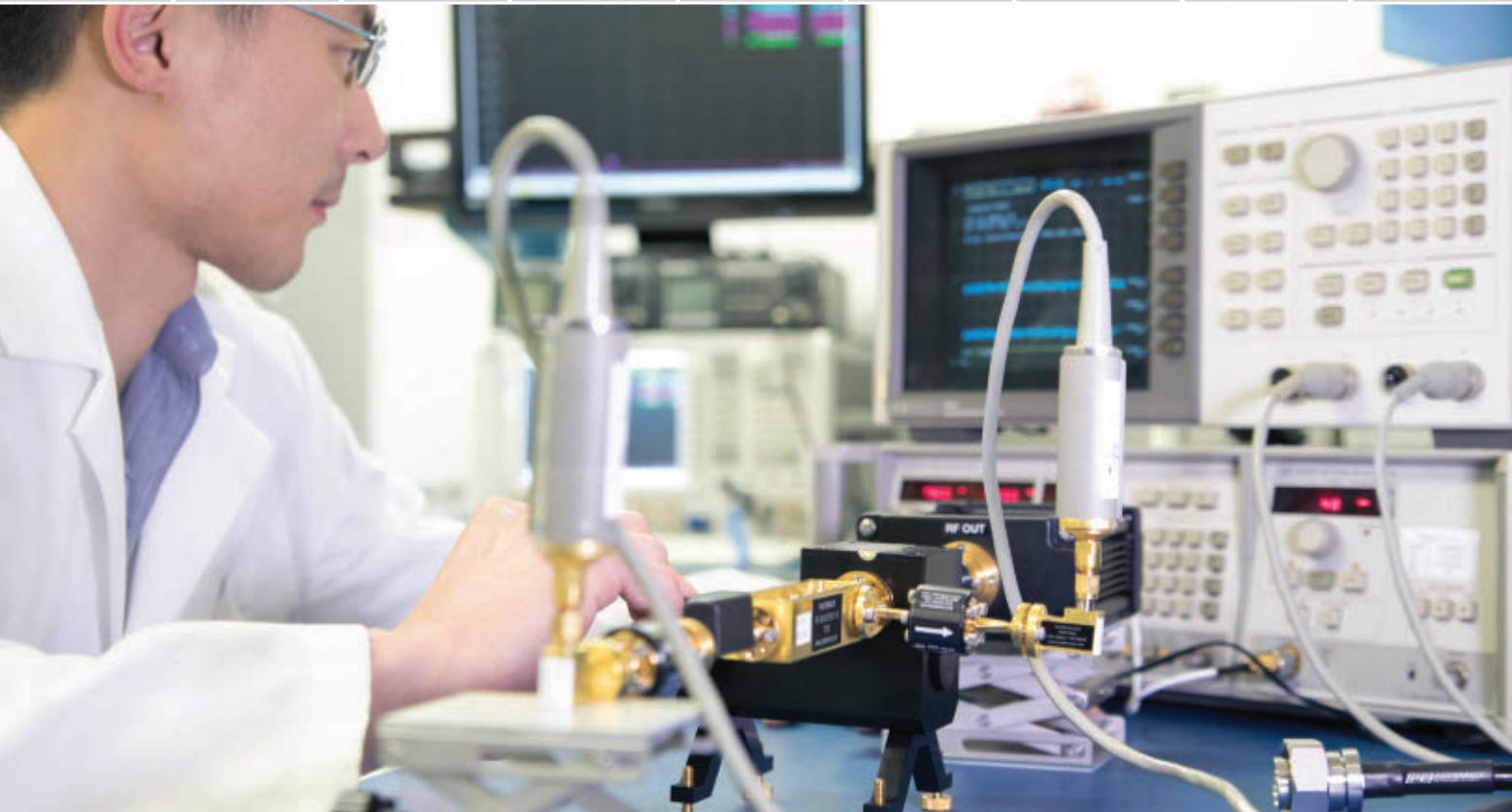
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March 12-15
Atlanta, GA
www.pe.gatech.edu

Counter Improvised Explosive Device Capability

March 18-22
Swindon, Wiltshire, UK
www.cranfield.ac.uk

Introduction to Open Systems Architecting Solutions for Decision Makers

March 20
Atlanta, GA
www.pe.gatech.edu

Infrared/Visible Signature Suppression

March 25-28
Atlanta, GA
www.pe.gatech.edu

Airborne AESA Radar

March 26-28
Denver, CO
www.pe.gatech.edu

Test and Evaluation of RF Systems

March 26-28
Atlanta, GA
www.pe.gatech.edu

APRIL

Directed Infrared Countermeasures: Technology, Modeling and Testing

April 2-4
Atlanta, GA
www.pe.gatech.edu

Signals Intelligence Fundamentals

April 16-17
Denver, CO
www.pe.gatech.edu

Basic RF Electronic Warfare Concepts

April 16-18
Atlanta, GA
www.pe.gatech.edu

DOD Simulations for RF Electronic Warfare

April 16-18
Atlanta, GA
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Infrared Countermeasures

April 16-19
Atlanta, GA
www.pe.gatech.edu

AOC Virtual Series Webinar: Self Interference Cancellation

April 18
1400-1500 ET
www.crows.org

Modeling and Simulation of RF Circuits

April 30-May 2
Atlanta, GA
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MAY

Adaptive Arrays: Algorithms, Architectures and Applications

May 7-10
Atlanta, GA
www.pe.gatech.edu

JUNE

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June 3-26
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EA-6B SUNDOWN

There has been a lot of activity related to Electronic Warfare (EW) and the Electromagnetic Spectrum over the last few months with the Air Force EW Enterprise Capability Collaboration Team (ECCT) results and recommendations being out-briefed, a reorganization occurring in the Air Force and an IDA-supported OSD analysis on-going. While these efforts will all raise the bar in our lanes of EW and EMS Operations (EMSO), we have the end of an epoch occurring at Marine Corps Air Station Cherry Point NC where on Friday, March 8, at 1300 the deactivation ceremony will take place for the last remaining EA-6B squadron, VMAQ-2.

The primary functions of the Prowler are electronic attack, kinetic suppression (HARM missiles) and electronic support. This squadron flew a wide variety of missions to include: suppression of enemy air defenses in support of strike aircraft and ground troops; counter-IED; C3 disruption; overwatch for troops in contact; and electronic reconnaissance. Four marines in a cockpit that had significant connectivity, provided superb battlefield situational awareness, and helped make the Prowler the premier EW aircraft in the world for four decades. As a low-density-high-demand aircraft, these EA-6Bs, and the men and women of the Marine Corps Prowler squadrons, have been continuously deployed flying in support of Marine Corps and Joint operations around the globe conducting expeditionary land and carrier based operations.

High tempo operations were the norm, family sacrifice was the norm, and these Marines (aviators, maintenance, intelligence, logistics and support) met every challenge, providing capability to the warfighter and delivering non-kinetic and kinetic effects on target on time. But, these Marines from VMAQ-2 did more than fly airplanes; they were instrumental in developing new tactics against the emerging SAM threat, they developed tactics to support close air support, they provided the critically needed EW expertise to develop war plans, they manned the Combined Air Operation Centers and Joint EW coordination centers, they supported Combatant Commander and Marine staffs, they worked in the Pentagon pushing to improve our EW and EMSO capabilities...they advanced and integrated our trade-craft. The impact these EW warriors have had on this Nation's war fighting capability cannot simply be measured by flight hours and missions flown but in their overall contribution as *the experts in EW*.

Deactivation ceremonies are always good and bad. The good – they bring together Marines you haven't seen in years but may have shared a tent or a state-room with for months. Stories will be told, libations will be consumed, and bad golf will be played, no doubt. But, as the squadron forms on the flight line for the last time and the colors are cased, this Old Crow may shed a tear as that moment will truly be the end of an era. Semper Fi VMAQ-2. – *Muddy Watters*

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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

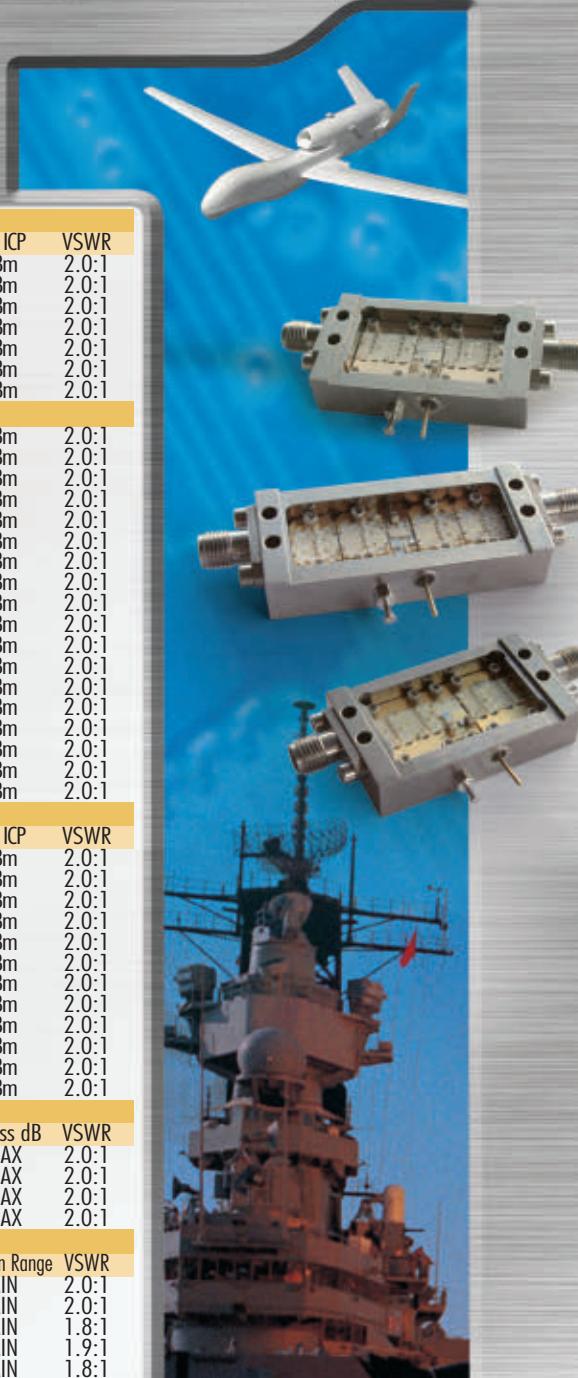
Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	Gain Attenuation Range	VSWR
CA001-2511A	0.025-0.150	21	5.0 MAX, 3.5 TYP	+12 MIN	30 dB MIN	2.0:1
CA05-3110A	0.5-5.5	23	2.5 MAX, 1.5 TYP	+18 MIN	20 dB MIN	2.0:1
CA56-3110A	5.85-6.425	28	2.5 MAX, 1.5 TYP	+16 MIN	22 dB MIN	1.8:1
CA612-4110A	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

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CA001-2110	0.01-0.10	18	4.0 MAX, 2.2 TYP	+10 MIN	+20 dBm	2.0:1
CA001-2211	0.04-0.15	24	3.5 MAX, 2.2 TYP	+13 MIN	+23 dBm	2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 MAX, 2.8 TYP	+17 MIN	+27 dBm	2.0:1
CA002-3114	0.01-2.0	27	4.0 MAX, 2.8 TYP	+20 MIN	+30 dBm	2.0:1
CA003-3116	0.01-3.0	18	4.0 MAX, 2.8 TYP	+25 MIN	+35 dBm	2.0:1
CA004-3112	0.01-4.0	32	4.0 MAX, 2.8 TYP	+15 MIN	+25 dBm	2.0:1

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US ARMY LAYS OUT PLANS FOR TERRESTRIAL LAYER SYSTEM

In January, the US Army, through the Program Manager (PM) Electronic Warfare (EW) and Cyber, held an industry day for the "SIGINT & EW Future Opportunities and Terrestrial Layer System (TLS)." The TLS is described as "an integrated ground intelligence, electronic warfare, and cyberspace capability for Brigade Combat Teams and Military Intelligence."

COL Kevin E. Finch, Project Manager, Electronic Warfare & Cyber, opened the discussion with some historical context surrounding the current requirement, noting that the original vision for the precursor to the TLS – the Multifunction Electronic Warfare (MFEW) concept – called for an "Army-organic EW system-of-systems consisting of ground and airborne assets that provide offensive/defensive electronic attack (EA) and electronic support (ES)." A Materiel Development Decision (MDD) for MFEW was released in 2011 and an Analysis of Alternatives (AOA) in 2013. The airborne

portion of MFEW is MFEW Air – a family of EW payloads that will provide Brigade Combat Teams with organic electronic warfare support, electronic attack, and offensive cyber capabilities. MFEW-Air Large reached Milestone B in 2018 and is now under development by Lockheed Martin. (See related article below.)

According to Colonel Finch's briefing at the TLS industry day, over the past few years, a number of factors came together to alter the plans for MFEW and shift toward the TLS approach including: urgent requirements from USAREUR and other commands together with a new National Defense Strategy and peer threat assessment; a convergence of EW, SIGINT, cyber and space; availability of National assets and advanced software capabilities; and approval for rapid EW force-structure growth. In addition, he pointed out that, with the new TLS approach, "air/ground integration is no longer at a system-of-systems level, but at the data management, processing,

and control level – EWPMT (EW Planning and Management Tool)." His presentation also stated, "Speed-to-delivery [is] now critical, [with] system commonality [becoming] less important." He also emphasized that the TLS architecture must leverage National assets, and it must abstract hardware from software for rapid adaptability to pace the threat.

In his presentation at the TLS industry day, MG Kirk F. Vollmecke, Program Executive Office Intelligence, EW & Sensors (PEO IEW&S), pointed to several initial design tenets for TLS, such as that it be "expeditionary," with a platform based on the supported maneuver unit. It must also be "modular," implementing an open architecture that enables future growth to pace the threat. It must have a "defined software framework," allowing for rapid integration of signal "libraries" instead of costly and time consuming integration of individual signals. It must be "automated," with machine learning for improved CEMA (Cyber-Electromagnetic Activities) responsiveness and reduced soldier workload; and it must be "rapid and agile" with early capability with multiple learning events and product improvements.

Speed is also clearly of the essence in the TLS development and acquisition strategy, which calls for a very rapid and parallel prototyping, production and fielding timeline. The "software-driven compute" environment and user interface development (B-Kit) will begin this year and continue throughout the program. At the same time, rapid prototyping and RF component development (C-Kit) are planned to begin in early FY2020, with rapid production and fielding beginning in FY2022. The rapid prototyping acquisition strategy will utilize Mid-Tier Acquisition (Section 804) authorities, with competitive pro-



The Joint Light Tactical Vehicle (JLTV) is among the first platforms targeted for TLS integration.
US ARMY

totyping in FY2020 planned to support a production decision as early as FY2021.

According to Vollmecke's presentation, "open, adaptable programs combating complexity" will be key to the TLS acquisition timeline, which will include leveraging commercial offerings; an agile acquisition process focused on small, frequent releases of capability; small, qualified, dynamic development and acquisition teams; and early and frequent involvement with system users.

LTC Scott Bailey, Product Manager "Prophet," and Ms. Abigail Jordan, Contracting Officer Army Contracting Command - APG, presented on the TLS program from the perspective of its "Acquisition and Contract Vision." The "Vision," according to their presentation, is driven by the 2018 National Defense Strategy (NDS) coupled with combatant commanders' missions and priorities, rapidly changing technology, an adaptive enemy, and the need to outpace the threat.

The TLS acquisition schedule calls for white papers to be reviewed and selected and a Statement of Work procurement package sent to Army Contracting Command (ACC) in the third quarter of FY2019. This will be followed by a Request for Proposals (RFP) released to members of the Consortium for Command, Control and Communications in Cyberspace (C5) in the fourth quarter of FY2019. Multiple Other Transaction Authorities (OTA)/Project Awards are scheduled for the first quarter of FY2020, with the initiation of a second round of OTA white paper requests in the second quarter.

The RF Components Development, or "C-Kit" effort is aimed at providing an integrated set of sub-systems that are tailored for specific unit/platform and operational environment (target) mixes. Overall, the goal is to develop a process to mature sub-systems, but the initial focus is on a complete C-Kit package for a Joint Light Tactical Vehicle (JLTV) platform. The process is expected to run approximately 24 months per cycle from the call for white papers in May of FY2019 through lab demonstration, to open-air demonstration (Tier 2), to platform integration with feedback loop. "Successful" Tier 2 solutions will become qualified source/directed solutions for the next TLS integration and two-year production cycle. C-Kit OTA awards are planned for November, 2019.

The A-Kit effort will integrate B and C-Kit elements onto Government Furnished Equipment (GFE) platforms and communications packages. Fixed Price Indefinite Delivery/Indefinite Quantity (ID/IQ) orders will cover the procurement of qualified components and the building, fielding, training and sustainment of systems based on targeted platforms. Production quantities will range from 50 to 100 units, with three Engineering Manufacturing Development (EMD) systems planned for FY21. A single A-Kit integration and production contract estimated at \$150-\$500 million will be awarded with a planned solicitation release date in the third quarter of FY2020. The Period of Performance will be from first quarter FY2021 to fourth quarter FY2028.

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PEO IEW&S is planning follow up sessions with industry in conjunction with an Advanced Planning Briefing to Industry (APBI) scheduled for April 29 - May 3, 2019, at Aberdeen Proving Ground, MD. - J. Haystead

US ARMY AWARDS FIRST MFEW AIR CONTRACT

The US Army, acting through the Consortium for Command, Control and Communications in Cyberspace (C5), has awarded an \$18 million contract to Lockheed Martin to develop a configurable electronic warfare and cyber attack system in support of the Army's Multi-Function Electronic Warfare (MFEW) Air Large effort. MFEW Air Large, which will be hosted on Group 4 unmanned aerial systems (UASs) such as the Army's MQ-1C Gray Eagle, is the first development program within the Army's envisioned MFEW Air family of systems. Other MFEW variants planned by the Army include MFEW Air Small for Group 3 UASs and MFEW Rotary Wing. The MFEW Air platforms will provide Brigade Combat Teams with organic electronic warfare support (ES), electronic attack (EA), offensive cyber operations (OCO) and dissemination of Military Information Support Operations (MISO) (i.e., PSYOP).

DARPA SEEKS HIGH PERFORMANCE COMPUTING FOR RF SIMULATION

The Defense Advanced Research Projects Agency (DARPA) is planning to issue a Broad Agency Announcement (BAA) to develop new high-performance

computing technologies that can support large-scale virtual RF test ranges for the next generation of electronic warfare (EW) and radar systems.

According to DARPA's Microsystems Technology Office (MTO), current RF simulation systems do not provide the scale, fidelity or complexity needed to meet the testing and training demands of Artificial Intelligence-enabled technologies, which will be incorporated into future EW and radar systems. To meet this challenge, DARPA has established the Digital RF Battlespace Emulator (DRBE) program. Under DRBE, MTO program officials will develop "a new breed of High Performance Computing (HPC) – dubbed 'Real Time HPC' or RT-HPC – that will effectively balance computational throughput with extreme low latency capable of generating the high-fidelity emulation of RF environments," according to a DARPA program description. Furthermore, "DRBE will demonstrate the use of RT-HPC by creating the world's first largescale virtual RF test range."

The DRBE program will focus on two areas. The first will explore "...designing and developing novel computing architectures and domain-specific hardware accelerators that can meet the real-time computational requirements of RT-HPC. Existing HPCs rely on general-purpose computing devices, which either prioritize high computational throughput while sacrificing latency (i.e., Graphics Processing Units (GPUs)), or have very low latency with correspondingly low computational throughput (i.e., Field Programmable Gate Arrays (FPGAs)). DRBE seeks to overcome the limitations of both by creating a new breed of HPC hardware that combines the GPU's and FPGA's best traits," according to the DARPA program description.

"The second research area will focus on the development of tools, specifications and interfaces, and other system requirements to support the integration of the RT-HPC system and the creation of the virtual RF test range. These components will help design and control the various test scenarios that could be run within the range, enable the DRBE's RT-HPC to interface with external systems for testing, and facilitate the resource

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allocation needed to support multiple experiments and beyond."

The program's aim is to develop a DRBE system that will "...enable numerous real RF systems (such as radar and EW systems), to interact with each other in a fully-closed-loop RF environment. Computationally, DRBE will be responsible for calculating the interactions of high-bandwidth RF waveforms with emulated objects in a physical environment (such as ground clutter and radar target returns). It is estimated that the HPC must achieve roughly 20 PFlop (Petaflop Operations)/s with a latency less than 2.5 micro-seconds."

DARPA explained that "DRBE is funded under Phase II of DARPA's Electronics Resurgence Initiative (ERI), a five-year, upwards of \$1.5B investment into the future of domestic, US Government, and Department of Defense (DoD) electronic systems. As a part of ERI Phase II, DRBE aims to apply the benefits of domain specific processing architectures to defense systems."

DARPA program officials held a DRBE Proposers Day on February 13. The solicitation number is BAA HR001119S0023, but the BAA had not yet been released as this issue of *JED* went to press. – *JED Staff*

IN BRIEF

The US Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) has issued a Request for Information (RFI) for compact high energy laser (HEL) systems to be installed on combat platforms for counter unmanned aerial system (counter-UAS), and counter-intelligence, surveillance, and reconnaissance (counter-ISR) missions, as well as to provide ISR. The technologies this RFI is focused on are the HEL, the beam control systems (BCS), and the fire-control software. In addition to the HEL and BCS, the Army is seeking information about high capacity power storage, compact power generation, adaptive optics, image trackers, target illuminators, fire control software and thermal management systems. The goal of this RFI is to enable a next generation HEL system for future tactical platforms.

The Army is seeking HEL systems that provide 25-35 kW of power with a system weight between 4 and 8 kg per kilowatt (100-280 kg). In addition, advances in fire-control software are also desired. Engagement times for future HEL platforms will be considerably shorter and the fire-control software should receive the cue and automatically select and maintain an aim-point on the target. The contracting point of contact is Neisha M. Mendiola, (256) 955-0066, e-mail neisha.m.mendiola.civ@mail.mil.



Northrop Grumman has received a \$17.7 million contract option for Joint Counter Radio-Controlled Improvised Explosive Device Electronic Warfare Increment One Block One (JCREW I1B1) full-rate production in support of Naval Sea Systems Command's Expeditionary Warfare Program Office. The additional orders will continue through November 2020.



The Naval Surface Warfare Center Crane has awarded **Irvin GQ** a \$386,500 contract for spares, repairs, and engineering services in support of the MK 59 Mod 0 passive offboard decoy and launching system. The contract includes engineering services in support of recertifying 30 decoys.

MK 59 is the US Navy designation for the Outfit DLF 3b decoy system previously supplied by Irvin GQ to the UK Royal Navy. The Mk 59 system has been fitted to a number of US Navy warships since 2013 under a Chief of Naval Operations Speed-to-Fleet initiative.



The US Army has announced plans to award a contract to **Textron Systems** for an Advanced Architecture Desktop Signal Generator, with two signal sources, for use at the Center for Countermeasures, White Sands Missile Range, NM). The Center for Countermeasures is a Joint Service agency under the OSD's Director, Operational Test and Evaluation. It coordinates and conducts countermeasures and counter-countermeasures evaluations of US and foreign weapons systems, sensors and subsystems.



The F-35 Joint Program Office has announced plans to award a contract to **BAE Systems** (Nashua, NH) to support the flight test demonstration of ASQ-239A EW suite upgrades. Under "Project Heisenberg," the F-35 JPO will assess new ASQ-239A capabilities on a surrogate aircraft – Lockheed Martin's 737 test aircraft known as the Cooperative Avionics Testbed or CATBird. As part of Project Heisenberg, the new contract calls for BAE Systems to develop, integrate and operate a modified ASQ-239A suite in a receive-only flight-test/demonstration configuration to support risk reduction and early assessment of Continuous Capability Development and Delivery (C2D2)/Block 4 EW software capabilities, along with evaluation of the associated Mission Data Files. The F-35 Program will provide the CATBird System Development and Demonstration EW system and the Digital Channelized Receiver/Technique Generator and Tuner Insertion Program (DTIP) JPO2 system as Government Furnished Equipment for this project. The F-35 JPO is expected to award the contract in the third quarter.



The Air Force Research Lab's Sensors Directorate (Wright-Patterson AFB, OH) has announced an upcoming Broad Agency Announcement (BAA) solicitation for a new effort named RF Analysis and Validation Engineering Software (RAVENs). The program, which is managed by the Sensors Directorate's Multispectral Sensing & Detection Division, Antennas & Electromagnetics Technology Branch (AFRL/RYMH), will fund research, development, and quality assurance within the Computational Research and Engineering Acquisition Tools and Environments RF (CREATE RF) suite of software tools. The RAVEnS effort will help with development of the algorithms and computational tools to provide decision makers and designers with high quality RF modeling of RF components integrated into next generation weapons systems. Specifically, RAVEnS will support five objectives: 1) research, develop, verify, validate, test, and apply computational electromagnetic design

tools – in concert with the government-led team to produce the next generation of HPCMP CREATETM tools; 2) research and develop advanced computational methods for the design and development of weapon systems – methods that exceed currently used techniques in accuracy, fidelity, time to solution, and usability; 3) develop and deploy multi-physics engineering software applications on increasingly capable high performance computing systems. These applications will accurately predict the performance of weapon systems and enable the trade space optimization of new and retrofit designs; 4) incorporate requirements and feedback from weapon systems analysts/designers (end users of the CREATE-RF tools) to develop and deploy next generation multi-physics engineering software applications; and 5) improve the productivity of the weapon system designers by incorporating new methodologies for CAD and mesh generation, analysis scenario descriptions, effective use of high-performance computer resources, management of models, and analysis results throughout design cycles, and use of computer graphical techniques to display engineering analysis results effectively. The RAVeNS contracts are expected to be awarded in August 2019, and the total value of the contracts is expected to be \$49.9 million. The technical point of contact is Lance Griffiths, AFRL/RYMH Project Engineer/Program Manager, (937) 713-8911, e-mail lance.griffiths.1@us.af.mil.



The US Navy's Joint Electronic Attack and Capabilities Office (JEACO) at the Naval Air Warfare Center – Weapons Division (Point Mugu, CA) has announced plans to award an Indefinite Delivery/Indefinite Quantity (ID/IQ) contract to **Harris Corp.** (Clifton NJ) to develop, fabricate and test the company's Disruptor SRx multifunction EW system and to integrate the system into the ALQ-231 Intrepid Tiger communications electronic attack (EA) pods. According to the Navy's announcement, "The hardware within this requirement includes, but is not limited to, Low Band ERTG, High Band ERTF, Ka Band ERTG, and v2

Test Card. These components will be utilized by the Navy to build and sustain communications jamming capabilities for airborne (Fixed Wing, Rotary Wing, and Unmanned Air Systems (UAS)), ground based systems, and in EW laboratory environments." The contract will cover a five-year ordering period and the Navy expects to award the contract over the summer.



Giga-tronics (Dublin, CA) has won a \$4 million contract from the Naval Air Warfare Center Weapons Division (Point Mugu, CA) for two GT-ASG-TEMS-103 2-channel Multi-ship Time Difference of Arrival (TDOA) Radar Signal Generators (MTRSG) and associated engineering services in support of Airborne Electronic Attack (AEA) Integrated Product Team (IPT). The contract also calls for engineering support services over a 24-month period.



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world report

NEW EW CAPABILITY PACKAGE FOR NATO JEWCS

A Leonardo-led industry team has been contracted to deliver a Capability Package (CP) intended to recapitalize the NATO Joint Electronic Warfare Core Staff (JEWCS) equipment inventory. Comprising both airborne and land/maritime electronic warfare (EW) assets, plus a mission planning infrastructure, the new inventory is planned to achieve full system acceptance in early 2023.

Team Newton – a partnership of Leonardo and Cobham – was awarded the CP contract valued at EUR 180 million by the UK Ministry of Defence (MOD) in December 2018. The MOD, as the territorial host nation for NATO JEWCS, has facilitated the procurement on behalf of NATO.

Based at RNAS Yeovilton in southwest England, NATO JEWCS is a multinational training and EW-subject-matter-expert organization that functions as a stand-alone Memorandum of Understanding (MOU) entity funded by its 12 member nations (the Czech Republic, France, Germany, Greece, Italy, the Netherlands, Norway, Poland, Romania, Spain, the UK, and the United States). The organization provides a range of EW services to the three NATO Strategic Commands and is a unique capability within NATO.

The JEWCS operates a variety of radar and communications jamming, simulation and surveillance equipment, which it deploys around Europe to deliver EW training for NATO nations. However, JEWCS's current equipment inventory is ageing and no longer able to represent the modern operational EW environment. In addition, the equipment suffers from reduced availability rates as a result of increasing obsolescence.

The successor CP – codified by NATO as CP 9A0700 – is intended to provide JEWCS with a modernized EW equipment suite that will enable the unit to deliver realistic training that reflects the advances in electromagnetic threat and countermeasure technology. As well as replacing

existing airborne jamming, threat simulation pods, and land/maritime EW assets, the CP also incorporates a requirement to acquire a NATO Anti-Ship Missile Defensive Evaluation Facility (NASMDEF) to evaluate soft-kill countermeasures used by ships to defend against anti-ship missiles.

Under the scope of the CP contract, Team Newton will deliver new airborne EW training equipment (using airborne pods), maritime/land EW training equipment (housed in modular shelters and vehicles) and NASMDEF (using "smart" pods). Other deliverables include the provision of laser, ultra-violet, and infrared stimulation equipment, a capability to disrupt/deny GPS over a controlled area, tools to simulate radio-controlled improvised explosive devices (RCIEDs) and a new mission planning system.

Team Newton's key subcontractors include Elettronica (which will deliver sheltered EW systems for land/maritime training through its Elettronica GmbH business in Germany), DRS (communications electronic support measures), Textron (EW stimulation equipment) and Leonardo's Canadian-based Tactical Technologies Inc. subsidiary (mission planning and tactical engagement simulation software).

The NASMDEF solution is to be derived from Eldes's Poseidon programmable seeker simulator. Already used as a land-based simulator, the Poseidon system will be adapted and repackaged for the airborne environment.

Spanish IT group Everis is expected to provide input into the mission planning system forming part of the CP. In late 2017, Everis was contracted for the supply and support of the NATO Emitter Database – Next Generation (NEDB-NG), which is managed by NATO JEWCS. As the JEWCS mission planning system must interface with NEDB-NG, Team Newton is looking to leverage the product development already undertaken by Everis. – *R. Scott*

ARDS ELINT POD FLIES ON PREDATOR B UAS

General Atomics Aeronautical Systems, Inc. (GA-ASI) and Raytheon Deutschland GmbH have successfully proved the performance of a new digital electronic intelligence (ELINT) payload on a Predator B/MQ-9 Reaper medium-altitude, long-endurance unmanned air system (UAS). Raytheon's Advanced Radar Detection System (ARDS) payload was integrated in a wing-mounted pod and flight tested at GA-ASI's Gray Butte Flight Operations facility near Palmdale, CA.

ARDS is an advanced exploitation of digital receiver technology previously embodied as an upgrade of the Emitter Location System fitted to Luftwaffe Tornado ECR aircraft. The ARDS payload has been designed to provide passive, wide-area ELINT over land and sea and enable high-fidelity detection and precision direction finding of RF emitters in order to auto-generate the electronic order of battle.

The prototype ARDS system covers 1- to 26-GHz (with extension available to expand frequency coverage to 0.5-40 GHz). Raytheon Deutschland claims a DF accuracy of less than 0.5 deg, sensitivity of -84 dBm (continuous wave), frequency resolution of 100 Hz or lower, frequency accuracy of less than 100 kHz for pulse signals, and less than 10 kHz for continuous wave emitters, and an instantaneous bandwidth of 1 GHz.

Flight testing was jointly funded by GA-ASI and Raytheon Deutschland. During flight testing against ground radar targets, the system verified its performance with regard to processing speed and geolocation precision. In addition to sensor performance, the use of aircraft data-link and ground station elements were also successfully demonstrated.

While the current ELINT pod design has been developed specifically for the unmanned Predator B platform, Raytheon Deutschland sees application for ARDS in other platforms, such as manned special mission aircraft and naval vessels. – *R. Scott*

Passive Radar Techno A Response to Stealth

By John Haystead

Just as radar transformed the air warfare paradigm of World War II, the public introduction of stealth technology in the 1980s, and its demonstration in combat in the 1990s, dramatically changed the way that military forces viewed the capabilities of their air defenses, as well as those of their air forces. But, as with all things military, technological advantage is fleeting, and researchers have been working industriously over the past decades to develop countermeasures and counter-countermeasures to stealth technology. They have not been without success.

Today, despite the fielding of next-generation stealth aircraft, modern military forces, at least those of the US, Russia, and China recognize that low-observable platforms can "kick down the door" of an advanced air defense network – taking out key surveillance and tracking radars, as well as long-range surface-to-air missile systems, and making it possible for more numerous but less-stealthy aircraft to operate in the airspace as well. But, what if this weren't the case at all? What if most nodes in an air defense system were themselves stealthy – effectively invisible to attacking aircraft or other weapons? And what if, at the same time, that system was also capable of detecting and tracking stealth attackers without their even being aware of it? That is the promise of passive radar technology, and in fact, it may already be the reality.

Passive radar is a form of bi-static radar which refers to a radar system in which the signal transmitter and the receiver are separated from each other by tens or even hundreds of kilometers.

But, as opposed to conventional bi-static radars, passive radar systems are exclusively receiver-based, using "signals-of-opportunity" transmitted by commercial or civil emitters for other purposes, but that are nevertheless reflected by possible targets of interest and detected. These reflected signals from "non-cooperative emitters" are processed, usually together with the known location of the emitters, to detect, determine range, and track targets by measuring and calculating the time-difference-of-arrival (TDOA) data between the signal arriving directly from the transmitter (reference channel) and the reflected signal arriving from the target. Doppler shift data is also often used to further refine the process. Today, examples of exploitable, non-cooperative emitters include televi-

sion, FM radio, cellular phone base stations, digital audio and video broadcasts, and GPS. The single greatest advantage of passive radars is that they themselves are completely stealthy, generating no appreciable signal footprint of their own.

There are different types of passive radar. Passive Coherent Location (PCL) or Passive Covert Radar (PCR) are of the type described above, while the non-cooperative signal used by a "parasitic" or "hitchhiking" radar can actually be the signal generated by an adversary's own radar. In fact parasitic radars were the earliest forms of passive radar to be used in conflict. In World War II, Germany used its (Kleine Heidelberg) radar system to exploit the signals generated by the RAF's own "Chain Home" air-defense radar system to detect and track airborne targets. (The Chain Home system operated from 20 – 30 MHz.)

In general, monostatic radar systems (co-located transmitter and receiver) have been the primary radars used for both commercial and military purposes to date – the principle advantages being easier/simpler and less-costly implementation and the dramatically lower signal-processing power needed to calculate target-signal return data. This began to change, however, with the emergence of more and more powerful microprocessor technology able to easily, and cheaply, provide the signal-processing power needed to handle the basic requirements of passive radar detection, and then some. Such processors could handle multiple non-cooperative emitters, making it possible to cross-correlate their signal data in real time.

At this point, it's important to note that it's not uncommon for passive ra-



Passive radars can use signals of opportunity, including signals from commercial emitters in the VHF bands, to detect and track aircraft and ships. Although passive radar technology must still evolve further before it finds wide military utility, it does hold the potential to track low-observable platforms, such as the Su-57 (above) in the future.

VITALY KUZMIN

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dar systems to be discussed in the same context as, or confused with, radar electronic support measures (ESM) and electronic intelligence (ELINT) systems, and in fact, some systems on the market today are capable of being used in either passive radar or ESM/ELINT modes. However, the distinct difference between the two is that, unlike ESM and ELINT systems, passive radars do not rely on signals actively generated by the target itself.

The effective range of passive radar systems varies significantly. According to open sources, passive radar systems exploiting signals from high-power, wide-elevation-beam, commercial FM radio stations (87.5 – 108 MHz) can operate effectively at approximately 100-mile distances. One disadvantage of these sources, however, is that their bandwidth depends on program content. High-power, digital television signals (170-230 MHz, 460-694 MHz, and 790 MHz), can serve at ranges nearly twice that of FM stations, and the bandwidth of their DVB-T standard (OFDM) signal is also independent of content. Cellular phone signals, on the other hand, while also exploitable, are generally useful only at ranges of less than twenty miles. GPS reflectometry and satellite signals in general, have for the most part been considered inadequate for passive radar use, given their low power and/or because their orbits provide infrequent illumination.

A principal range-limiting factor for passive radars is that their receivers must detect and process the reflected signals-of-interest in the presence of continuous interference from the original transmission source.



Hensoldt introduced its TwInvis passive radar system at the International Aerospace Exhibition (ILA) in Berlin last year. It builds an air picture by simultaneously monitoring a large number of frequency bands – up to 16 FM transmitters (analog radio) plus 5 frequencies used by several DAB and DAB+ transmitters (digital radio) as well as DVB-T and DVB-T2 (digital, terrestrial television).

HENSOLDT

Adaptive filtering techniques are often employed to mitigate this. Digital beamforming is also usually used to determine the direction of arrival of signals and spatial rejection of strong in-band interference, although this is also sometimes done with analog beamforming of multiple antennas and digital processing.

FIELDING CAPABILITIES

Although it's increasingly clear that both China and Russia have been actively developing (and fielding) pas-

sive radar systems and networks, in the "West," there's been a somewhat cyclical ebb and flow in the interest level given to the potential of the technology, as well as the number of countries and companies investing in passive radar research and development.

One US company doing work in the area for decades, however, is SRC Inc. (North Syracuse, NY). SRC's research work has included both bi-static and multi-static operation, including efforts using ground, airborne, and space-based assets, with a variety of processing algo-



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rithms applied to the test data collected including space-time adaptive processing (STAP), synthetic aperture radar (SAR), ground moving target indication (GMTI), air moving target indication (AMTI), motion compensation, tracking and a variety of high-performance exploitation algorithms.

One early SRC program used a large receive antenna to capture analog television reflections off satellites in low-earth orbit. As described by Dr. Daniel Thomas, SRC Fellow, "Tuning to any TV

channel resulted in multiple returns from the satellite because there were multiple TV stations transmitting on the same channel that simultaneously illuminated the satellite in orbit. These returns were sorted and the Doppler traces used to update the satellite's orbital elements. The downside of this is that you need a very large antenna to detect small satellites."

In another experimental program in 2001, the company built a long VHF antenna array as part of a cooperative



Digital TV and FM radio stations can provide the signals of opportunity used by passive radar systems.

SANJO

bi-static system. The array was tuned to a frequency being used by an HDTV transmitter, which as Thomas notes was relatively new at the time, to demonstrate short-range detection of cars, trains and aircraft.

Another early example of a passive radar program was the "Silent Sentry" program conducted in 1998 by Lockheed Martin Mission Systems (Gaithersburg, MD) in conjunction with the University of Illinois at Urbana-Champaign (Urbana, IL). Silent Sentry combined a passive radar system capable of exploiting FM radio and analog television transmitters with an automatic target recognition system.

The raw signal data scattered from the commercial transmissions were processed using a Bayesian pattern-matching engine to estimate the radar cross section (RCS) of a potential target and compare it to those stored in a target library. As noted by the researchers, however, since RCS is a function of a target's aspect with respect to both the illuminators and the receiver (also varying with the frequency and polarization of the incident wave), "this unknown aspect is a nuisance parameter which must be dealt with in our Bayesian formulation...and it is also worth mentioning that this unknown aspect angle typically will change from sample to sample as the target maneuvers." To deal with the issue, the researchers interpolated between polarization matrix look-up tables calculated using the Fast Illinois Solver Code (FISC) developed at the University of Illinois for each class





The Multistatic Coherent Location (MUSCL) system from Patria uses FM and DVB-T/T2 broadcasting signals to simultaneously track up to 100 small-sized, stealthy and low altitude targets. It can be configured for deployable or fixed operation.

PATRIA

of target. At the time of the work, they were able to demonstrate the successful classification of an unknown target in a four-class experiment using data supplied by Lockheed Martin (position/velocity estimates and reflected power).

In 2014, ERA (Prague, Czech Republic) introduced its "Silent Guard" Passive Coherent Location (PCL) passive radar system at the Deployable Multi-band Passive Active Radar (DMPAR) Evaluation Trials for Operationally Upgraded Radar (DETOUR) event conducted around NATO's Science and Technology Organization (STO) Sensors & Electronics Technology (SET)-195 panel. Trials were conducted at three East Bohemian airports and included researchers and systems from the Czech Republic, Poland, Norway, Germany, Italy and France. The goal was to assess the use of DMPAR radars for air defense and specifically the impact, and possible complementary performance upgrade, of primary radars operating together with passive radiolocation and passive radar systems.

The PCL system demonstrator was an FM-based multi-static radar, us-

ing up to eight element circular array antennas and commercial FM radio transmitters as illuminators of opportunity. ERA believes passive radar concepts and integrated multi-role radar sensors can potentially be mutually complementary, providing improved capabilities, such as improved low-level coverage, anti-stealth, high update rate, foliage penetration, long detection range, high resolution and non-cooperative target identification (NCTI) capability. In a 2017-published

report, the NATO-SET-195 results "confirmed, demonstrated and quantified the potential performance upgrade for air defence radar systems applying the DMPAR principle. In the short term, coastal surveillance, gap filling and asset protection tasks can considerably benefit from the proposed DMPAR principle when applied to a system of state-of-the-art active and passive radar systems."

Tuomas Halonen, Business Development Director at Patria (Tampere,

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Finland), also sees these expanding opportunities for passive radar. "There's definitely growing interest in passive radar technology. One driver is that the focus of military planning has clearly shifted from crisis management and expeditionary forces back to more traditional scenarios of defending home country against capable adversaries. In addition, we see that the emergence of drones and other low-flying and small targets that require technologies that can complement tra-

ditional radars, and passive radars are one good solution to fill the gaps of traditional surveillance radars."

Launched last summer, Patria's Multistatic Coherent Location (MUSCL) passive radar system is one such example. Exploiting FM and Digital Video Broadcasting-Terrestrial (DVB-T/T2) signals, the MUSCL system implements a multistatic receiving geometry and covers lower operating frequencies than those used by conventional air surveillance radars. According to the

company, it can detect small (i.e., drone size) and stealthy targets at ranges up to hundreds of kilometers, simultaneously track over 100 targets, and discriminate fixed-wing, propeller, and helicopter types. Says Halonen, "The threat posed by drones is a reality right now, and we believe that passive radar technology can provide anti-drone capability – e.g., in border control, airport traffic monitoring, public event or military base protection. Finally, it's worth mentioning that it's already been proven in the field that in addition to target detection, passive radar is capable of supporting non-cooperative target classification and identification with its ability to provide target category or type specific features from target echo signals." Patria is currently in the final stages of productizing the MUSCL system and has already received initial contracts.

LOWER COST IMPLEMENTATIONS POSSIBLE

As a general rule, passive radars typically use dedicated low-noise, linear, digital receivers. However, as noted by SRC's Thomas, "While this may be true, it's not uncommon to see low-budget systems that use software-defined radios as receivers (that may not be particularly low noise) and arrays (often circular) of simple antennas (TV, or FM antennas, for example). Often the antennas are switched in one at a time to a single receiver, but with broadcast transmitters, multiple receiver channels can be assigned to multiple antennas to increase instantaneous coverage. Low-budget systems have enabled universities to perform research in this area."

One such example can be seen in the Software-defined Multiband Array Passive Radar (SMARP) demonstrator developed by the Radar and Surveillance Systems National Laboratory (RaSS Lab) in Pisa, Italy, and reported on by NATO's Science and Technology Organization (STO) Sensors & Electronics Technology (SET) panel in 2016. The RaSS Lab is a branch of the Italian National Inter-university Consortium for Telecommunications (CNIT), a non-profit organization of 38 Italian Universities, and involved

in several NATO task groups working on passive radar topics (SET-164, SET-186, SET-195, SET-196, SET-207).

The SMARP demonstrator was a multiband passive radar based on a software-defined solution and oriented to coastal-surveillance applications. Based on exploiting DVB-T and Universal Mobile Telecommunications Service (UMTS) standard signals, the SMARP demonstrated advances in several areas including: multiband receiving array antennas (UHF and S-band) with dual polarization reception, a software-defined multiband flexible receiver based on commercially available solutions, digital-array processing techniques, and advanced radar signal processing algorithms implemented on commercial off the shelf (COTS) processing architectures implementing multicore CPUs and GPUs.

NATO research work in passive radar technology is continuing. Initiated in 2014, the objective of NATO SET-207, "Advanced Situation-Specific Modeling, Sensing and Vulnerability Mitigation Using Passive Radar Technology"



The AULOS passive radar from Leonardo exploits signals from FM radio stations, TV broadcasters, and broadband communications signals "for covert surveillance and tracking of stealth and low flying air targets." It can be configured in a fixed-site configuration using log periodic antennas (above) or in a deployable configuration using two uniform circular arrays.

LEONARDO

was to develop and validate a robust model-based approach to passive radar design and procurement consisting of: a comprehensive prediction of propagation effects and a characterization of bi-static clutter, target modeling, characterization of RFI, and development of agile mitigation techniques for clutter and interference.

The study's statement of objectives notes that one benefit of bi-static radars, particularly at VHF/UHF, is their ability to use forward-scatter techniques to detect low-observable targets, however it also observes that this "forward-scatter behavior is only achieved over a limited set of directions, and networking between multiple transmit-

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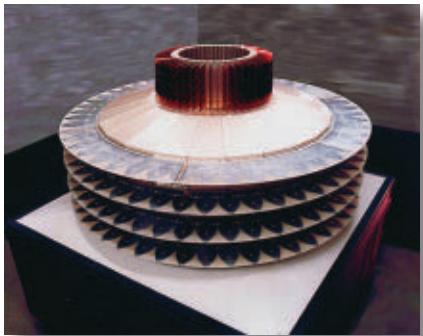


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ter/receiver pairs is required to obtain complete coverage." As such it states that, "The topic of passive radar sensor integration needs to be studied...to accurately determine sensor performance and to enhance siting for strategic advantage in a net-centric domain." The role of passive radar for border surveillance and maritime surveillance applications was also to be investigated, together with analysis of motion compensation and alternative illuminating sources. A pre-release report was issued for SET-207 in July of 2018.

LOOKING FORWARD

SRC's Thomas sees a lot of interest across the board in passive radar technology, including within the US and especially at the DOD, where they're noting a growing number of solicitations in the bi-static and multi-static radar technology arena, as well as in Europe, both at the academic and government-sponsored level. "One of the themes over the years has been this idea that we should be able to take advantage of all this radiation out there, pretty much for free. Of course, taking advantage of it, isn't free, but there are a lot of opportunities out there, and a lot of work going into, trying to take advantage of it."

Today at SRC, Thomas says, "As opposed to exploiting non-cooperative commercial RF signals, the company's passive radar work has largely focused on non-cooperative radar bi-statics – i.e., hosting off conventional radars." A form of parasitic passive radar, as noted by Thomas, these could potentially be either enemy or friendly radars. "This avoids many of the issues that result

from using broadcast waveforms. We apply basically the same techniques with the addition of "pulse-chasing" for use with mechanically rotating radar antennas." Thomas describes pulse-chasing as "starting with a circular/cylindrical phased array antenna and pointing a beam at the transmitter. This is used to track the scan pattern of the transmitter. Then, using that as a timing source, we dynamically steer a surveillance beam to the region of space that is illuminated by the transmitter at any point in time. This allows us to perform 360 degree surveillance with a single receiver channel." Thomas says SRC was the first to reduce pulse-chasing to practice. "Nowadays, with advances in digital receiver technology, pulse chasing is also being accomplished with digital beamforming."

Thomas says among other trends his company sees emerging in passive radar development are: migration to larger, more-capable, phased-array antennas; increasing amounts of fusion of multi-static data; multichannel receivers with digital beamforming and multi-channel processing techniques; wideband receivers that can capture the returns of multiple broadcast transmitters simultaneously (with parallel processing to go with them); and moving the processing from hardware (field-programmable gate arrays, digital signal processing chips) to software, though he notes that hardware also continues to improve and come down in price.

Patria's Halonen also sees dependency on third-party emitters as a potentially significant challenge for passive radar systems. "System suppliers or end users, will not have direct control of the emitters used (location, beam directions, waveforms). In addition, it's good to keep in mind that third-party-emitter locations are chosen for purposes other than being illuminators for passive radar sensors. This means that, it's important to have a specific mission planning tool which enables end-users to determine suitable geographic locations for passive radar sensors before actual deployment. On the other hand, it's fairly straightforward to make one's own dedicated transmitters for the system. Own transmitters can



SRC's Wideband Electronic Assembly: a single, rack-mounted, bistatic receiver assembly that could perform pulse-chasing and could fully process and track returns from circularly scanning air surveillance hosts.

SRC PHOTO

either mimic those third-party emitters, or be more specifically designed for multi-static operation than a basic passive radar."

Overall, from his viewpoint, Thomas sees the past history of 20-30-year cyclical coming and going of interest in passive radar as over. "There will continue to be significant advances in passive radar technology and the opportunities to implement it, and I predict that it's really here to stay this time. It's a permanent trend, and will not fade away as in the past."

SEEING IS BELIEVING

As raised at the outset of this article, the truly potentially-alarming-possibility posed by the real-world emergence of passive radar technology is its threat to stealth platforms and to stealth-based air-defense-penetration strategies. In fact, many of the individuals and companies contacted for this article were reluctant to even discuss this particular aspect of passive radar technology. That reaction, of course, speaks volumes, in and of itself, to the level of concern it is generating. Patria's Halonen did, however, offer the following straightforward assessment. "Passive radars typically use different (lower) frequencies than traditional radars. As such, stealth technology is not optimized against them. Also, multistatic geometry (several receivers and transmitters at different locations), poses problems for stealth technology. Passive radar technology can be considered a great threat to current stealth designs."

And so, the chess game of measure and countermeasure continues. ↗



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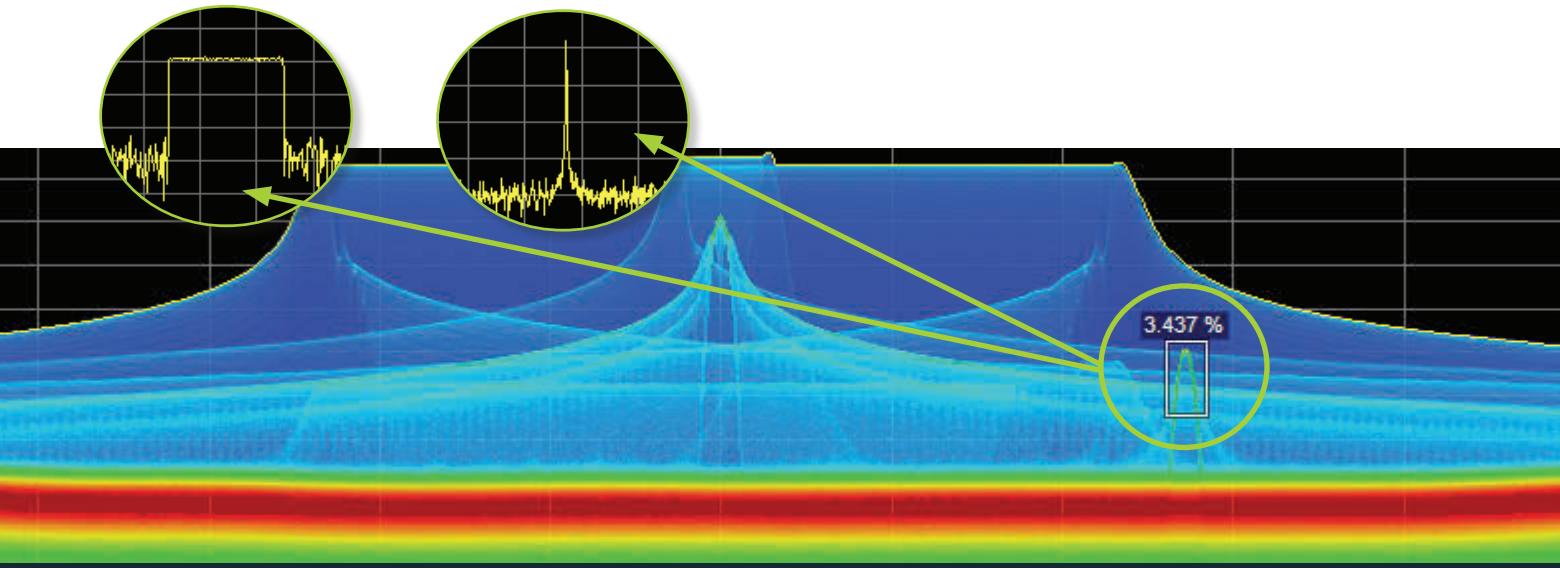
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TECHNOLOGY SURVEY

A SAMPLING OF BENCHTOP SPECTRUM ANALYZERS

By Barry Manz

The exploration of the middle reaches of the millimeter-wave region by both commercial and defense organizations is arguably one of the greatest challenges ever faced by the test and measurement community. Combine this with the need to analyze more complex waveforms, increase spurious-free dynamic range and linearity, and accommodate rapidly-broadening signal bandwidths, while keeping costs as low as possible, is exceptionally difficult.

Nevertheless, new radar and communications systems continue to appear at these frequencies, which means EW and SIGINT systems must cover these frequencies, too. Consequently, defense technology developers and DOD labs require the measurement tools to detect, measure and analyze them. Fortunately, test equipment manufacturers have managed to divine the required measurements well in advance of when those measurements will be needed and have delivered the tools to achieve them.

Spectrum analyzers have evolved continuously in step with customer requirements since the first instruments were introduced, from swept-tuned instruments to vector signal analyzers and the latest real-time spectrum analyzers. Swept-tuned spectrum analyzers, although too-often regarded as "old" technology, are nevertheless very capable, and can deliver high-dynamic-range measurements with low phase noise and distortion products. However, this approach met its match when signals began to vary faster than the sweep speed, allowing spectral events to be missed.

The vector signal analyzer mitigated this problem by capturing a much broader frequency range, digitizing the analog signals in the passband, storing them, and then downconverting, filter-

ing and analyzing them in the digital domain using FFT algorithms. These instruments can detect not just amplitude but phase information as well, which allows more advanced processing and demodulation techniques. That said, the processing and conversion time of the analog-to-digital converter (ADC) still leaves a "blind spot" between acquisitions where transient effects may not be detected. So, if low-intensity signals appear in the same acquisition window as higher-power signals, they may be missed or masked by the stronger signal.

To solve this problem, multiple ADCs with overlapping IF bandwidths in a staggered-capture approach can be used so they overlap with the previous acquisition. The ADCs process so rapidly that acquisitions overlap, which ensures that no information will be lost. This is the basic technique employed in a real-time spectrum analyzer. The amplitude, phase, and modulation data are captured in real time, which allows the "multi-domain" data to be represented in the time domain. The result is that spectrum populated by high-speed data signals can be monitored for transient responses, and comprehensive analysis of the modulation schemes can be analyzed and corrections can be applied in real time.

Along with finding transients, real-time spectrum analyzers can capture and export in-phase and quadrature (IQ) data, and they are extremely well suited for measuring the dynamic and transient performance of devices used in spread-spectrum systems, as well as higher-order modulation schemes. Real-time spectrum analyzers can also ensure optimum performance of the tuning structure of a voltage-controlled oscillator. Both can have random behavior that would be invisible to other types of spectrum analyzers. These instruments

can also produce a time-as-temperature plot that measures the incidents of dynamic signals, depicting them using a color code. This allows frequent and infrequent transients to be differentiated.

Regardless of the type of instrument employed, all spectrum analyzers have benefited from the move toward digitization of signals at or near the point where they are captured, whether an antenna or the output of a device under test. With signals converted to the digital domain almost immediately, the ability to use advanced signal processing has been dramatically improved. These benefits include triggering on transients using two-dimensional triggers, multi-domain correlated displays, and remote viewing and control.

THE SURVEY

The following survey table focuses on benchtop and rack-mount spectrum analyzers. (We will cover portable and handheld spectrum analyzers in a future technology survey.) The first few columns focus on the type of spectrum analyzer and the technology it uses and its operating frequency range. The next columns indicate the unit's center frequency and span options, as well as its resolution bandwidth. The "detector" column defines the technique used to determine the signal magnitude. The minimum event duration column defines the smallest amount of time in which an event can be detected, and the dynamic range column indicates the operational dynamic range from the lowest power signal detected to the highest power signal, which can be a function of the bandwidth selected. "Trigger types" define options for starting a measurement of a specific signal.

Our next technology survey, which will focus on counter-UAS solutions, will appear in the May JED.

BENCHTOP SPECTRUM ANALYZERS

Model	Spectrum Analyzer Type	Operating Freq. Range	Center Freq. and Span Options	Resolution Bandwidth	Detector	Min. Event Duration	SFDR
Anritsu Company; Allen, TX, USA; +1 800-267-4878; www.anritsu.com							
MS2840A	Hybrid	9 kHz — 44.5 GHz*	CF: 9 kHz-44.5 GHz; span 0 Hz, 300 Hz to 44.5 GHz (model dependent)	1 Hz-31.25 MHz	Positive and negative, +peak, sample, negative peak, RMS	*	169 dB
MS2830A	Hybrid	9 kHz — 43 GHz*	CF: 9 kHz-43 GHz; span 0 Hz, 300 Hz to 43 GHz (model dependent)	30 Hz-3 MHz in 1-3 sequence. 1 Hz, 50 kHz, 5 MHz, 10 MHz, 20 MHz, 31.25 MHz	Positive and negative, +peak, sample, negative peak, RMS	*	168 dB
MS269xA	Hybrid	50 Hz — 26.5 GHz	CF: 50 Hz-6 GHz; span 0 Hz, 300 Hz to 26.5 GHz (model dependent)	30 Hz-3 MHz in 1-3 sequence. 1 Hz, 50 kHz, 5 MHz, 10 MHz, 20 MHz, 31.25 MHz	Positive and negative, +peak, sample, negative peak, RMS	*	177 dB
Good Will Instrument Co., Ltd.; New Taipei City, Taiwan; +886-2-22680389; www.gwinstek.com							
Model GSP-9330	Swept-tuned	9 kHz-3.25 GHz	CF: operating freq. range: 0 span or 100 Hz-3.25 GHz	3 dB: 1 Hz-1 MHz (1-3 step); 6 dB: 200 Hz, 9 kHz, 120 kHz, 1 MHz	Positive-peak, negative-peak, sample, normal, RMS (not video), quasi-peak(EMI), avg. (EMI)	*	*
Model GSP-9300	Swept-tuned	9 kHz-3 GHz	CF: operating freq. range: 0 span or 100 Hz-3 GHz	3 dB: 1 Hz-1 MHz (1-3 step); 6 dB: 200 Hz, 9 kHz, 120 kHz, 1 MHz	Positive-peak, negative-peak, sample, normal, RMS (not video)	*	*
Keysight Technologies; Santa Rosa, CA, USA; +1 800-829-4444; www.keysight.com/find/sa							
N9041B UXA Signal Analyzer	Swept-tuned, FFT, and Real-time	2 Hz to 110 GHz external mixers to 1.1 THz	CF adjustable over the full frequency range of the instrument. In swept and FFT modes, frequency span is settable to 0 Hz (zero span), 10 Hz to max frequency of the instrument.	1 Hz-25 MHz standard, up to 1 GHz optional	Normal, peak, sample, negative peak, log power average, RMS average, voltage average, and quasi-peak	3.51 µsec	Real-time SA mode with 510 MHz BW: -78 dBc
N9040B UXA Signal Analyzer	Swept-tuned, FFT, and Real-time	2 Hz to 50 GHz external mixers to 1.1 THz	CF adjustable over the full frequency range of the instrument. In swept and FFT modes, frequency span is settable to 0 Hz (zero span), 10 Hz to max frequency of the instrument.	2 Hz-25 MHz standard, up to 1 GHz optional	Normal, peak, sample, negative peak, log power average, RMS average, voltage average, and quasi-peak	3.51 µsec	Real-time SA mode with 510 MHz BW: -78 dBc
N9030B PXA Signal Analyzer	Swept-tuned, FFT, and Real-time	3 Hz to 50 GHz external mixers to 1.1 THz	CF adjustable over the full frequency range of the instrument. In swept and FFT modes, frequency span is settable to 0 Hz (zero span), 10 Hz to max frequency of the instrument.	1 Hz-25 MHz standard, up to 510 MHz optional	Normal, peak, sample, negative peak, log power average, RMS average, voltage average, and quasi-peak	3.51 µsec	Real-time SA mode with 510 MHz BW: -78 dBc

Trigger Types	Applications	Form Factor	Size	Weight	Features
Free run, external, manual	Tx and Rx signal characterization for R&D and manufacturing for custom/proprietary digital modulation schemes and analog modulation.	Benchtop	426 x 177 x 390 mm	≤ 15.3 kg	Mixers extend frequency coverage to 325 GHz; Built-in signal generator
Free run, external, manual	Tx and Rx signal characterization during manufacturing for commercial digital modulation schemes and analog modulation.	Benchtop	426 x 177 x 390 mm	≤ 13.5 kg	Mixers extend frequency coverage to 325 GHz
Free run, external, manual	Tx and Rx signal characterization for R&D for commercial digital modulation schemes and analog modulation.	Benchtop	340 x 200 x 350 mm	≤ 13.5 kg	Built-in vector signal generator; built-in AWGN generator
Free run, video, external positive edge, external negative edge	LNB, EMI precompliance test and debug, GPS receiver, antenna, tuner, RF component, spectrum monitoring	Benchtop	13.8 (W) x 8.3 (H) x 3.9 (D) in.	9.9 lb	High freq. stability: 25 ppb (0.025 ppm); IF output
Free run, video, external positive edge, external negative edge	LNB, EMI debug, GPS receiver, antenna, tuner, RF component, spectrum monitoring	Benchtop	13.8 (W) x 8.3 (H) x 3.9 (D) in.	9.9 lb	Spectrogram and topographic display modes
Level, level with time qualified (TQT), line, external, RF burst, frame, frequency mask (FMT), FMT with TQT.	RF, microwave and millimeter wave signal analysis	Box instrument	(H) 281 mm (11 in.) x (W) 459 mm (18 in.) x (L) 575 mm (22.6 in.)	34.9 kg; 76.9 lb	Optional applications available for vector signal analysis, pulse measurements, and real-time I/Q data streaming (3 hours at 255 MHz bandwidth)
Level, level with time qualified (TQT), line, external, RF burst, frame, frequency mask (FMT), FMT with TQT.	RF, microwave and millimeter wave signal analysis	Box instrument	(H) 280 mm (11 in.) x (W) 459 mm (18 in.) x (L) 500 mm (19.8 in.)	30.9 kg; 68 lb	Optional applications available for vector signal analysis, pulse measurements, and real-time I/Q data streaming (3 hours at 255 MHz bandwidth)
Level, level with time qualified (TQT), line, external, RF burst, frame, frequency mask (FMT), FMT with TQT.	RF, microwave and millimeter wave signal analysis	Box instrument	(H) 177 mm (7 in.) x (W) 426 mm (16.8 in.) x (L) 556 mm (21.9 in.)	22 kg; 48 lb	Optional applications available for vector signal analysis, pulse measurements, and real-time I/Q data streaming (3 hours at 255 MHz bandwidth)

BENCHTOP SPECTRUM ANALYZERS

Model	Spectrum Analyzer Type	Operating Freq. Range	Center Freq. and Span Options	Resolution Bandwidth	Detector	Min. Event Duration	SFDR
Narda Safety Test Solutions GmbH; Pfullingen, Germany; +49-7121-9732-0; www.narda-sts.com							
Narda Remote Analyzer NRA-3000 RX	Hybrid	9 kHz-3 GHz	Set with CF and span or with start and stop; CF: 9.5 kHz-3 GHz; span: 1 kHz-3 GHz	10Hz-20 MHz; zero span 100Hz-32 MHz	Act, max, avg, min, +peak, RMS, -peak	TP0I≤64 nsec @ zero span CBW=32 MHz	60 dB
Narda Remote Analyzer NRA-6000 RX	Hybrid	9 kHz-6 GHz	Set with CF and span or with start and stop; CF: 9.5 kHz-6 GHz; span: 1 kHz-6 GHz	10Hz-20 MHz; zero span 100Hz-32 MHz	Act, max, avg, min, +peak, RMS, -peak	TP0I≤64 nsec @ zero span CBW=32 MHz	60 dB
Rohde & Schwarz; Munich, Germany; +49 89 4129-0; www.rohde-schwarz.com							
R&S FSVA	Hybrid	10 Hz-40 GHz	CF: operating freq. range; span: 0 Hz, 10 Hz to full span	1 Hz-20 MHz, up to 40 MHz in 0 span, demodulation bandwidth 160 MHz	Sample, peak, RMS, avg., quasi-peak, RMS, CISPR avg (opt.)	*	-80 dBc
R&S FSW	Hybrid	2 Hz-90 GHz	CF: operating freq. range; span 0 Hz, 10 Hz to full span	1 Hz-10 MHz, 20/50/80 MHz optional RBW/VBW, demodulation bandwidth 2 GHz, realtime analysis BW 800 MHz	Sample, peak, RMS, avg., quasi-peak, RMS, CISPR avg (opt.)	0.46 μsec	-100 dBc
S2 Corporation; Bozeman, MT, USA; +1 406-922-0334; www.s2corporation.com							
S2 Spec-An, Extreme Bandwidth Analyzer and Correlator (EBAC)	Optical FFT, Hybrid	30 MHz -110 GHz	User configurable, up to 35 GHz IBW per channel, over any frequency (30 MHz – 110 GHz)	10 kHz-50 MHz	Power spectrum, peak detection, avg detection, max hold	No limit if energy is above the noisefloor at < -126 dBm/10 kHz.	> 62 dB SFDR, third-order intermodulation limited
Signal Hound; Battle Ground, WA, USA; +1 360-217-0112; www.signalhound.com							
SM200A	FFT	100 kHz-20 GHz	Any span	0.1Hz (<200kHz span) to 3MHz (any span) using 40 MHz IBW; 30 kHz to 10 MHz using 160 MHz IBW	Min, max, avg	12 μsec @ 300 kHz RBW	118 dB @ 1 Hz RBW

Trigger Types	Applications	Form Factor	Size	Weight	Features
Free run, single, multiple, time controlled	L-Band analyzer for satellite pointing and tracking, antenna peaking, and carrier monitoring; troubleshooting and wideband monitoring of TV / radio / telemetry carriers; managing wireless transmission systems, from radio to cellular (GSM / UMTS / LTE) and WiMAX	Rack mountable (1U)	482 x 45 x 362 mm; 19 x 1.75 x 14.3 in.	< 5 kg; 11 lb	Designed for radio reconnaissance and radio surveillance, signal demodulation and decoding, signal analysis and classification, COMINT and ELINT
Free run, single, multiple, time controlled	L-Band analyzer for satellite pointing and tracking, antenna peaking, and carrier monitoring; troubleshooting and wideband monitoring of TV / radio / telemetry carriers; managing wireless transmission systems, from radio to cellular (GSM / UMTS / LTE) and WiMAX	Rack mountable (1U)	483 x 45 x 362 mm; 19 x 1.75 x 14.3 in.	< 5 kg; 11 lb	Remote control of NRA into measurement environment via Ethernet; high speed measurement; fan-less design for silent, continuous operation
External, IF power, RF power, video	Phase noise, noise figure, AM/FM/PM modulation measurements, distortion analysis	Benchtop	7.7 x 16.2 x 16.4 in.	9.5-11.1 kg	Touch screen operation via block diagrams or standard hard- and soft-keys; signal analysis with up to 160 MHz bandwidth up to 40 GHz; emulation mode for many obsolete spectrum analyzers; removable SSD standard
External, IF power, RF power, video, frequency mask trigger (with realtime option)	Phase noise, noise figure, pulse measurements (time sidelobe), transient analysis (chirp & hopping), AM/FM/PM modulation measurements, multi carrier group delay, noise power ratio	Benchtop	9.4 x 18.1 x 19.8 in.	18-26.6 kg (FSW85)	Complete radar and radio analysis SW; multi-standard radio analyzer for analyzing signal interactions; real-time mode w/ persistence spectrum (2.3 M FFTs/s); gapless spectrogram and realtime IQ output
Continuous operation with active reporting.	EW, EMS Awareness, geolocation, radar processing, covert communications	Rack-mount	25 U rack, 14 U compressor	500 lb + HD storage and UPS	Geolocation via time-difference of arrival (TDoA) or direction finding (DF), event reporting, tipping/cueing, radar processing, covert communications
Video, external	Remote monitoring, EW, automated test, general benchtop analysis	Benchtop	10.2 x 7.2 x 2.15 in.	7.77 lb	20 MHz to 20 GHz sub-octave preselector, headless analyzer – connected to PC for spectrum display, open and flexible API

BENCHTOP SPECTRUM ANALYZERS

Model	Spectrum Analyzer Type	Operating Freq. Range	Center Freq. and Span Options	Resolution Bandwidth	Detector	Min. Event Duration	SFDR
Tektronix; Beaverton, Oregon, USA; +1 800-438-8165, www.tek.com							
RSA5100B	Real Time	1 Hz to 26.5 GHz	Real time Bandwidth 165 MHz	0.1 Hz-10 MHz	+Peak, -peak, avg (VRMS), sample, CISPR avg, CISPR peak, CISPR QPK, avg (of logs), CISPR avg (of logs)	434 nsec	80 dBc
RSA7100A	Real Time	16 kHz to 26.5 GHz	Real time Bandwidth 800 MHz	0.1 Hz-10 MHz	+Peak, -peak, avg (VRMS), sample, CISPR avg, CISPR Pk, CISPR QPK, avg (of logs), CISPR avg (of logs)	419 nsec	<-80 dBc to 3.6 GHz <-65 dBc to 26.5 GHz

Textron Systems Electronic Systems; Hunt Valley, MD, USA; +1 410-666-1400; www.textronsystems.com

SASI 240	Dual-channel FFT (Single channel variants also available)	AC Coupled Range 10 MHz – 40 GHz DC Coupled Range of DC to 20 MHz	Anywhere in range with up to 40 GHz span	1Hz-10MHz	Peak and avg	50 nsec	80 dB
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SURVEY KEY – SPECTRUM ANALYZERS

MODEL

Product name or model number

SPECTRUM ANALYZER TYPE

- FFT = fast Fourier transform

OPERATING FREQUENCY RANGE

Operating frequency or center frequency

CENTER FREQUENCY AND SPAN OPTIONS

The center frequency and span of the spectrum analyzer unit

- CF = center frequency

RESOLUTION BANDWIDTH (RBW)

Bandwidth of the filter (swept or digital) used for signal processing

DETECTOR

The technique used to determine the signal amplitude

- avg. = average
- CISPR = International Special Committee on Radio Interference
- EMI = electromagnetic interference
- RMS = root mean square (power averaging)
- VRMS = root mean square voltage

MIN. EVENT DURATION

Minimum event duration for 100% probability of intercept

- IBW = instantaneous bandwidth
- POI = probability of intercept

SFDR

Spurious Free Dynamic Range (SFDR)

TRIGGER TYPES

Options for starting measurement of a specific signal

Trigger Types	Applications	Form Factor	Size	Weight	Features
Power, frequency mask, frequency edge, DPX density, runt, time qualified	Advanced radar/EW design evaluation; environment evaluation, monitoring, and recording; wideband communications design; spectrum management	Benchtop/rack-mount	282 x 473 x 531 mm; 11.1 x 18.6 x 20.9 in.	29 kg; 64.7 lb	Real time analysis, streaming
Power, frequency mask, DPX density, time qualified	Wideband radar and pulsed RF signals; frequency agile communications; broadband satellite and microwave backhaul links; EMC/EMI pre-compliance and troubleshooting	Benchtop/rack-mount	445.5 x 177.1 x 577.9 mm; 17.54 x 6.79 x 22.75 in.	24.2 kg; 53.2 lb	Real time analysis, streaming
2 TTL Trigger Inputs 50Ω impedance BNC connector ; 8-Channel MLVDS Wire Interface Trigger Bus conforms to TIA/EIA-899 Molex 83614- 9016 Connector; Provisions for two programmable internal trigger sources	Multi-purpose combined spectrum analyzer, vector network analyzer, downconverter and oscilloscope for EW, radar, COMMS, SATCOM and automated test equipment	Benchtop or rack-mount	5 x 19 x 25 in.	37.5 lb	Compatible LXI RF sources also available for comprehensive test capability. Two LXI RF sources and one SASI 240 provide combined capability of two signal generators, dual downconverters, dual-channel spectrum analyzers, vector network analyzer, dual-channel oscilloscope

APPLICATIONS

Uses of the spectrum analyzer

- DF = direction finding
- EW = electronic warfare
- Rx = receiver
- SATCOM = satellite communications
- TSCM = technical surveillance countermeasures
- Tx = transmitter

FORM FACTOR

Suitable operating environments (lab or field) for the spectrum analyzer

SIZE

Length, width and depth in inches or millimeters.

WEIGHT

Unit weight in pounds or kilograms

OTHER ABBREVIATIONS

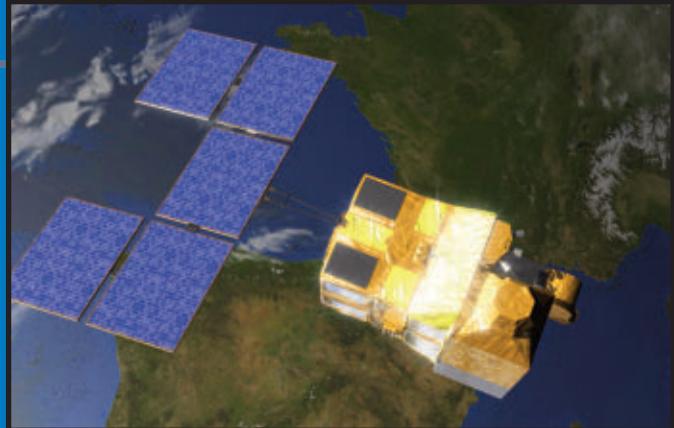
- BW = bandwidth
- freq. = frequency
- IF = intermediate frequency

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

MAY 2019 PRODUCT SURVEY: COUNTER-UAS SYSTEMS

This survey will cover counter-unmanned aerial systems that use electronic warfare (EW) technology. Please e-mail JEDEditor@naylor.com to request a survey questionnaire.

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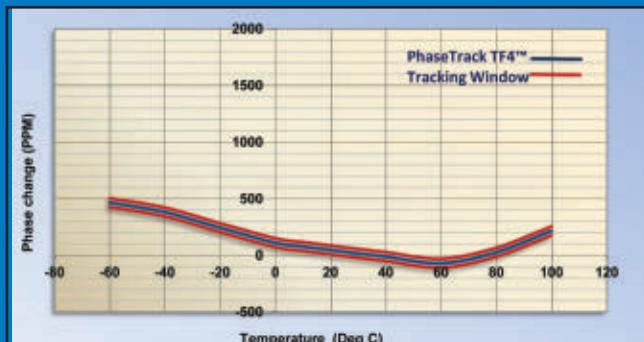


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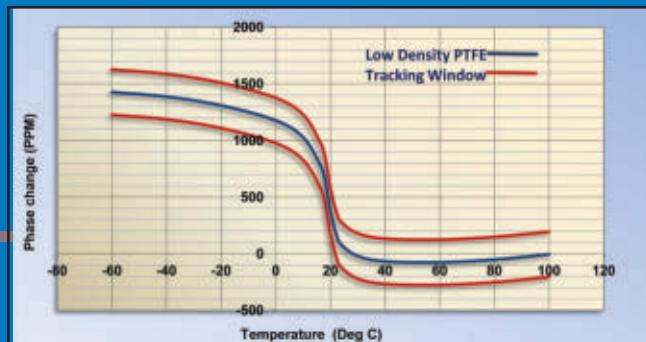
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New EA Techniques Part 2

Remote Jamming

By Dave Adamy

Last month, we talked about self-protection jamming. This month, we will cover remote jamming. This includes stand-off jamming, stand-in jamming, and a technique that can be called stand-on jamming, but our main emphasis will be on stand-off jamming, which has been greatly emphasized for several years, and has significant impact from the features of many new types of radars.

STAND-OFF JAMMING

The lethal range of a radar-controlled weapon is limited by the effective range of the associated target-tracking radar. As shown in **Figure 1**, the main beam of the radar's antenna is aimed at the target. The lethal range line shown in the figure is the effective range of the tracking radar. However, the radar being jammed can be any associated radar: the tracking radar, an acquisition radar or a fusing radar. The target is shown as a single aircraft, but it is typically a formation of attacking aircraft. In the figure, the target is shown as being within the lethal range of a radar-controlled weapon. The jammer is actually a special aircraft carrying a high-power jammer. These jamming aircraft usually carry externally mounted jamming pods which cause the jamming aircraft to have a very large radar cross section. This means that the jamming aircraft is easy for a radar-controlled weapon to attack. Also, these types of aircraft are low-density/high-demand assets. Thus, they are flown outside the lethal range of the weapons. In stand-off jamming calculations, the jamming aircraft is treated as though it holds a fixed position during the engagement. The related equations also treat the engagement as though

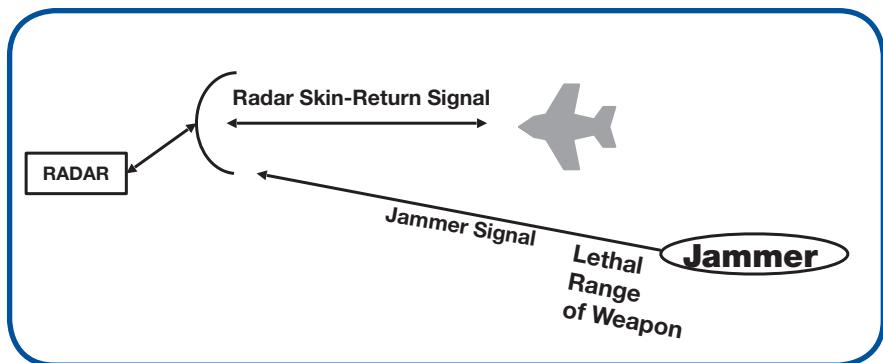


Figure 1: Stand-off jamming is performed from beyond the lethal range of the weapon associated with the jammed radar. The jamming is received in the side lobes of the radar's antenna.

a single target aircraft faces a single enemy radar and is protected by a single stand-off jammer.

JAMMING TECHNIQUES

Deceptive jamming techniques (which will be discussed in detail in a later column) require that the jammer "know" what is happening at the victim radar in the sub-microsecond time

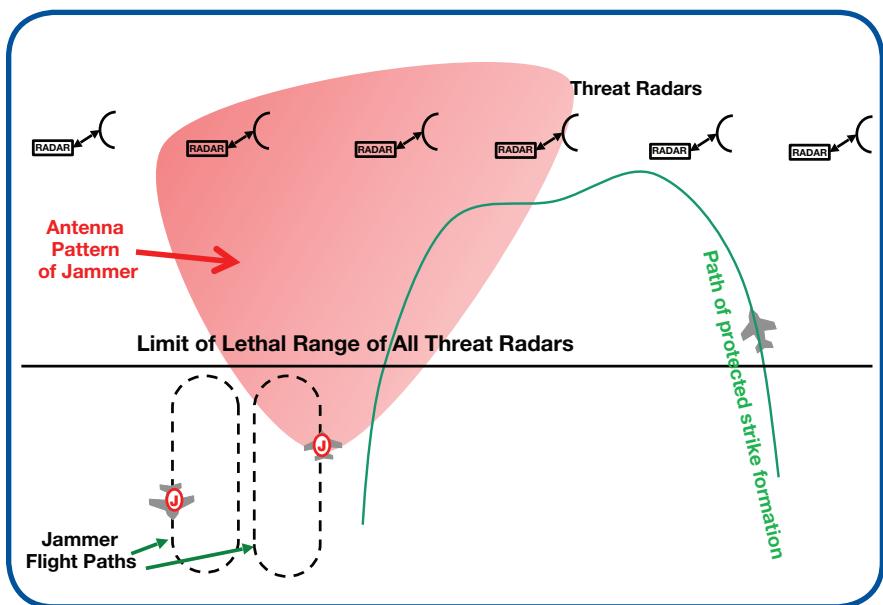


Figure 2: Stand-off jamming actually employs a pair of jamming aircraft flying race track patterns in a fixed location to protect one or more formations of aircraft which fly into the lethal zones of multiple threats.

frame. Since stand-off jamming is not performed from the target location, this is very challenging. (Much more about this and some controversy later.) Therefore, stand-off jamming is largely considered to be cover jamming and is most commonly frequency-modulated noise.

Figure 2 is a more realistic representation of the engagement. At the right of the figure, the attacking formation is shown following a flight plan that takes it into the lethal range of multiple weapons served by hostile radars.

There are two stand-off jamming aircraft that fight as a team. Each aircraft has multiple jamming pods, and flies a race track pattern toward and away from the enemy radars just outside the lethal range of the weapons present. In the planning of a mission, jamming aircraft pod-loads are selected based on the types of hostile radars expected to be encountered. For legacy systems, there are several types of pods, each covering a frequency range and providing specific jamming capabilities. Each pod has antennas fore and aft. Typical antennas cover about 20 degrees, 3 dB beam width, as shown in the figure. If the lethal range limit is 30 km from the threat radars, the jammer flight paths will be placed about that far from the hostile radars. This means that the jamming antennas cover about 33 km of cross-range threat dimension.

The two jamming aircraft fly in a small area, coordinating their turns to effectively provide continuous jamming coverage against the hostile radars. Because of the large threat area covered, the two jammers can protect multiple strike aircraft against multiple threat radars.

THE ENGAGEMENT

The hostile radar has its antenna boresight directed at the protected formation, and the jamming aircraft are in a different location, so the jammers cannot transmit into the jammed radar's boresight. The radar antenna has side lobes in all directions, but the side-lobe gain is significantly lower than the boresight gain, so the jamming power received by the jammed radar is reduced. The amount of jamming power required to break the lock of a tracking radar is 7 to 10 dB greater than the jamming power required to prevent the radar from acquiring lock on a target. Therefore, stand-off jammers are typically targeted against acquisition radars and modes.

STAND-OFF JAMMING EQUATIONS

The way we apply stand-off jamming equations is shown in **Figure 1** above. The pair of jammers is treated as a single jammer that is protecting a single target against a single radar. In reality, it

is necessary to determine the jamming effectiveness against each threat radar present, or set up the equation for a typical or worst-case threat. Remember that the boresight of the threat radar is aimed at the target aircraft, while the jamming aircraft is in a side lobe of the threat radar.

The formula for the jamming-to-signal ratio achieved in stand-off jamming is:

$$J/S = ERP_j - ERP_s + 71 + G_s - G_m - 20 \log R_j + 40 \log R_t - 10 \log RCS$$

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

ERP_j is the effective radiated power of the jammer in dBm,

ERP_s is the effective radiated power of the jammed RADAR in dBm,

G_s is the side lobe gain of the radar antenna in dB, G_m is the main lobe bore-sight gain of the radar antenna in dB,

R_j is the range from the radar to the jammer in km,

R_t is the range from the radar to the target in km, and

RCS is the radar cross section of the target in m^2 .

Note that the J/S produced in stand-off jamming increases with the ERP of the jammer and range from the radar to the target. It decreases with the radar ERP, the range to the jam-

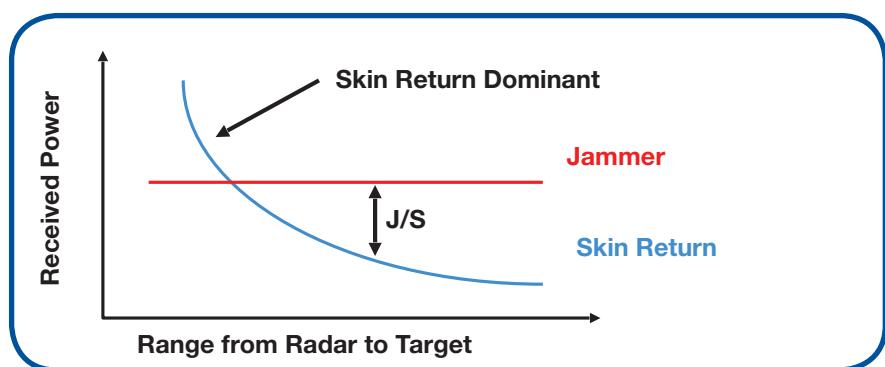


Figure 3: Because the stand-off jamming aircraft fly in a limited area throughout the engagement, the received jamming power is relatively constant. However, the received skin return varies as the fourth power of range to the target.

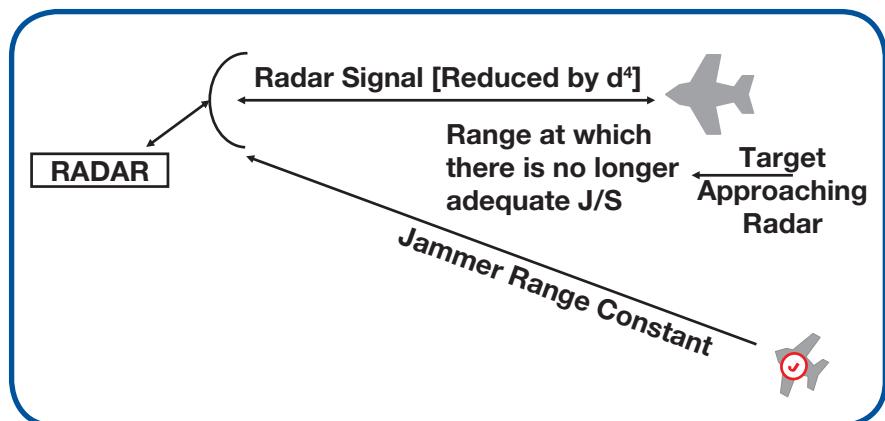


Figure 4: Burn-through for stand-off jamming occurs when the target is close enough to the jammed radar that the radar can re-acquire the target in the presence of the stand-off jamming. The jammer is treated as though it does not move during the engagement.

mer from the radar, the target RCS, and amount that the side lobe gain is down from the main lobe boresight gain of the radar antenna.

STAND-OFF BURN-THROUGH

Figure 3 compares the received power in the threat radar as a function of range from the target aircraft. Since the range from the stand-off jammer to the radar is assumed to remain constant through the engagement, the burn-through range is defined in terms of the distance from the radar to the target. Note that the blue curve in the figure (received skin return power) reduces as a function of the 4th power of range from the radar to the target while the red line (received jammer power) remains constant. As the range to the target decreases, the J/S reduces. At the range where the radar can re-acquire its target in the presence jamming, the radar is said to "burn through" the jamming. For mission planning, it is common practice to determine the minimum acceptable J/S to protect the target and predict the burn through range (from radar to target) at which this minimum J/S is achieved.

Figure 4 shows the burn-through geometry which is the basis for the burn-through formula. The formula for the *range to the target term* (at burn-through) is:

$$40 \log R_{BT} = ERP_s - ERP_j - 71 - G_s + G_m + 20 \log R_j + 10 \log RCS + J/S \text{ Req}$$

Where: R_{BT} is the range from the radar to the target in at burn-through in km and
 $J/S \text{ Req}$ is the minimum required J/S value at which the jammer can effectively jam the radar.

The formula for the burn through *range* solves the *range term* for the actual range:

$$R_{BT} = \text{Anti-log} \{ [40 \log R_{BT}] / 40 \}$$

Like in the self-protection jamming case last month, this formula looks strange because we use the *value* of the **40 log R_{BT}** term.

WHAT'S NEXT

Next month, we will continue our discussion of jamming techniques and the associated formulas for legacy radars. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com. 



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KEYNOTE SPEAKER

**Brig Gen Hersey,
Commandant Cyber School
- Fort Gordon**

BANQUET SPEAKER

**Lt Gen Bradley Heithold,
USAF (ret)**

6TH ANNUAL THE CROW'S

N.E.S.T. (Novel Experiments with Science & Technology)

The Dixie Crow Chapter of the Association of Old Crows Science, Technology, Engineering, and Mathematics (STEM) Robotics displays and technology demonstrations, are an interactive experience that will capture the minds and hearts of students, parents and teachers. The displays are a collaborative effort between local military, government civil service, academia, defense industry and volunteers designed to inspire students to pursue STEM careers. Interacting with the robotics displays and technology demonstrations will demonstrate to students that STEM can be both fun and engaging. Enthusiastic workers in STEM fields will also be on hand to answer questions and help students learn how they can prepare to enter the exciting world of STEM. Make time to visit and participate in our Crows N.E.S.T. displays and technology demonstrations.



WEDNESDAY, MARCH 27 // 10:00 A.M. - 2:00 P.M.
// MUSEUM OF AVIATION CENTURY OF FLIGHT HANGAR

We are looking for Academia, Industry, Government/Military and other Organizations to display their creative robotic talents and/or interactive technological products!!!

We look forward to your participation in this fantastic opportunity to interface with our STEM Leaders of tomorrow!

If you have any questions and/or would like to participate, please feel free to contact:

Robert Usher at Robert.Usher@us.af.mil (478) 222-0022
Event open to Students age 8 and up.

PREPARE TO BE AMAZED!

SCHEDULE OF EVENTS

SUNDAY, MARCH 24

Registration	Marriott Courtyard, Warner Robins, Georgia	5:00 PM-8:00 PM
Hospitality Suite	Marriott Courtyard, Warner Robins, Georgia	5:00 PM-8:00 PM

MONDAY, MARCH 25

Registration	Landings Golf Club	10:00 AM-2:00 PM
Spring Golf Tourney	Landings Golf Club	12:00 PM-5:00 PM
Registration	Century of Flight Hangar, Museum of Aviation	2:30 PM-5:00 PM
Sports Banquet and BBQ Dinner	Landings Golf Club	5:00 PM-7:00 PM

TUESDAY, MARCH 26

Registration	Century of Flight Hangar, Museum of Aviation	7:00 AM-6:00 PM
Plenary Session	Scott Theater, Eagle Building, Museum of Aviation	8:00 AM-11:00 AM
Exhibits Open	Century of Flight Hangar, Museum of Aviation	11:00 AM-7:00 PM
Chapter President's Mtg	Century of Flight Hangar, Museum of Aviation	11:30 AM-1:00 PM
Exhibitor Reception	Century of Flight Hangar, Museum of Aviation	5:00 PM-7:00 PM

WEDNESDAY, MARCH 27

Registration	Century of Flight Hangar, Museum of Aviation	7:00 AM-2:00 PM
Exhibits Open	Century of Flight Hangar, Museum of Aviation	10:00 AM-3:00 PM
Crows N.E.S.T.	Century of Flight Hangar, Museum of Aviation	10:00 AM-2:00 PM
Banquet	Nugteren Exhibit Hangar One	Cocktails – 5:30 PM-6:30 PM Dinner – 6:30 PM-8:30 PM

WELCOME TO DIXIE CROW SYMPOSIUM 44!

Our Symposium Committee, Dixie Crow Chapter President, Matthew Bryant, and the Chapter Directors cordially invite you to join us for all the exciting events described here. Thank you in advance for your support of this important electronic warfare/information operations trade show.

Sincerely, Karen Brigance, *Co-Chair* | kkbbrigance@gmail.com
Lisa Frugè-Cirilli, *Co-Chair* | lisa.fruge@baesystems.com

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Technical Courses are being solely sponsored by AFLCMC/WNY, Robins AFB

2019 INDUSTRY & INSTITUTE/UNIVERSITY MEMBER GUIDE

Guide listings were updated based on changes received from companies during the month of January 2019. Please send any listing changes to Elaine Richardson, Managing Editor, elaine@naylor.com.

SUSTAINING MEMBERS

B

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www.boeing.com/boeing/bds
President and CEO, Defense, Space & Security: Leanne Caret
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C

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www.chemring.co.uk
Group Chief Executive: Michael Flowers
Chemring North America President:
Tank Williams
AOC contact: Ginny Wood, Head of Group Marketing

Chemring Group is the largest producer of IR expendable countermeasure decoy/ flares. Operating through its three key companies – Alloy Surfaces Inc. (US), Chemring Countermeasures (UK), and Kilgore Flares (US) – Chemring provides a full range of IR decoy/ flares to all the US armed forces, NATO and non-NATO countries. Chemring Group companies are key providers in leading advanced IR expendable countermeasure programs.

Alloy Surfaces produces special material decoys (SMDs) that are compatible with most available dispenser systems and are used by all US armed services. These advanced, spectrally matched decoys can be used in both preemptive and reactive mode, providing a significant capability for aircraft to operate at all altitudes against the most advanced IR missiles.

Chemring Countermeasures is the UK design authority for IR decoys and chaff payloads. The company provides an extensive range of spectral and MTV decoys and payloads for most types of air platforms, naval ships and land vehicles.

Kilgore Flares is the largest US producer of a wide range of airborne IR flares that are compatible with most available dispenser systems. Kilgore leads the MTV decoy mass production industry with its state-of-the-art and fully automated plant. They also have a range of shipboard countermeasures, including RF, IR and acoustic types.

E

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Harris Corporation is a leading technology innovator, solving customers' toughest, mission-critical challenges by providing solutions that connect, inform and protect. Harris supports government and commercial customers in more than 100 countries and has approximately \$6 billion in annual revenue. The company is organized into three business segments: communication systems, space and intelligence systems, and electronic systems. Learn more at www.harris.com.

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Keysight Technologies is a global technology leader, delivering critical tools and technologies that sense, measure and interpret the physical and radio frequency world. The company's innovative solutions enable a wide range of aerospace and defense customers to make technological advancements that drive productivity and improve the way the military operates in the electromagnetic spectrum and the cyber domain.

Keysight designs and builds leading edge software and hardware measurement solutions for next-generation radar test and electronic warfare (EW) test, military communications, satellites, signal intelligence (SIGINT), avionics, guidance, navigation, GPS and operational test. Keysight's solutions are used across the armed forces for sea, ground, air, space and cyber applications.

L

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Systems include: SEWIP Blk 2 AN/SLQ-32V6, AOEW ALQ-248, BLQ-10, Symphony, APR-48B, APR-52, ALQ-210, ALQ-217, GSTAR, and CHALS.

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R

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S

SAAB

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INSTITUTES/ UNIVERSITIES

E

ELECTRONIC WARFARE STUDYING GROUP, KOREAN INSTITUTE OF ELECTROMAGNETIC ENGINEERING & SCIENCE

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G

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The Georgia Tech Research Institute (GTRI) is nationally renowned in Electronic Warfare. As the applied R&D arm of Georgia Tech, GTRI has been nationally recognized for more than 35 years as experts in the analysis, design and development of effectiveness analysis and threat simulation systems. It was also more than 30 years ago that the Peachtree Roost was formed by members of GTRI. Today, our excellence continues not only in the EA technique development, modeling and analysis areas but in modernization of radar warning receivers, jamming systems and test systems. GTRI has participated in the development of future integrated electronic warfare systems and is working in the next-generation systems of systems, or net-centric warfare. Because GTRI is not a manufacturer, its researchers can provide government and industry unbiased, independent technique effectiveness

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M

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Senior Director of Engineering and Programs

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A

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Alaris Antennas, with its head office in Centurion, designs, manufactures and



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 MODEL 870	<p>670-850 MHz 40 kW 0.2% Duty 0.5-1.0 uS 0-5 kHz</p>	 MODEL 176S	<p>2.0-3.0 GHz 1.25-1.8 kW 6% Duty 0.07-100 uS 0-400 kHz</p>
 MODEL 1051X	<p>8.5-9.6 GHz 160 kW 0.154% Duty 0.2-0.7 uS 0-4 kHz</p>	 MODEL 176SC	<p>3.6-6.5 GHz 1.7 kW 6% Duty 0.07-100 uS 0-400 kHz</p>
 MODEL 174L	<p>1.0-1.1 GHz 2 kW 0.32% Duty 0.07-1.0 uS 0-5 kHz</p>	 MODEL 176CX	<p>6.5-10.0 GHz 1.1-1.4 kW 6% Duty 0.07-100 uS 0-400 kHz</p>
 MODEL 1051X	<p>7.6-8.5 GHz 185 kW 0.13% Duty 0.3-0.6 uS 0-2143 Hz</p>	 MODEL 176X/Ku	<p>10.0-18.0 GHz 1.6-2.0 kW 6% Duty 0.07-100 uS 0-400 kHz</p>
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2019 AOC INDUSTRY MEMBER GUIDE

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for complex receivers, beamformers for satellite communications antennae, and switch matrices for redundancy and signal routing.

ANNAPOLIS MICRO SYSTEMS, INC.

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ASELSAN is a defense electronics company established in 1975 that designs, develops, manufactures, integrates and supports state-of-the-art system solutions and is composed of five major business sectors:

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CDM Electronics specializes in the distribution of interconnect products and contract manufacturing services.

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Darkblade Systems Corporation is a Service-Disabled Veteran-Owned Small Business (SDVOSB) providing scientific, engineering, technical, operational support, and training services to Federal government and Commercial clients. Engineering specialties include development and design services for hardware and software systems fulfilling the mission needs of the Department of Defense and Intelligence Communities. Operational and Cyber services include full spectrum project and program support, including planning, training, management, and technical evaluation.

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E

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ELDES was founded in 1993 to provide solutions for radar systems and radar simulators. In the Defence market we are world leader of HWIL radar simulators for EW systems evaluation. The E-PRS generic radar simulator is flanked by the E-PSS Poseidon anti-ship missile simulator.

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Epiq Solutions designs and builds state-of-the-art small form factor wireless systems for both commercial and government applications. With a broad portfolio of flexible RF cards, radio platforms and signal processing IP, Epiq can bring radio solutions to market to meet the rapidly changing requirements of our customers. Typical applications include cellular survey, RF platforms, sensors, security products and RF analytics, as well as real-time processing and decoding of Layers 1, 2 and 3 for numerous wireless radio standards (including 2G/3G/4G cellular). For more information regarding Epiq Solutions' products and services, please visit <http://www.epiqsolutions.com>.

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Jeff Edgar is a business development professional specializing in Electronic Warfare. He served in the Navy for 22 years as a cryptologist and EW professional, and then spent 16 years in industry as a BD leader. Throughout, he has been deeply involved with surface and submarine cryptologic and EW systems. Jeff has also had significant proposal writing / color team experience as well.

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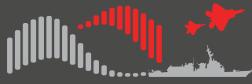
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Modern Technology Solutions, Inc. (MTSI) is a 100 percent employee-owned engineering services and technology solutions company delivering first-choice capabilities to solve problems of global importance in the critical mission areas of missile defense, cyber security, intelligence, unmanned/autonomous systems, aviation, space and homeland security. MTSI's mission is to make important and lasting contributions to the nation's defense and security by providing leadership and best-value solutions to solve America's most technically challenging strategic problems. Founded in 1993, MTSI today has over 800 employees, based at over 20 offices and field sites worldwide.

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MyDefence System Integration is a new innovative company, founded 2017, engaged in development of new smart small form factor mission systems and network communication

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N

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Planar Monolithics Industries, Inc. has been in business for over 30 years as a manufacturer of electronic components for defense applications. Since its founding in November 1989 by Dr. Ash (Ashok) Gorwara, Planar Monolithics Industries,

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RADX is a small business developer of the LibertyGT Family of COTS, real-time, scalable, modular, cost-effective software and integrated system solutions for advanced RF Test & Measurement (T&M). RADX also develops the FrontierEQ Family of reference technology and software for OEM SDR/CR applications. RADX is a Silver NI Alliance Member with expertise in real-time FPGA, CPU and GPU-based DSP implementations. Based on COTS PXIE, PCIe and SDR-based COTS, RADX LibertyGT and FrontierEQ COTS Solutions are employed by U.S. DoD, contractors and commercial companies for a wide range of mission-critical RF T&M and SDR/CR applications, including real-time spectrum analysis, multi-channel synchronized, spectrum recording, playback and channel emulation, and advanced, real-time radio T&M and wideband, adaptive SDR/CR systems. For Aerospace, Defence and Educational Customers, RADX products and solution are primarily distributed via TEVET, LLC (sales@tevetllc.com).

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Headquartered in Fredericksburg, VA with satellite offices in Washington, D.C.; Dahlgren, VA; Quantico, VA; Virginia Beach, VA; San Diego, CA; and Tampa FL, SimVentions performs Systems Engineering, Software Engineering, Cybersecurity, and Modeling & Simulation solutions for the Department of Defense. Experience spans these disciplines beginning with the engineering of capabilities to meet customer needs, prototyping solutions, and ultimately designing, developing and deploying Cyber secure solutions to meet the need. SimVentions is a major provider of Surface Electronic Warfare solutions to the Navy's Program Executive Office for Integrated Warfare Systems (PEO IWS) and for the Naval Surface Warfare Center Dahlgren Division (NSWCDD).

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SMAG is worldwide the only manufacturer of Mobile Antenna Masts up to a height of 40m without using any kind of guy wires. The antenna masts have been manufactured in Salzgitter/Germany since as early as 1974 and more than 1900 masts are worldwide in operation for disaster relief and military operations, for communication, observation and surveillance missions.

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Spherea GmbH is the German subsidiary of Spherea Group with headquarters in Toulouse and sites in Ferndown, Paris and Ulm. Spherea Group is the leading company in Europe for the development of electronic test systems in defense and civilian domain with an annual turnover of over EUR 100 million with 500 employees. In Ulm, we are specialized in providing AGE (Aerospace Ground Equipment) and shop level tester for electronic warfare suites (e.g. NH90, TIGER, A400M, TORNADO) or subequipment (sensors, counter measures, jammers); therefore, our customers are the national MODs as well as agencies like.

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Syntonic Microwave specializes in wideband microwave tuners ranging up to 40 GHz. We offer upconverters, downconverters, up/down converters and block converters. Configurations include stand alone and multi-channel, phase coherent implementations. Rack mount and ruggedized packaging is for all products, supporting a wide range of usage models and service conditions.

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SPEC's current product lines include Advanced Dynamic Engagement Processor (ADEP), Coherent Target Generator, Digital RF Memory (DRFM) devices, range based RADAR scene generation systems, miniaturized LADAR and LIDAR sensor systems, and space/missile countermeasure and pen-aid products.

T**TCI INTERNATIONAL INC.**

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TCI's diverse experience delivers proven solutions for regulatory compliance, monitoring and security, and communications intelligence applications. With advanced spectrum mapping and analytics, data recording capabilities and precision geolocation technology, TCI systems provide vital data for government and military agencies in over 100 countries worldwide. TCI is also a recognized leader in the design and manufacture of antennas for communications and high-power radio broadcasting. TCI is a wholly owned subsidiary of SPX Corporation. TCI products include: 9091 High Performance HF DF; 802C HF COMINT DF; 803E V/U/SHF COMINT DF; 8903S Man-Portable COMINT DF; Blackbird NextGen H/V/U/SHF Integrated SIGINT and Geolocation.

TECH RESOURCES, INC.



48th Annual Collaborative EW Symposium

2-4 APRIL 2019



Pt. Mugu, CA

THEME : Collaboration and Collaborative EW

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

TOPICS :

1. Coherent Electronic Attack:

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

2. Cooperative Electronic Attack:

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

3. Collaborative Electronic Attack:

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

4. Collaborative EW enablers to improve EA effectiveness:

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

5. Warfighter Perspective

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KEYNOTE SPEAKERS



Rear Admiral Steve Parode – Director, Warfare Integration Directorate, N2/N6F, Office of the Chief of Naval Operations



Captain Jeff Chism – Commanding Officer, Naval Base Ventura County (NBVC)

Security Clearance due March 8

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The Association of Old Crows (AOC) and the Georgia Tech Research Institute (GTRI) look forward to hosting International and U.S. attendees at the 2019 Security Cooperation Symposium at the GTRI Conference Center in Atlanta, Georgia, April 29 – May 1, 2019. This world-class symposium will serve as a platform for information exchange and education on defense technology interoperability (EW, Datalinks, Communications, Command and Control (C2), Navigation, and Avionics systems) and associated U.S. FMS and Export Control policies and processes.

Attendees will include U.S. Government (DOD, Commerce, and State Department), U.S. Military (Air Force, Army, Navy, & Marines), International Defense/Government civilians, International Military, U.S. and International Defense Industry, AOC Members, and Academia.

KEYNOTE AND DISTINGUISHED SPEAKERS



Rear Admiral Francis D. Morley, USN, Director, Navy International Programs Office (IPO), Washington Navy Yard (invited)



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The Science, Technology, Engineering and Mathematics (STEM), exhibit at the 2018 National AOC Symposium focused on informing high school students about STEM benefits as well as providing them with insights into STEM-related careers and educational opportunities.

The exhibit has seen increases in participation from local schools, industry partners, and academia over the past three years. Over 1,000 students participated this year compared to 500 student participants last year. The composition of the students also diversified, which was reflected in a 50 percent increase in participation of students from home, charter and alternative schools as a result of raising our outreach to 20 schools, up from 12 schools at previous exhibits. We anticipate that 2019 participation will continue this trend.

Your AOC staff and Board of Directors worked diligently to engage industry, and increased the number of interactive dis-

plays by 50 percent, as well. These displays represent industry partners who volunteer their time and resources to aid the AOC's effort to inform and encourage young adults to get involved in STEM.

Academic recruiters from seven universities actively discussed educational opportunities and provided students with insight into university culture and future benefits. Hearing first-hand about STEM benefits from current college students will encourage our high school participants to continue their education and stay engaged with STEM. If you think your alma mater is a good candidate to add as a participant, please contact the AOC STEM Committee, comprising members of the AOC Board of Governors (Gary "Mongo" Lyke and Brian Hinkley), and Blain Bekle blain@crows.org.

Donations and volunteer applications are open for 2018. Please submit online, or contact blain@crows.org for any questions.



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Each year, the membership of the AOC determines the future of this organization by electing representatives to the Board of Directors. Nominations will be accepted between January 2 and March 15, and elections will be from June 1-30. Current AOC members are able to be nominated for the following positions: President-Elect, At Large Director (2), Regional Director (International Region 1 & Pacific Region).

Learn more about 2019 nominations at www.crows.org/page/elections.

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JED, The Journal of Electronic Defense (ISSN 0192-429X), is published monthly by Naylor, LLC, for the Association of Old Crows, 1555 King St., Suite 500, Alexandria, VA 22314.

Periodicals postage paid at Alexandria, VA, and additional mailing offices. Subscriptions: *JED, The Journal of Electronic Defense*, is sent to AOC members and subscribers only. Subscription rates for paid subscribers are \$160 per year in the US, \$240 per year elsewhere; single copies and back issues (if available) \$12 each in the US; \$25 elsewhere.

POSTMASTER:

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