DECEMBER 2019
Vol. 42, No. 12

ASSOCIATION OF OLD CROWS

# JED

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*The Journal of Electronic Defense*

# 2020 EW/SIGINT Resource Guide

**Also in this issue:**

**Technology Survey: Radar ESM and ELINT Receivers**

**EW 101: Radar Threats and Impact of Leading Edge Tracking**

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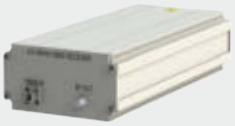

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*Secretary of the Navy Richard V. Spencer receives an overview of AN/SLQ-32(V)6 electronic warfare system training during a familiarization brief and tour of the Center for Information Warfare Training and Information Warfare Training Command Corry Station onboard Naval Air Station Pensacola Corry Station, Florida.*

US NAVY PHOTO BY GLENN SIRCY



## News

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**World Report** 20
Canada Develops NOMAD USV-Based Active Offboard Decoy

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**Technology Survey: ESM and ELINT Receivers** 23
*By Barry Manz*
Electronic support measures (ESM) and electronic intelligence (ELINT) receivers must contend with a variety of radars. From legacy systems that are constantly undergoing upgrades to advanced radars that are designed to be difficult to detect and track. This month, *JED* looks at the offerings from more than 20 companies.

COVER PHOTO COURTESY OF US ARMY

**2020 EW/SIGINT Resource Guide** 31
*By* JED *Staff*
The 2020 EW and SIGINT Resource Guide is your reference to electronic warfare (EW) and signals intelligence (SIGINT) companies and the products and services they provide.

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the view
from here

# FLIPPING THE GRAY ZONE

At the 56th AOC International Symposium in October, The Ukrainian Armed Forces top electronic warfare (EW) planner delivered some excellent insights about the electromagnetic contest between Ukrainian Forces and Russian-backed separatists in Ukraine's eastern Donbass region. In his presentation, "Application of Electronic Warfare on the East of Ukraine," Col Ivan Pavlenko, Deputy Chief of Combat Support Units, Joint Forces HQ, Joint Staff Armed Forces of Ukraine, discussed the EW activities of Russian and Ukrainian Forces during the past five years of the fighting in Ukraine's Donbass region.

Russian EW capabilities were essential to the initial success of their Donbass operations. Russia was able to use its EW and SIGINT advantage to support attacks against Ukrainian forces without using a level of force that might trigger a conventional response from NATO. One Russian method was to use UAVs fitted with ELINT payloads to geolocate Ukrainian anti-artillery firefinder radars. A separate UAV, fitted with an electro-optical payload would precisely locate and identify the firefinder radar position. Finally, Russian long-range artillery would attack the radar. Another type of Russian attack was to use UAVs equipped with time-delayed incendiary grenades to attack Ukrainian weapons depots. In addition, Russia was very good at using EW to take down UAVs. From 2015 to 2017, Ukrainian Forces lost approximately 100 UAVs, mostly to Russian GPS spoofing.

Colonel Pavlenko explained that after 2014-2015, the electromagnetic contest with Russian forces gradually began to change. As the Ukrainian Forces began to step up their EW capabilities, Russia began to reduce its EW personnel and equipment. For the past few years, Ukrainian Forces have become more adept at detecting, tracking and jamming Russian UAVs. Colonel Pavlenko said that so far in 2019, Russian UAVs have not crossed the line of separation. As Russia withdrew some of its EW forces, it scaled down its ground-based communications jamming operations, which used to penetrate up to 20 miles beyond the line of conflict. Ukraine's government has also been able to jam Russian propaganda broadcasts aimed at the civilian population well beyond the conflict area in eastern Ukraine.

While Colonel Pavlenko was careful to say that he does not know for certain why the Russian Forces have scaled back their EW activities in recent years, I think it's important to point out the correlation between the rise of Ukrainian EW proficiency and the restriction this has imposed on Russian activity, especially with regard to reconnaissance and strike missions that depend on UAVs. Russia is extremely adept at Gray Zone operations, and it understands the importance of the electromagnetic contest within that operational concept. It's certainly possible that Ukraine's EW operations have helped to "flip" the Gray Zone against Russia, at least to the point where it is Russia that would have to escalate the conflict in order to achieve its objectives. This is not to say that Russia cannot ratchet up its EW activity in the Donbass whenever it chooses. But it would be an escalation that Russia would have to carefully weigh. – *J. Knowles*



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## DECEMBER

**Expodefensa 2019**
December 2-4
Bogota, Colombia
www.expodefensa.com.co

**I/ITSEC**
December 2-6
Orlando, FL
www.iitsec.org

## JANUARY

**Surface Navy Association 32nd Annual National Symposium**
January 14-16
Arlington, VA
www.navysna.org

**Directed Energy Test and Evaluation Conference**
January 27-30
Albuquerque, NM
www.deps.org



## FEBRUARY

**AOC EW Asia**
February 4-5
Singapore
www.crows.org

**Defexpo 2018**
February 5-8
Lucknow, Uttar Pradesh, India
defexpoindia.in

**Singapore Airshow**
February 6-11
Singapore
www.singaporeairshow.com

**6th International Conference on EW – EWCI 2018**
February 18-20
Bangalore, India
www.aoc-india.org

**EW Releasability and Export Control Workshop**
February 24-25
Washington, DC
www.crows.org

**AFA Air Warfare Symposium**
February 26-28
Orlando, FL
www.afa.org

## MARCH

**AFCEA West Conference and Exhibition**
March 2-3
San Diego, CA
www.westconference.org

**Annual Directed Energy Science and Technology Symposium**
March 9-13
Destin, FL
www.deps.org

**DIMDEX 2018**
March 16-18
Doha, Qatar
www.dimdex.com

**AUSA Global Force Symposium and Exposition**
March 17-19
Huntsville, AL
www.ausa.org

**Dixie Crow Symposium 45**
March 23-26
Robins AFB, GA
www.dixiecrowsymposium.com

**49th Annual Collaborative Electronic Warfare Symposium**
March 31 – April 2
Point Mugu, CA
www.crows.org

**FIDAE 2020**
March 31 – April 5
Santiago, Chile
http://www.fidae.cl/en

*AOC conferences are noted in red. For more info or to register, visit www.crows.org. Items in blue denote AOC Chapter events.*

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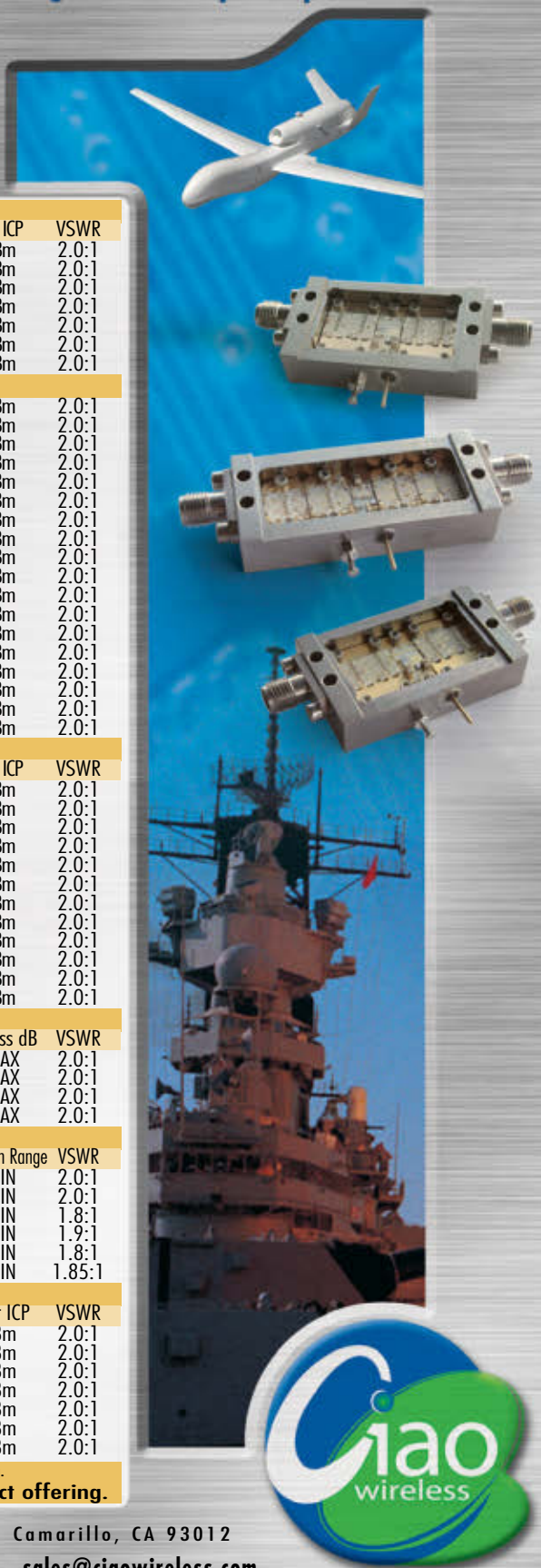

### OCTAVE BAND LOW NOISE AMPLIFIERS

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

### NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

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

### ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

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

### LIMITING AMPLIFIERS

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

### AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

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

### LOW FREQUENCY AMPLIFIERS

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

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## JANUARY

**AOC Virtual Series Webinar: Electronic Warfare Modeling and Simulation**
January 16
1400-1500 EST
www.crows.org

**Fundamentals of Radar Signal Processing**
January 27-30
Atlanta, GA
www.pe.gatech.edu

**AOC Virtual Series Webinar: Infrared Countermeasures: A Heated Topic**
January 30
1400-1500 EST
www.crows.org

## FEBRUARY

**Radar Electronic Warfare**
February 3-7
Swindon, UK
www.cranfield.ac.uk



**AOC Live Professional Development Web Course: 21st Century Electronic Warfare, Systems, Technology and Techniques**
February 3-21
8 sessions, 1300-1700 EST
www.crows.org

**Communications Electronic Warfare**
February 10-14
Swindon, UK
www.cranfield.ac.uk

**Basic RF Electronic Warfare Concepts**
February 11-13
Atlanta, GA
www.pe.gatech.edu

**Modeling and Simulation of Phased Array Antennas**
February 11-13
Atlanta, GA
www.pe.gatech.edu

**AOC Virtual Series Webinar: Electronic Warfare in the New Threat Environment**
February 13
1400-1500 EST
www.crows.org

**Advanced Radar**
February 24-28
Swindon, UK
www.cranfield.ac.uk

**Advanced RF Electronic Warfare Principles**
February 24-28
Atlanta, GA
www.pe.gatech.edu

**Principles of Millimeter-Wave EW**
February 26-27
Atlanta, GA
www.pe.gatech.edu

## MARCH

**AOC Live Professional Development Web Course: EW Modeling and Simulation**
March 2-25
8 sessions, 1300-1600 EST
www.crows.org

**Aircraft Survivability**
March 9-13
Swindon, UK
www.cranfield.ac.uk

**AOC Virtual Series Webinar: RF Challenges in the Modern EW Battlespace**
March 12
1400-1500 EST
www.crows.org

**AOC Virtual Series Webinar: How the West Is Losing the Navigation and Timing War – and Risking Everything**
March 26
1400-1500 EST
www.crows.org

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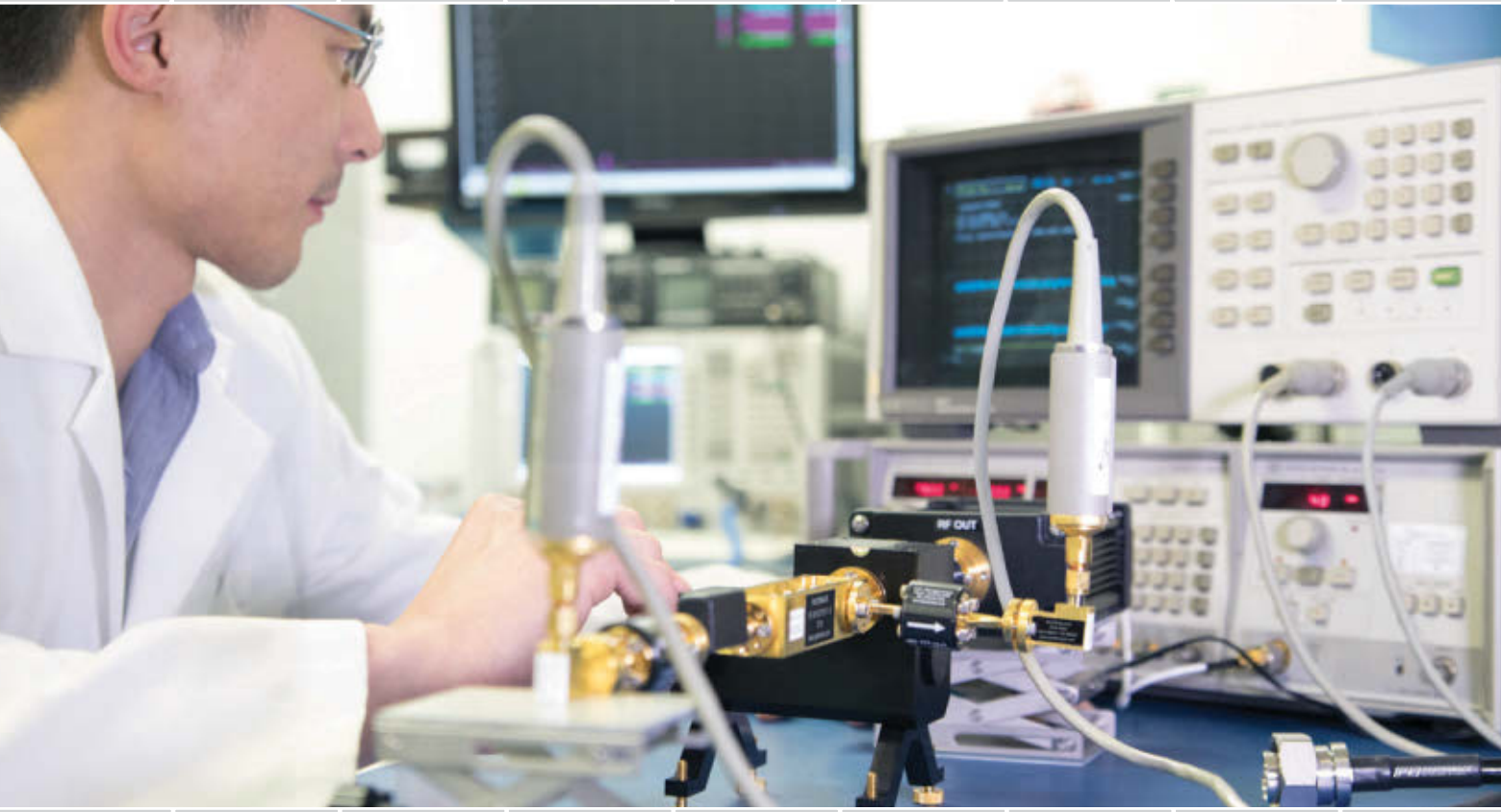

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# LEVERAGING DIRECTED ENERGY

The 56th Annual AOC International Symposium and Convention was a great event, and I just wanted to take a moment to thank and recognize our AOC Staff Members, Symposium Chair, Board of Directors, all of the AOC Chapters, and the volunteers who gave their time and effort to make the symposium and our STEM program a success.

During the Symposium, the breakout session on Directed Energy (DE) was very well attended, and I would like to expand on this topic. As we have seen over the past few years, the threat from weaponized drones, unmanned air systems, advanced missile systems and hypersonic weapons continues to increase in capability and capacity. In response, we must focus our efforts and resources on DE development, testing, acquisition and deployment. DE technologies – high-energy lasers, high-power microwave weapons, and electromagnetic pulse-based capabilities – are emerging, prototypes are being deployed, and we will be evaluating the operational impact of these systems. But in parallel we must be working the issues of integration with sensors and kinetic weapons to include compatibility, interoperability, deconfliction, doctrine and rules of engagement. Modeling and simulation and Electromagnetic Battle Management (EMBM) tools/capabilities will need to be adapted or developed; training facilities and ranges will need to be expanded or developed; and warfighting specialties will need to be recognized, defined, and assigned. My point: are we thinking about DE from an enterprise approach (the theme of our 2019 Symposium)? As DE technology emerges and is deployed in scale, will we be ready to fully leverage the advantages DE offers?

If we are ready, the added capability DE will provide to the warfighter will be revolutionary – multi-domain speed-of-light engagement, deep magazines (1,000s of pulses), SWARM defeat and multi-functionality. The 2018 CSBA Air and Missile Defense at a Cross Roads report, authored by Carl Rehberg and Mark Gunzinger, focused on "New Concepts and Technologies to Defend America's Overseas Bases." A significant take-away was the analysis of a Patriot-only air base defense approach – 56 engagements and $274 million. With DE and other alternative weapons integrated into the mix, this increases to 214 engagements while the cost drops to $77.6 million. As this example shows, integration of DE into our warfighting capabilities will significantly increase capacity while reducing cost, enabling our ability to impose a cost imbalance on our adversaries and providing a counter to the weapons-capacity imbalance. Another point worth noting is that DE is a form of electronic attack, and it must be part of our arsenal if we are striving to dominate in the electromagnetic environment.

In closing, 2019 has been a good year for the AOC, we have made a difference in shaping the conversation on the EMS as a critical operational Domain and the fact that we must organize, train, and equip our EMS forces in order to achieve Control within the EMS Domain. I would like to thank each of you for your support and contribution to this effort. Have a great holiday season, and I'm looking forward to 2020. – *Muddy Watters*

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# EW Releasability and Export Control Workshop

ASSOCIATION OF OLD CROWS

24-25 FEBRUARY 2020 Washington, DC

## REGISTRATION OPENS DECEMBER 3, 2019

## THEME:

**Outlining Approval Paths and Best Practices to Export EW Technology.**

This forum provides a venue for stakeholders, thought-leaders and experts in Releasability, Export Control and Electronic Warfare to come together to focus on the USG processes required to acquire export approval via direct commercial sales (DCS) and foreign military sales (FMS) of EW technology. The first day will be classified SECRET / US Only and outline the specific technology release processes and best practices to enable positive export decisions for industry and the USG. The second day will be focused on our foreign allies and outline best practices and ways to leverage USG DCS and FMS modalities of sale to procure capabilities that fulfill EW operational requirements.

## CLASSIFICATION:

**US Secret Only (Day 1) and Unclassified (Day 2)**

VISIT **CROWS.ORG/EWRELEASABILITY2020** FOR MORE INFORMATION

## ONR AWARDS CONTRACTS FOR LEAP PAYLOAD CONCEPTS

The Office of Naval Research (ONR) has disclosed the award of initial concept design contracts in support of payload development for a projected long endurance soft-kill countermeasure for anti-ship missile defense.

Forming part of the wider Advanced Offboard Electronic Warfare (AOEW) program, the Long Endurance AOEW Platform (LEAP) project envisions the development of both an expendable carrier flight vehicle and compatible countermeasure payload(s) which could achieve Low Rate Initial Production in the 2026-2027 timeframe. The current concept design effort is intended to inform requirements for a potential follow-on Future Naval Capabilities program.

Specific requirements for the LEAP decoy include: the ability to deploy and transition to stable controlled flight while providing safe and stable separation from the ship; autonomous flight control capability, to include collision avoidance, with an ability to accept mission tasking at launch with waypoint updates from a shipboard control station and the ability to reposition and realign to maintain focus on the threat; ship-relative navigation with air and sea platform awareness with the ability to operate in a GPS-denied environment; a minimum flight endurance of one hour on station; the capability to employ modular EW payloads in both the primary RF and electro-optic/infrared (EO/IR) domains; operation in conditions up to Sea State 5 (>20 kt steady winds); and secure bi-directional communication between the decoy and the control station. It is anticipated that the LEAP decoy will be cued by a Soft Kill Coordination System to a particular threat and sector.

The ONR in April 2019 issued a solicitation for the LEAP concept design effort in two related Technical Areas (TAs), namely the LEAP autonomous airborne carrier (TA1) and the LEAP RF payload (TA2). Under concurrent and parallel ONR efforts, concept designs and component technologies are being developed for low size, weight and power modular EO/IR payloads; ONR has set indicative limits of no more than 20 lb and 1,000 cubic inches for both RF and EO/IR payloads.

ONR has characterized the LEAP RF payload as an encapsulated, modular RF system capable of maintaining situational awareness in the electromagnetic spectrum, communicate with the host platform, and operate both autonomously and under direction from the host ship command system.

In September 2019 the ONR awarded BAE Systems Information and Electronic Systems Integration a $733,000 contract under TA2. This award provides for BAE Systems to mature a payload concept known as LURE [LEAP Universal RF EW].

As regards the EO/IR payload, ONR is envisioning components including visible and infrared receivers, internal fine pointing control, control electronics, processor and a local inertial navigation system. As well as receiving cues via the carrier vehicle communication link, it is also expected that the payload will be able to request the carrier platform to point within a +/- 10-degree window at any given time during flight maneuvers.

In August 2019 the Raytheon business in Tucson, AZ, was awarded a $604,000 contract to develop a LEAP Compact Electro-Optic Infrared Payload. The following month, Raytheon in Tewksbury, MA, received a $245,600 in respect of a LEAP Compact Electro-Optic Infrared Payload under the description Filters Incorporating Rare Earths. – *R. Scott*

## 56TH AOC INTERNATIONAL SYMPOSIUM WRAP-UP

The AOC held its 56th Annual International Symposium and Convention October 28-30 in Washington, DC. The Symposium's theme, "Building the EMS Enterprise," was discussed throughout the week by keynote speakers, as well as in the symposium sessions. Below are some of the highlights from the event:

### *Keynote Speakers*

Stephen "Muddy" Waters, AOC President, pointed to this year's symposium theme and asked, "So now that we have this thought process started, how do we do this?" He said the solution is through an enterprise approach. "When we talk enterprise, it's across the board. It's a strategic vision, it's investment in manpower, training, development of doctrine, modeling and simulation, and more. This is the rock we must push forward, as we look at building the enterprise."

Alan Shaffer, Deputy Under Secretary of Defense for Acquisition and Sustainment (A&S), was keen to call attention to the current and increasing capabilities of near-peer adversaries, such as Russia and China. Shaffer emphasized the need for speed and agility in the acquisition and fielding of capabilities.

He spoke of acquisition at the "speed of relevance," asking, "How do you deliver a capability in an acquisition system that is designed to deliver chunks in ten-year increments when technology moves on at 18 months?" Shaffer pointed to the DOD's mid-tier acquisition process as a solution. "Mid-tier acquisition allows us to go out and prototype either a technology or a production prototype within a five-year time horizon without going through the formal requirements process. I see no reason why, using mid-tier acquisition, that we can't get things out within six months to two years."

James Faist, SES, Director, Advanced Capability, OUSD Research & Engineering, returned to this point observing that, "We can never assume that we have EW or Spectrum Dominance. The challenge is constant and daunting to maintain our position. The solution rests with rapid prototyping of core capabilities, and with the mid-tier acquisition approach, we're really working hard to get that right. We're looking at how to best inject new technology into programs as we go along, as well as making sure that we're placing our bets in the right areas to invest in, and to advance and prototype."

Dr. Tim Grayson, Director, DARPA Strategic Technology Office (STO), also addressed the speed at which adversaries are fielding new capabilities vs. the DOD's own cycles. To address this, Grayson pointed to DARPA's efforts aimed at what they refer to as "monolith busting," which is focused on the notion of replacing monolithic platforms with distributed sets of capabilities. "Instead of a self-contained effects chain all on a single platform, the system-of-systems says that elements of the effects chain will be distributed across many sensors and platforms." In this scenario, said Grayson, architecture becomes key, but he also warned that, "Because developing an architecture is really hard, there is a real danger in trying to decide today what that architecture will be that will have to last us for the next 20-30 years." As a result, Grayson said that DARPA is not only working to bust monolithic platforms, but to bust monolithic architectures as well. "The objective is to create more diversity of options for the warfighter, but at a speed that allows adaptation – ideally at the time of need."

### *Symposium Sessions*

In the session, "Threat-Based Intelligence for EMS Operations," Joseph Kirschbaum, Director, Defense Capabilities and Management, Government Accountability Office, discussed the GAO's December 2018 report on long-range national security threats. He said that other countries are exploiting dual-use technologies, such as Artificial Intelligence, Quantum Information Science and autonomous and unmanned systems, which will pose a significant challenge to US forces in the future. Emerging technologies are enabling potential adversaries to improve existing capabilities, such as weapons of mass destruction, electronic warfare, missiles and aircraft, as well as to develop new weapons, such as hypersonic-class weapons, counterspace weapons and offensive cyber capabilities. He noted that many of these threats are influenced by or rely on the Electromagnetic Environment.

The "Multi-Functional EMS Technologies" panel looked at the future of defense electronics not only from a technology perspective, but (in keeping with the "enterprise" theme of the symposium), also in terms of the external factors that will influence the adoption of multifunction systems in the future. Mike Meaney, VP of Maritime Electronic and Information Warfare at Northrop Grumman Mission Systems, described how defense electronics technology is evolving from time-interleaved (e.g., AESA radar and shared-aperture) (e.g., US Navy Integrated Topside) solutions to reconfigurable solutions that feature multispectral RF/EO passive/active performance in a single system. Anthony Nigara, VP Strategy and Business Development, Space and Airborne Systems, at L3 Harris Technologies, talked about the "why" – the operational constraints driving the need for low SWaP multifunction systems. He also discussed the implications for industry how multifunction technology will drive fundamental shifts in the business model. He believed software licensing will continue to increase and hardware procurement will continue to decrease, as well as predicting that upgrade cycles will be shorter and contracts will be competed more frequently.

In the session, "Demand Signal for the EMS Workforce," panelists discussed why a dedicated, skilled EMS workforce is necessary and how this might be achieved among the Services. The discussion was led by Session Chair Tom Taylor, Gs15, EMS Policy & International Engagement, DoD CIO, and he, alongside panelists, identified three reasons EMS workforce development is so critical: 1) data is useless without a workforce; 2) the increasing number of electronic attack (EA) targets in theater; and 3) the need to fill positions left by an ever-ageing EMS workforce. With these issues in mind, how did panelists suggest meeting EMS workforce needs? Two main suggestions emerged. The first was the creation of clear organizational EMSO structures within and among the Services. According to CAPT Brian Hinkley, USN (Ret), Vice President for EMS Strategic Operations, AECOM, the EMS is a battlespace that is "on par with other warfighting domains," and the various Services should be organized accordingly. The second suggestion was workforce incentivization. Angela Lane, Deputy Chief, Joint Electromagnetic Spectrum Information Analysis and Fusion, Joint Electronic Warfare Center, suggested direct hiring incentives for EMS professionals, in-house training and degree programs for existing EMS professionals, and creating more sharing and internship programs within the EMS enterprise.

The Symposium also provided a "High-Power Electromagnetic Weapons Update," which included a presentation from Dr. Kelly Hammet, SES, Director of the Air Force Research Lab's Directed Energy Directorate. Dr. Hammet discussed the Air Force's High-Power Microwave (HPM) technology roadmap. After demonstrating the performance of a second-generation HPM weapon system on a conventional air-launched cruise missile in the 2016-2018 timeframe, The directorate is now focused on demonstrating HPM payloads on smaller missiles in the next five years. This involves S&T work to reduce HPM source and pulse-

powered SWaP, optimizing waveforms to improve effectiveness and developing new concepts of employment. Further out (2029 and beyond), the Directorate wants to develop advanced HPM concepts for future applications. Work will include developing a "smart waveform HPM for enhanced range-to-effect from re-useable platforms" and "performing cooperative target engagement and real-time BDA." He also discussed several HPM technology challenges, including developing conformal HPM antennas and reducing breakdown issues in compact pulsed power systems.

The Symposium also looked at "The Mechanics of Great-Power Competition in the EMS." Dr. John Evans, CEO of Carillon Technologies, discussed how, in Great Power Competition, innovation efficiency must be a cornerstone of national security strategy. He added that the United States' current innovation innovation strategy doesn't focus very much on efficiency. He said the DOD must drive innovation itself rather than relying heavily on defense contractors and commercial companies.

In the session on "Readiness in the EMS," LTC Gary Lyke, Chief of Operations, Joint Electromagnetic Preparedness Center at US Strategic Command, talked about the current state of EMS Readiness in the DOD. He said the DOD is finding EMS readiness gaps at a faster rate than it is improving readiness. In addition, many of these identified gaps are in areas, such as emissions control (EMCON), where the DOD should have been more proficient to begin with. During most training exercises, it is very difficult to replicate a congested Electromagnetic Environment. In addition, the use of Red Force electronic warfare and cyber operations is typically very short due to restrictions that are set by planners. Furthermore, training exercises often do a poor job of developing scenarios that reflect an enemy's most likely and most dangerous course of action in the EME. Lyke spelled out a way ahead for EMS readiness, which included demanding tough and realistic iterative training in the EMS, including investing in home station training.

In the session on "Advanced Technologies for EMS Operations," Dr. William Conley, recent Director, Electronic Warfare, OUSD for Acquisition & Sustainment/A/Platform & Weapon Portfolio Management (P&WPM), as well as Executive Secretary for the EW Executive Committee (EW EXCOM), and now Chief Technology Officer, Mercury Systems (Andover, MA), pointed out that, in terms of total R&D spending, China was effectively matching the US and noted that in, looking back to 1960 and total Federal government R&D spending, "This was twice the level of commercial industry, while today, this is basically three to one in the other direction." As a result, Conley said, "We instead need to look at how we can leverage modern commercial microelectronics R&D and drive that into being appropriate and applicable in the defense ecosystem. That is the challenge in advanced technology that all of us really face today."

In the same session, Dr. Dan Green, PM for EW at the Office of Naval Research (EW), agreed and said, "When working toward seeing and responding to the entire spectrum, it becomes a huge signal-processing problem. In order to do this, you need to take advantage of advances in digital signal processing (DSP) and compute power. The good news is the major advancement of this technology in the commercial sector, but we need to leverage this for our needs." Going forward, Green, emphasized that, "The importance of artificial intelligence and compute architectures becomes greater, and right now we're at an inflection point in terms of deciding what is the best path going forward for our requirements. It's not necessarily the same path that the commercial sector will pursue. Our job at ONR is to figure out how to best bridge that gap and to bring those capabilities to the edge."

Col William "Dollar" Young, USAF, Special Assistant to the Commander, USAF Warfare Center, reinforced the critical importance of getting the DOD's AI architectures for the EMS battle right, and in making them adaptable and agile to multi-domain operation mission needs. "In terms of AI, perpetual novelty is not your friend. If you've trained your algorithms on established patterns, adversaries will work to turn your functionality against you. The solution comes from being able to pull together diverse teams with diverse capabilities operating in multi-domains to deliver stuff that has never been seen before. That is where we're going, and it rides on commercial advances, such as those in software-defined radios (SDRs)."

More stories from the 56th AOC International Symposium are available in the AOC Show Daily editions on the AOC Website (www.crows.org). – *H. Swedeen, J. Haystead, J. Knowles*

## IN BRIEF

The Air Force Research Lab Sensors Directorate, Spectrum Warfare Division (AFRL/RYW), has issued an Advanced Research Announcement (ARA) to develop methodologies, tools, techniques, and capabilities to identify cyber susceptibilities and mitigate vulnerabilities in avionics systems. The effort, known as Trusted and Elastic Military Platforms and Electronic Warfare (EW) System Technologies (TEMPEST), will focus on cyber hardening and improving the cyber resilience of Air Force manned, unmanned, autonomous, and remotely piloted vehicles, on-board Intelligence, Surveillance, and Reconnaissance (ISR) systems, Electronic Warfare (EW) systems, munitions, and any equipment, component, or subsystem that could compromise mission assurance of the Air Force weapon system or tactical platform. AFRL will issues specific solicitations under this research topic in the near future. Technical areas of interest include 1) technologies for assessing platform cyber security; 2) technologies for cyber hardened platforms; 3) technologies for cyber resilient platforms; 4) agile system architecture development and integration; 5) open system architectures for trusted and agile platforms; 6) technologies for Modeling & Simulation; 7) technologies to advance RF simulation; 8) techniques, methods and technologies for measuring sensor system performance; and 9) design, development and evaluation of high fidelity models. The program budget is estimated at 808.5 million, with multiple awards ranging from $1 million to $200 million. The contracting point of contact is Jo Ann Sillaman; +(937) 713-9965, e-mail jo.sillaman@us.af.mil.

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The Defense Advanced Research Project Agency's (DARPA's) Tactical Technologies Office (TTO) has issued a Request for Information (RFI) to help the Agency develop potential new DARPA programs that could enable a High Energy Laser (HEL) hardened system to detect a HEL (both continuous wave and puled emitters) strike, geo-locate the source (on- and off-axis), and rapidly disrupt attack. DARPA envisions a Counter High Energy Laser (C-HEL) system that can be integrated onto current and future relevant platforms in air, ground, and maritime domains. Specific challenges involve: 1) off-axis detection of scattered laser irradiation at long standoff distances; 2) detecting HEL weapons before laser is fired; 3) rapid onboard processing to geo-locate, target, and track the source in real-time; 4) techniques to disrupt the HEL kill chain within milliseconds of attack onset; 5) material solutions that protect against HEL attack and enable completion of the mission, including Counter High Energy Laser missions, during such an attack; 6) collaboration of multiple fielded HEL counter-weapon systems to include real-time cooperative sensing and data processing; and 7) determining point at which HEL weapon attack has been successfully disrupted. Responses can be sent to DARPA-SN-19-81@darpa.mil.

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# world report

## CANADA DEVELOPS NOMAD USV-BASED ACTIVE OFFBOARD DECOY

Rheinmetall Canada has been contracted to develop a new long-endurance active offboard decoy system using an unmanned surface vessel (USV) as a carrier vehicle. Known as the Naval Off-Board Anti-Missile Active Decoy (NOMAD) program, the project will see an Elbit Systems electronic attack (EA) payload integrated with the Humpback USV developed by QinetiQ Target Systems.

Designed to address the requirements of the Royal Canadian Navy's Naval Electronic Attack Recapitalization – Unmanned (NEAR-U) project, NOMAD is an offboard active decoy using the Humpback variant of QinetiQ Target Systems' Hammerhead unmanned surface target as a payload carrier.

One of a number of initiatives intended to recapitalize the RCN's surface ship EA capability, the goal of NEAR-U project is to implement and test a potential solution to improve naval platform survivability by incorporating a NOMAD system into an existing USV platform. The NOMAD system will be tested and evaluated as offboard active decoys or jammers for ship and task group anti-ship missile defense, as well as serving as an electronic warfare test set for radar testing and training.

Rheinmetall Canada will deliver two NOMAD systems under the terms of its CAN$4.5 million contract. It was announced in October 2019 that Elbit would supply the small form factor digital EA payload for integration with the Hammerhead USV.

The Humpback USV is based on the existing Hammerhead unmanned surface target vehicle but modified for specific payload and special uses. In the case of NOMAD, the payload will be installed utilizing the mast assembly and allocated spaces inside the USV.

The USV and the NOMAD system will be launched, recovered, and remotely controlled from the controlling platform, with line-of-sight control to be maintained from the controlling platform. Prior to launch, the mast and the mast-mounted components of the NOMAD system will be installed on the Humpback USV. For recovery, the USV with the NOMAD system will be recovered from the sea and, once on board the host ship, the mast and mast-mounted components of the NOMAD system will be removed from the USV and prepared for storage. – *R. Scott*

## SAAB STARTS FLIGHT TESTING OF NEW ESCORT JAMMER

Saab (Järfälla, Sweden) has begun flight testing of a new low-band Electronic Attack Jammer Pod (EAJP), developed as part of the company's Arexis family of fast jet electronic warfare (EW) systems.

Intended to provide strike packages with an airborne electronic attack capability to defeat early warning radars, the EAJP pod incorporates L-band and S-band GaN-based active electronically scanned AESA antennas in the fore and aft sections of the main pod structure, with large VHF and UHF fin antennas mounted externally.

Saab took the decision in 2017 to self-invest in the build of a prototype system, with the assembly and integration of the demonstrator pod completed at the company's Järfälla site near Stockholm at the start of 2019. A Swedish Air Force two-seat Gripen D aircraft made a first test flight with the EAJP pod on 4 November: Saab said the pod's interfaces with the aircraft's hardware and software, as well as cockpit control and monitoring, were tested during the flight "with successful results."

The pre-production pod, covering the L- and S-bands only, is intended to demonstrate product engineering with regard to issues such as packaging, cooling, power supply, radome performance and power levels, said Saab. – *R. Scott*

## TWLNVIS PASSIVE RADAR IN NATO MEASUREMENT CAMPAIGN

Hensoldt (Ulm, Germany) has demonstrated the detection performance of its Twlnvis passive radar sensor during a NATO Science and Technology Organization measurement campaign led by the Polish armed forces.

Twlnvis locates aircraft by evaluating and fusing signals reflected off the target from existing external broadcast transmitters (VHF and UHF transmissions from analogue and digital radio and television transmitters) to generate a comprehensive air picture. The system is able to simultaneously evaluate up to 16 FM transmitters (analog radio) and five frequencies with several contributing transmitters from DAB and DAB+ (digital radio), as well as DVB-T and DVB-T2 (digital terrestrial television).

In military applications, the Twlnvis system enables covert surveillance of large areas using networked receivers. Passive radar offers advantages in that it cannot be located by hostile forces and is very difficult to jam.

For the purposes of the recent measurement campaign, a Twlnvis passive radar cluster with two sensors was installed on the Polish Baltic coast (a system integrated in a container was used alongside a system variant integrated in a van). The live data from the TwInvis cluster was fed into the Polish MilRad network and analyzed and evaluated in a nearby Polish control and reporting center. Detection ranges of up to 300 km were achieved over the Baltic Sea coast. – *R. Scott*

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# TECHNOLOGY SURVEY

## A SAMPLING OF RADAR ESM AND ELINT RECEIVERS

**By Barry Manz**

Electronic intelligence (ELINT) receivers may not need to make split-second, life-or-death decisions like their radar warning receiver (RWR) counterparts, but that doesn't make their job any easier or their design less complex. Since we last surveyed them two years ago, there's a noticeable increase in their overall performance and capabilities in keeping pace with the radars they're up against.

The tasks required of an ELINT receiver have never been simple to execute, but today, they are far more difficult. The service life of a radar system is typically measured in decades rather than years. This means that an ESM or ELINT system must cover a growing list of radars – some new and some old – whose signatures can change over time as upgrades are implemented, components are replaced and their performance evolves with new technologies.

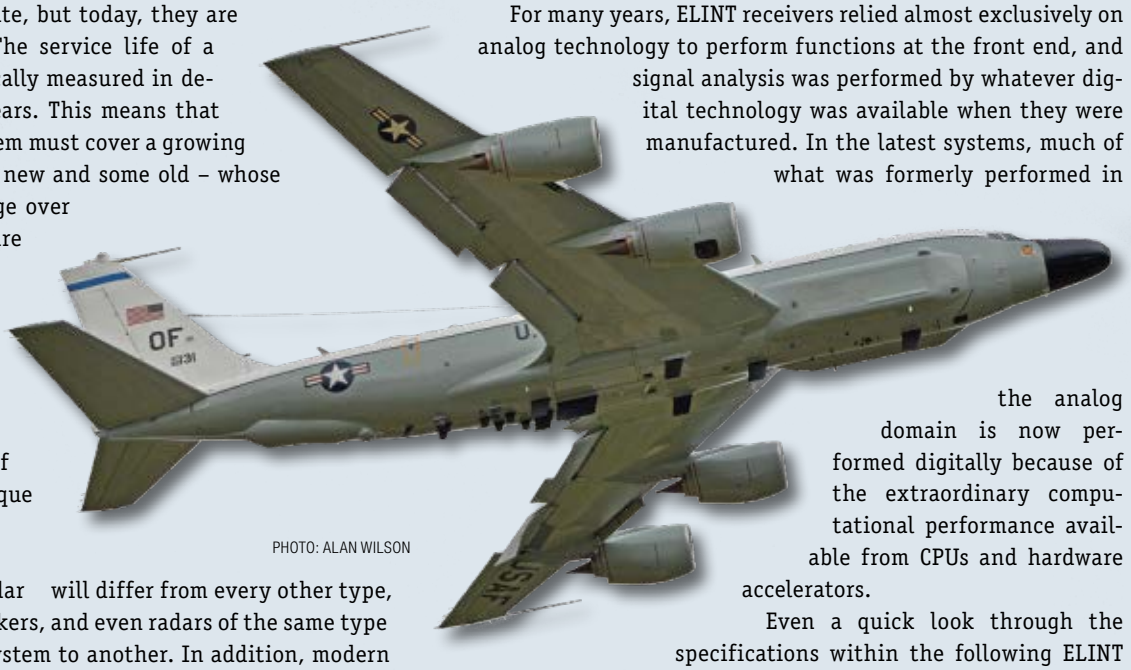

PHOTO: ALAN WILSON

Different types of radars also have unique electromagnetic profiles, so a ballistic missile defense radar will differ from every other type, including missile seekers, and even radars of the same type will vary from one system to another. In addition, modern multimode, multifunction radars combine complex pulse modulation schemes with frequency agility, intra-pulse waveform changes, exotic waveforms such as pseudo-noise modulation, as well as lightning-fast changes to sidelobes, digital beamforming, and a variety of other deceptive techniques.

Worse yet are low-probability-of-intercept (LPI) radars, such as those using frequency-modulated continuous-wave (FMCW) and frequency-modulated interrupted continuous-wave (FMICW) that often cannot even be detected let alone identified and analyzed by older ESM and ELINT receivers. In short, while it may be possible to detect a radar, characterizing it can sometimes be next to impossible.

Some types of radars are also moving higher in frequency, well into the millimeter-wave region, which presents a unique set of challenges. At the same time, other radars are operating in the densely-populated electromagnetic environment between HF and about 6 GHz, which makes detection even more difficult and signifying a trend that will continue to become more problematic as commercial wireless services expand their footprint, even overlaying multiple services on the same frequencies.

To address all these challenges, ELINT receivers are exploiting technologies developed in the consumer market. These include very-high-performance host processors, ADCs and DACs that have high sampling rates, resolution, and spurious-free dynamic range (SFDR).

For many years, ELINT receivers relied almost exclusively on analog technology to perform functions at the front end, and signal analysis was performed by whatever digital technology was available when they were manufactured. In the latest systems, much of what was formerly performed in the analog domain is now performed digitally because of the extraordinary computational performance available from CPUs and hardware accelerators.

Even a quick look through the specifications within the following ELINT receiver survey table illustrates how these marvels of analog and digital technology have been enhanced. Many now have instantaneous bandwidths of 1 GHz, operating frequencies from HF through 40 GHz, and superheterodyne, as well as digital, receiver architectures in a single system.

Spurious-free dynamic range (SFDR) of at least 50 dBc is a given, and total dynamic range is often greater than 90 dB. All have multiple interfaces for transferring signals to high-speed signal recorders for detailed analysis, and many are supported by analysis software and the ability to become part of complete, single-vendor platforms in form factors compatible with different operating environments.

This month's survey includes nearly 40 ESM and ELINT receivers from 23 companies.

JED's next technology survey, which will be published in the February 2020 JED, will look at FPGA boards for EW and SIGINT applications.

# RADAR ESM AND ELINT RECEIVERS

| MODEL | RECEIVER TYPE | OPERATING FREQ. | INST. BANDWIDTH | INSTALLED SENSITIVITY | TOTAL DYNAMIC RANGE | INST. DYNAMIC RANGE |
|---|---|---|---|---|---|---|
| **ASELSAN A.S.; Ankara, Turkey; +90-312-592 1000; www.aselsan.com.tr** | | | | | | |
| Wide Band | IFM | S to Ku Band | * | * | * | * |
| Narrow Band | Digital Channelized | L to Ka Band | * | * | * | * |
| Low Band | Digital Channelized | UHF, L band | * | * | * | * |
| **Chordell Systems Ltd.; Oxford, UK; +44 1865 784384; www.chordell.com** | | | | | | |
| Wolverine | Digital | 0.5-18 GHz | 17.5 GHz | CRLB +0.2 dB | 140 dB | * |
| **Collins Aerospace; Richardson, TX, USA; +1 972-705-3920; www.rockwellcollins.com/ewsigint** | | | | | | |
| DPAU-4001 Digital Pulse Analyzer Unit | Digital | 0.5-18 GHz; 0.5-40 GHz | 500, 100, 50, 25, 10 and 1 MHz | * | > 100 dB | 60 dB |
| IFMR-6070 IFM Receiver | IFM | 0.5-18 GHz | 0.5-18 GHz | * | 65 dB | 65 dB |
| **DAS Photonics; Valencia, Spain; +34 963 556 150; www.dasphotonics.com** | | | | | | |
| RESM/ ELINT Receiver | * | 0.5-40 GHz | 40 GHz | * | * | * |
| **D-TA Systems; Arlington, VA, USA; +1 (571) 775-8924 x7712; www.d-ta.com** | | | | | | |
| MFEL-5000 | Scanning superhet | 0.5GHz to 18GHz (ext. 40 GHz) | 500 MHz | -80 dBm | 90 dB | 60dB |
| **Elbit Systems EW and SIGINT - Elisra; Bene Beraq, Israel; +972-3-6175411; www.elbitsystems.com** | | | | | | |
| WBR | Wideband | 0.5-40 GHz | 0.5-40 GHz | * | > 75 dB | > 60 dB |
| DSHR | Superhet/Tuner | 0.5-40 GHz | 4, 40, 140, 500, 3000 MHz | * | > 75 dB | > 60 dB |
| QSHR | Superhet/Tuner | 0.5-40 GHz | 4, 40, 140, 500, 3000 MHz | * | > 75 dB | > 60 dB |
| **Elettronica Group; Rome, Italy; +39 0641541; www.elt-roma.com** | | | | | | |
| ELT/800 family | Superhet/Digital/ IFM | C to J Band min | * | * | * | * |
| ELT 1000 | Digital Direct RF Sampling | E to J + D Band | 1GHz min | * | 60 dB | 50 dB |
| ELT/819 A | Superhet/Digital/ IFM (with wide open integrated channels and functions) | from A to D Band | 65 MHz and 1 GHz | * | 80 dB | 60 dB |
| **ELTA Systems Ltd.; Ashdod, Israel; +972-8-857-2312; www.elta-iai.com** | | | | | | |
| ELL-8385 ESM/ ELINT Digital Receiver | Superhet, Digital (Direct sampling) | 0.5-18 GHz | > 500 MHz | > -80dBmi | 80 dB | 60 dB |
| **ESROE Ltd.; Fareham, Hampshire, UK; +44 (0)1329 237285; www.esroe.com** | | | | | | |
| MicroESM 1t | * | 2-18 GHz | * | -60 dBm | 40 dB | * |
| **FEI-Elcom Tech, Inc.; Northvale, NJ, USA; +1 201-767-8030 ext 271; www.fei-elcomtech.com** | | | | | | |
| SIR-4001-8-9 | Airborne Microwave Wideband DSP Receiver | 0.5-18 GHz; 0.5-26.5 GHz; 0.5-40 GHz | Up to 2 GHz | At L Band 500, 1, 2 GHz; 160 MHz 1, 5, 10, 20, 40, 80 MHz | 65 dB (Including non-carrier related spurious, carrier prelated, IP3, IP2) per 1 MHz BW | IP3 > 0 dBm; NF < 15 dB |

| SUPPORT DF | CHANNELS | POWER (W) | SIZE (HxWxL inches/cm) | PLATFORM | WEIGHT (lb/kg) | FEATURES |
|---|---|---|---|---|---|---|
| | | | | | | |
| Amplitude | 4 | < 300W | * | Air, grd, shp | < 20 kg | Full capability against modern threats (high sensitivity, precise parameter measurement). |
| Phase | 8 | < 500W | * | Air, grd, shp | < 50 kg | * |
| Amplitude | 4 | < 350W | * | Air, grd, shp | < 25 kg | * |
| | | | | | | |
| Yes, TDOA, FDOA Phase | 4 for DF and 3d Geo | 300W Input | 15U Typical | * | 120 kg | Offers real time wideband staring across 17.5GHz of spectrum. |
| | | | | | | |
| Amplitude, time, phase | 1 | 250W | 4U rack mount, 7 x 17 x 21 in. | * | 32 lb | Precision parameter & intrapulse measurement, recording and analysis. |
| Amplitude, time | 1 | 250W | 2U rack mount, 3.5 x 17 x 21 in. | * | 35 lb | Continuously staring from 0.5 to 18 GHz. Generates detection Tips and PDW data. |
| | | | | | | |
| Yes | * | * | * | * | * | 360 deg coverage; DF accuracy 1 deg RMS |
| | | | | | | |
| Ampliude; phase or spinner | 2 min for Amp DF; 4+ phase | 300W Input (Typical) | 6U Typical (3U min) | Grd-fix, grd-mob, air, shp | 40+ kg | Offers autonomous situation assessment & collection. |
| | | | | | | |
| Amplitude | Multiple | 400W | 44 x 72 x 77(D) cm | * | 60 kg | >99% POI, digital map, remote control. |
| Amplitude, phase | 2 | 260W | 17 x 18 x 29(D) cm | * | 11 kg | Synthesized and fast tuning, digital map, remote control. |
| Amplitude, phase | 4 | 550W | 17 x 36 x 29(D) cm | * | 23 kg | Synthesized and fast tuning, digital map, remote control. |
| | | | | | | |
| Amplitude monopulse (4-8 antennas), TDOA | 4 min. | * | * | Air | * | Airborne: fast localization. |
| * | 4 | 200W typ. | 3U x 12 Modules typ. | Air | 12 kg typ. | Wideband radar emitters detection, discrimination and identify cation; radar emitter measurement and technical parameters extraction. |
| Interferometry correlative vectorial | 5 superhet, 2 wide open | 700W typ. | RPU: 26 x 20 x 60; Signal Routing; 29 x 17 x 29 in. | Shp, grd, air | 8 kg signal routing; 31 kg RPU; weight of antenna varies w/ installation | Very low ELINT; ground, aircraft and naval: localization by triangulation. |
| | | | | | | |
| Amplitude, phase, time | Multichannel (4 channels) | 400W | 11.4 x 8.26 x 18 in. | Air, grd-mob, grd-fix, ship, sub | 25 kg w/o antennas | Software defined reciver with automatic system process. Integrated with ELTA's radars for complete active and passive situation picture. |
| | | | | | | |
| Yes | * | <20W | 18 x 18 x 9.6 cm | Grd-fix, grd-mob, air, ship, sub | 1.5 kg (main unit); 1kg (tablet); 0.62 kg (9Ah battery) | DF accuracy 10 deg. RMS; can report 100 simultaneous emitters. |
| | | | | | | |
| No | 1 | 95 - 265 VAC, 47-440 Hz, 150 Watts | 19-in. Rack 1U | * | 20 lb | ELINT, RWR, EW, SIGINT |

# RADAR ESM AND ELINT RECEIVERS

| MODEL | RECEIVER TYPE | OPERATING FREQ. | INST. BANDWIDTH | INSTALLED SENSITIVITY | TOTAL DYNAMIC RANGE | INST. DYNAMIC RANGE |
|---|---|---|---|---|---|---|
| **FEI-Elcom Tech, Inc.; Northvale, NJ, USA; +1 201-767-8030 ext 271; www.fei-elcomtech.com *cont'd.*** | | | | | | |
| SIR-1024 | ChirpSounder Receiver | 2-30 MHz | * | (For 10 dB SINAD) AM (6.4 KHz BW): -103 dBm input<br>CW (300 Hz BW): -122 dBm input<br>SSB (3.2 KHz BW): -112 dBm input<br>FM (16 KHz BW): -98 dBm input, 5 KHz deviation, 400 Hz modulation: 20 dB SINAD | -135 dBM MDS | 80 dBm IP2 90 dBm IP3 |
| SIR-3200 | NHF/UHF Wideband DSP receiver | 20 MHz to 3000 MHz | 80 MHz | 20 kHz IF Bandwidth: -101 dBm type<br>1 MHz IF Bandwidth: -84 dBm type<br>20 MHz IF Bandwidth: -70 dBm type<br>AM Sensitivity Condition: 50 % Modulation, 1 kHz tone, 10 dB S+N/N ratio<br>FM Sensitivity Condition: 30 % of Selected IF Bandwidth Deviation, 1 kHz tone, 17 dB S+N/N | >95 dB @1 MHz BW | 25 dBm IP2 15 dBm IP3 |
| **HENSOLDT Sensors GmbH; Ulm, Germany; 0049 731 392 0; www.hensoldt.net** | | | | | | |
| HENSOLDT Kalætron® Elint Rx | Full digital receiver | 0.5-40 GHz | ≥2 GHz | Depending on used antenna frontendend ≥ -95 dBm for high gain antenna | ≥ 70dB | ≥ 60dB |
| **iRF - Intelligent RF Solutions; Sparks, MD USA; +1 443-310-2814; www.irf-solutions.com** | | | | | | |
| iWR-6500 | Superhet; stepped sweeper | 0.5-26.5GHz | 500 MHz @ 1 GHz IF; 85 MHz @ 160 MHz | * | 94 dB @ 1MHz | 65 dB STSFDR |
| SMR-5550i | Superhet; set-on/ collection | 0.1-18 GHz | 100 MHz @ 160 MHz | * | > 90 dB @ 1MHz | 53 dB min. @ 50MHz BW |
| **Kratos General Microwave Israel Ltd.; Jerusalem, Israel; +972-2-5689444; www.kratosmed.com** | | | | | | |
| WBR-0518-MOD | Superhet | 0.5-18 GHz | up to 500 MHz | -58 dBm | 60 dB + 60 dB DCA | 60 dB |
| **L3Harris Technologies – Surveillance Solutions; Van Nuys, CA, USA; +1 818-988-2600; www.L3Harris.com** | | | | | | |
| ES-5080 | Superhet, digital | To Ka Band | 500 MHz | Depends on high gain antenna; to -95 dBmi typical | > 75 dB | 60 dB |
| **Leonardo DRS; Germantown, MD, USA; +1 301-948-7550; www.leonardodrs.com/SignalSolutions** | | | | | | |
| SI-9172/3 Vesper | Superhet | 3 MHz - 6.2 GHz | Selectable bandwidths, 100, 30 & 15 MHz | 13 dB NF, -122 dBm sensitivity @ 10 kHz BW | 88 dBc SFDR in 10 KHz BW | VITA 49 packetized digital IF via Aurora transport protocal |
| SI-9170A Sparrow | Superhet | 20 MHz - 18.25 GHz | 500 MHz BW @ 1000 MHz C.F. | 15 dB NF max | -2 dBm input P1dB | 10/100Base-T Ethernet |
| **Lockheed Martin Mission Systems and Training; Owego, NY, USA; +1 607-751-7089; www.lockheedmartin.com** | | | | | | |
| Advanced Digital Receiver Processor (ADRP) | Superhet, digital | * | * | * | * | * |
| **Mercury Systems; Andover MA, USA; +1 866-627-6951; www.mrcy.com** | | | | | | |
| RFM3101 | Superhet | 6-18 GHz | 1 GHz | NA | 50 dB Gain Control | 60 dB (1 MHz BW) |
| RFT-3200 | Superhet | 0.1-40 GHz | Selectable: 2 GHz, 1 GHz; 500, 200, 100, 50 MHz | 12 dB NF, typ at max gain | Input 1 dB Compression Point: -15 dBm typ | <-60 dBc Spurious, at rated output level |
| FM021814-001 | IFM | 2-18 GHz | 16 GHz | -10 dBm / -50 dBm | 20 dB / 60 dB | 20/60 dB |
| **Patria; Tampere, Finland; +358-20-4691; www.patria.fi** | | | | | | |
| ARIS | Digital | 0.5-18 GHz (optional 20 MHz - 40 GHz) | Variable 0.1-500 MHz | -130 to -80 dBm depending on BW and resolution settings | 130 dB | 56-81 dB depending on BW and resolution settings |

| SUPPORT DF | CHANNELS | POWER (W) | SIZE (HxWxL inches/cm) | PLATFORM | WEIGHT (lb/kg) | FEATURES |
|---|---|---|---|---|---|---|
| No | 1 | 95 - 265 VAC, 47-63 Hz, 100 Watts | 19-in. Rack 2U | * | 35 lb | 2 Slot, VME 6U Optional |
| No | 2 | 95 - 265 VAC, 47-63 Hz, 100 Watts | 19" Rack 2U | * | 35 lb | 2 Slot, VME 6U Optional |
| Receiver is supporting Amplitude and Phase DF technology | 4 fully digital, independent channels | 28 VAC, 380W | 250 x 128 x 380 mm | Air, grd-mob, grd-fix, ship, sub | ELINT Rx < 10 kg | Software upgradable; continuous IQ raw data recording and spectrum analysis; PDW recording; operator tasking online; offline supported by AI technologies;type classification of unknown emitters; qualified according MIL tandards |
| Yes | Single | 45W | 1.6 x 5.5 x 10 in. | Grd-mob, grd-fix, air | 3.5 lb | Next-generation digital-based search receiver; supports SIGINT collection, N-channel DF. |
| Monopulse DF, Cross Pole | Single, expandable to multi-channels | 100W | 1.75 x 20.16 x 17 in. | Grd-mob, grd-fix, air, sub | 20 lb | Very low integrated phase noise and up to 40 GHz integrated freq. extension. SEI certifed. |
| No | 1 | 70 | 220 x 440 x 40 mm | shp | 6kg | LAN communication, BIT, scan/search modes, demodulator AM&FM video output. |
| High gain, spinning DF | 2 standard | < 1kW | Varies with installation | grd-mob, grd-fix, shp, air | Varies with installation | Detect, ID FMCW radars; supports many operators (local or remote over TCP/IP). |
| N-channel coherent or full independent tuning | SI-9173 up to 8 Rx & 1 Tx, SI-9172 up to 4 Rx & 1 Tx | 50/111W | 3U VPX & 6 U VPX | 3U VPX & 6U VPX | 4.5 lb | Highly configurable with multiple channels. |
| Phase coherent up to N channels | 2 channels phase coherent | 46W cond. cooled | 3U VPX | 3U VPX | 4.5 lb | Highly configurable with multiple channels. |
| * | Multiple | 350W | 6 x 7.7 x 10 in. | * | 29 lb | Open architecture, high performance digital receiver for RWR, ESM, ELINT applications. |
| Yes | 2 | 20W | VPX 3U card | Air, grd, shp | * | Modular OpenRFM design |
| Yes | 4 | 35W | 1.75 x 17 x 22 typ | Grd-fix, shp | < 20 lb typ | Agile IF, configurable |
| No | 1 | 20W | 1.2 x 5 x 6.5 in | Air, grd, shp | 2.5 lb | Low/ High DR options |
| Amplitude and phase monopulse and spinning dish | Independent microwave channels (2) and 2 V/UHF channels feeding digital channelizers | 1130W (including recorder unit) | 10U (receiver processor) + 3U (recorder unit) 19-in. rack mount chassis | Grd-fix, grd-mob, ship, air (optional) | 85 kg (including receiver processor, 55 kg and recorder unit, 30 kg) | Continuous real-time and offline ELINT analysis capability. Recording capability of IF up to 500 MHz BW. Channelized pulse processor. Radar identification and automatic recording. |

# RADAR ESM AND ELINT RECEIVERS

| MODEL | RECEIVER TYPE | OPERATING FREQ. | INST. BANDWIDTH | INSTALLED SENSITIVITY | TOTAL DYNAMIC RANGE | INST. DYNAMIC RANGE |
|---|---|---|---|---|---|---|
| **Rohde & Schwarz GmbH & Co.KG; Munich, Bavaria, Germany; +49-89-4129-0; www.rohde-schwarz.com** | | | | | | |
| R&S®WPU2000 | Superhet, digitizer and pulse analyzer (full Nyquist sampling) | 8 kHz - 18 GHz (optional to 40 GHz) | Digital; from 2.5 kHz to 2000 MHz in 8000 steps | Max. -120 dBm (DANL) | > 110 dB | > 72 dB |
| **Space and Defence Technologies (SDT); Ankara, Turkey; +903122101015; wwwsdt.com.tr** | | | | | | |
| Wideband Microwave Receiver | Superhet | 0.1-18 GHz | 1 GHz | * | > 60 dB at- 30 dBm input | * |
| **Teledyne Defence Limited; Shipley, West Yorkshire, UK; +44-1274-535147; www.teledyne.com** | | | | | | |
| Phobos-R QR020-M1 | CV IFM | 2-18 GHz (options to 500 MHz, 20 GHz and 40 GHz) | 16 GHz | * | 62 dB | 62 dB |
| DR068 | CV IFM | 2-18 GHz | 16 GHz | * | 65 dB | 65 dB |
| **TUALCOM; Ankara, Turkey; +90 312 485 22 85; www.tualcom.com.tr** | | | | | | |
| Compact ESM/ ELINT Receiver | * | 2-18 GHz | 16 GHz | * | 65 dB | * |
| **Ultra Electronics - TCS; Ottawa, Ontario, Canada; +1 613-592-2288; www.ultra-tcs.com, info@ultra-tcs.com** | | | | | | |
| xLR-501 | Superhet, digital, channelized | 0.5-40 GHz | 500 MHz, Selectable down to 3 MHz | -94 dBm at 2 GHz<br>-101 dBm at 18 GHz | > 90 dB | > 70 dB |
| xLR-510 | Superhet, digital; channelized, interferometer | 0.5-18 GHz | 500 MHz, Selectable down to 3 MHz | <-78 dBm | > 90dB | > 70 dB |



# SURVEY KEY – ELINT RECEIVERS

### MODEL
*Product name or model number*

### RECEIVER TYPE
*Superheterodyne, Channelizer, IFM, etc.*
- CV = crystal video receiver
- IFM = instantaneous frequency measurement
- Superhet = Superheterodyne

### OPERATING FREQUENCY
*Indicated in kHz, MHz or GHz*

### INSTANTANEOUS BANDWIDTH
*Includes selectable bandwidths if more than one.*

### INSTALLED SENSITIVITY
*Indicated in dBm or dBmi*
CRLB = Cramer-Rao Lower Bound
DANL = Displayed Average Noise Level
NF = Noise Figure
SINAD = Signal-to-Noise and Distortion Ratio

### TOTAL DYNAMIC RANGE
*Total dynamic range, indicated in dB, dBm or dBc*

### INSTANTANEOUS DYNAMIC RANGE
*Instantaneous dynamic range, indicated in dB or dBm*
- BW = bandwidth

### SUPPORT DF
*Does it support DF and with what technology and accuracy?*
- RMS = root mean square
- TDOA = time difference of arrival

### CHANNELS
*Single channel receiver, multiple channels or single expandable to multiple?*

### POWER
*Power dissipated in Watts*

### SIZE
*H x W x L in inches/cm*
- ATR = Air Transport Rack

| SUPPORT DF | CHANNELS | POWER (W) | SIZE (HxWxL inches/cm) | PLATFORM | WEIGHT (lb/kg) | FEATURES |
|---|---|---|---|---|---|---|
| Spinning dish | 8 | 250-400W | 426 x 176 x 450 mm (4HU, 19 in.) | Grd-fix, grd-mob, air, shp, sub | 44 lb | Superhet tuner, digitizer, digital channelizer and pulse analyzer in one device. Digital signal processing for CW and LPI radars. |
| * | * | * | 6U, 19-in. rack mount | Grd-fix, grd-mob, air, shp, sub | 40 kg | Extendable up to 40 GHz; Eremote programming via Ethernet 1000 Base-T |
| monopulse amplitude comparison | 4 | 24W | 31 D x 12 H cm | grd-mob | < 8.5 kg | Man-portable and deployable; suitable for remote deployment and operation with no fixed ground infrastructure requirement. |
| * | 1 | < 40W | 2 6U VME slots | * | 1.5 kg | Can also include switched multiplexer preselecter to manage dense signal environments. |
| * | 4 | 1.8 A @ 28 VDC | 41 x 26 x 7.5 cm | Grd-fix, grd-mob, air, ship, sub | 8 kg | Signal processor an generate more than 3 million PDWs per sec.; can store more than 2 million PDWs in internal memory. |
| High gain spinning DF antenna; rotation speed up to 200 rpm | 1 or 2 | 421 | Rackmount Receiver: 3U x 19 x 24 in. Antenna Unit: 21.3 (D) x 17.9 (H) in. | Grd-fix, grd-mob, air, ship | 60 kg | Multiple sub-channels for improved system sensitivity. Front end pre-selector with band specific filters and LNAs; can be integrated with wideband IFM receiver to support situational awareness |
| Interferometer. DF accuracy better than 1° rms and better than 140° IFOV Port and Starboard | 4 | 500 | ATR: 11.3 x 11.1 x 18.9 in. AHU: 70 x 15.4 x 5.4 in | Grd-fix, grd-mob, air, ship | 72 kg | Multiple sub-channels for improved system sensitivity; front end pre-selector with band specific filters and LNAs; pulse-by-pulse emitter polarization detection; can be integrated with wideband IFM receiver to support situational awareness. |



### PLATFORM

*Host platform*

- air = airborne
- grd-fix = ground-fixed
- grd-mob = ground-mobile
- ship = shipboard
- sub = submarine

### WEIGHT

*Weight in lb/kg*

### FEATURES

*Additional features*

- CW = continuous wave
- EDW = emitter descriptor word
- FDOA = frequency difference of arrival
- FMCW = frequency-modulated continuous-wave
- GUI = graphical user interface
- POI = Probability of Intercept
- PDW = pulse descriptor word
- TDOA = time difference of arrival

### OTHER ABBREVIATIONS USED

- < = greater than
- > = less than
- min = minimum
- max = maximum
- deg = degree
- freq = frequency

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

## FEBRUARY 2020 PRODUCT SURVEY: FPGA BOARD FOR EW AND SIGINT APPLICATIONS

**This survey will cover Field Programmable Gate Array boards for electronic warfare (EW), communications intelligence (COMINT) and electronic intelligence (ELINT) applications. Please e-mail JEDeditor@naylor.com to request a survey questionnaire.**

# 49th Annual Collaborative EW Symposium

ASSOCIATION OF OLD CROWS

31 MARCH - 2 APRIL 2020 Pt. Mugu, CA

**Registration Opens: December 16**
**Base Access Deadline: February 14**
**Security Clearance Deadline: February 28**

## CALL FOR PRESENTATIONS:

The 49th Annual Point Mugu Collaborative Electronic Warfare Symposium will provide a venue to disseminate current research in the fields of Collaborative Electronic Warfare, with an emphasis on EW in support of distribute maritime Operations. Prominent leaders, contributors, and representatives from the military, government, academia, and industry will come together to address current Electronic Warfare gaps to support distributed operations and emerging technologies required to address these gaps.

This call for presentations or demonstrations challenges presenters to explore collaborative EW through innovation and invention. Presentations or demonstrations from all Services, DoD, Industry, and Academia are requested to identify technical paths, options, and potential opportunities for EW collaboration with a support to Distributed operations focus. Submitted abstracts are specifically requested to address one or more of the symposium topics:

- **Jointly interoperable EW technologies**
- **EW technology advancements impact on TTPs**
- **Speed to DMO Fleet**

**Visit crows.org/CollaborativeEW2020 for full submission instructions.**

- **Submittal deadline: Monday, January 20, 2020**
- **Notification of acceptance: Monday, February 3, 2020**
- **Final presentations and disclosure paperwork due: Wednesday, March 18**

VISIT **CROWS.ORG/COLLABORATIVEEW2020** FOR MORE INFORMATION

NAVY PHOTO: MASS COMMUNICATION SPECIALIST 2ND CLASS TAYLOR DIMARTINO

# 2020 EW/SIGINT Resource Guide



**Welcome to the 2020 Electronic Warfare and Signals Intelligence Resource Guide. This guide is the print snapshot of the AOC's online EW/SIGINT Resource Guide, edited by *JED* editors. It is designed to list companies and organizations that manufacture products or provide services in the areas of electronic warfare and signals intelligence. This year, we added some new categories.**

AIR FORCE PHOTO: ARMAN 1ST CLASS PEDRO TENORIO

Visit the AOC EW/SIGINT Resource Guide on-line at

**www.ewsigint.net**

## ABOUT THIS GUIDE

This guide was assembled by *JED*'s editorial staff, based on our own research and from updated information provided to us by companies. Though we have attempted to produce a comprehensive listing, we expect this guide to continue to grow. If your company conducts business in the EW or SIGINT markets and it does not appear in this year's guide, please see the note below on how to have your company listed.

## HOW TO USE THIS GUIDE

The guide's first section contains a "company listing," in which companies are featured in alphabetical order. The second section includes product and service categories, roughly organized by components/subsystems, software and services. The third section lists the companies in each category. Refer back to the company section for website and location data on listed companies.

## GET LISTED

If your company is missing or your data requires additional updates, please provide your information to us via e-mail to JEDeditor@naylorcom so we may update our files. Please note that our next print guide will appear in October 2020, however, the online resource guide is live year-round at **www.ewsigint.net**.

## COMPANY LISTINGS

ISTOCK.COM/MAXIPHOTO

# #

**3dB Labs**
www.3db-labs.com

**3SDL**
www.3sdl.com

# A

**Aaronia AG**
www.aaronia.com

**Abaco Systems**
www.abaco.com

**Acromag**
www.acromag.com

**Adamy Engineering**
dave@lynxpub.com

**Advanced Electronics Company – Military Systems Business Unit**
www.aecl.com

**Advanced Microwave Inc**
www.advmic.com

**Advanced Protection Systems**
www.apsystems.tech

**Advanced Testing Technologies Inc.**
www.attinet.com

**Advantech**
www.advantech.com

**AECOM**
www.aecom.com

**Aegis Corea**
aegiscorea.en.ec21.com

**Aero Telemetry**
www.aerotelemetry.com

**Aeromaoz**
www.aeromaoz.com

**Aeronix, Inc.**
www.aeronix.com

**Aethercomm, Inc.**
www.aethercomm.com

**Airborne Systems Limited**
www.airborne-sys.com

**Airborne Tactical Advantage Company**
www.atacusa.com

**AirScan Inc.**
www.airscan.com

**AKON, Inc.**
www.akoninc.com

**Alaris Antennas**
www.alarisantennas.com

**Albrecht Telecommunications**
www.albrecht-telcom.ch

**Alion Science and Technology**
www.alionscience.com

**Alker Optical Equipment**
www.alker.co.uk

**Allen-Vanguard Corp.**
www.allenvanguard.com

**Alpha Design Technologies Pvt. Ltd**
www.adtl.co.in

**American Microwave Corp.**
www.americanmicrowavecorp.com

**Ampex**
www.ampex.com

**Amplifier Solutions Corp.**
www.amplifiersolutions.com

**AmpliTech**
www.amplitechinc.com

**Amplus Corporation**
www.amplus-corp.com

**AMT Microwave Corp.**
www.amt-microwave.com

**Analog Devices Inc.**
www.analog.com

**Anaren, Inc.**
www.anaren.com

**Anatech Electronics**
www.anatechelectronics.com

**Annapolis Micro Systems, Inc.**
www.annapmicro.com

**Anritsu**
www.anritsu.com

**ANSYS, Inc.**
www.ansys.com

**Antenna Authority**
www.antennaauthorityinc.com

**Antenna Experts**
www.antennaexperts.in

**Antenna Products**
www.antennaproducts.com

**Antenna Research Associates**
www.ara-inc.com

**AntiDrone**
https://anti-drone.eu

**API Technologies Inc.**
www.apitech.com

**ApisSys**
www.apissys.com

**ApolloShield**
www.apolloshield.com

**Applied EM Inc.**
www.appliedem.com

**Applied Radar Inc.**
www.appliedradar.com

**Applied Research Associates**
www.ara.com

**Applied Systems Engineering Inc.**
www.applsys.com

**Applied Thin Film Products**
www.thinfilm.com

**AR RF/Microwave Instrumentation**
www.arworld.us

**ARC Technologies**
www.arc-tech.com

**ARA, Inc.**
www.ara-inc.com

**Arctan, Inc.**
www.arctan-group.com

**Argon ST, a Boeing Company**
www.argonst.com

**ARS Products**
www.arsproducts.com

**ArtSYS360**
www.artsys360.com

**ASELSAN Inc.**
www.aselsan.com.tr

**Assemblies Inc.**
www.assembliesinc.net

**Association of Old Crows**
www.crows.org

**Astronautics C.A. Ltd**
www.astronautics.co.il

**Astronics**
www.astronics.com

**ATDI**
www.atdi.com

**Atkinson Aeronautics and Technology Inc.**
www.ataero.com

**Atlanta Micro**
www.atlantamicro.com

**Atos**
www.atos.net

**Avalon Electronics, Inc.**
www.avalonelectronics.co.uk

**AVdef – Avition Defence Service**
www.avdef.fr

**Azure Summit Technology**
www.azuresummit.com

**Alpha Design Technologies Pvt. Ltd**
www.adtl.co.in

# B

**B&K Precision**
Yorba Linda, CA, USA
www.bkprecision.com

**Babcock International Group, Defence and Security Div.**
London, UK
www.babcockinternational.com

**BAE Systems**
www.baesystems.com

**BARCO**
www.barco.com

**Base2 Engineering LLC**
www.base2engineering.com

**BATS**
www.bats.be

**Battelle**
www.battelle.org

**Battlespace Simulations**
www.bssim.com

**BC Systems**
www.bcpowersys.com

**Behlman Electronics**
www.behlman.com

**BEL – Bharat Electronics Ltd.**
www.bel-india.com

**Berkeley Nucleonics Corp.**
www.berkeleynucleonics.com

**BIRD Aerosystems**
www.birdaero.com

**Bird Technologies**
www.bird-technologies.com

**BittWare**
www.bittware.com

**BJG Electronics**
www.bjgelectronics.com

**Black Sage**
www.blacksagetech.com

**Blue Ridge Envisioneering, Inc.**
www.br-envision.com

**Boeing Military Aircraft**
www.boeing.com

**Boger Electronics**
www.boger.de

**Booz Allen Hamilton, Inc.**
www.boozallen.com

**Boyd Corporation**
www.boydcorp.com

**Broadfield Security Services**
www.bssholland.com

**BSC Filters**
www.dovermpg.com/bscfilters

## C

**C&S Antennas**
www.csantennas.com

**Cablex PTY Ltd**
www.cablex.com.au

**CACI Technologies Inc.**
www.caci.com

**CAL-AV Labs Inc.**
www.cal-av.com

**Carlisle Interconnect Technologies**
www.carlisleit.com

**CDI Corp.**
www.cdicorp.com

**CDM Electronics**
www.cdmelectronics.com

**CEA Technologies**
www.cea.com.au

**CellAntenna Corp.**
www.cellantenna.com

**CerbAir**
www.cerbair.com

**Chemring Australia**
www.chemring.com.au

**Chemring Countermeasures UK**
www.chemringcm.com

**Chemring Countermeasures USA**
www.alloysurfaces.com

**Chemring Technology Solutions**
www.chemringts.com

**Chesapeake Technology Intl. Corp.**
www.chesapeake technology.com

**Chordell Systems Ltd.**
www.chordell.co.uk

**CI Systems (Israel) Ltd.**
www.ci-systems.com

**Ciao Wireless, Inc.**
www.ciaowireless.com

**CILAS**
www.cilas.com

**CISR Babcock International Group**
www.babcockinternational.com

**Citadel Defense**
www.dronecitadel.com

**Clausewitz Technology**
www.clausewitztechnology.com

**Clearbox Systems**
www.clearboxsystems.com.au

**Cobham**
www.cobham.com

**Coherent Nufern**
www.nufern.com

**COJOT**
www.cojot.com

**Coleman Microwave Company**
www.colemanmw.com

**Collins Aerospace**
www.rockwellcollins.com/ewsigint

**Colorado Engineering Inc.**
www.coloradoengineering.com

**COMINT Consulting**
www.comintconsulting.com

**CommsAudit**
www.commsaudit.com

**Communication Power Corporation**
www.cpcamps.com

**Communications & Power Industries, Inc (CPI)**
www.cpii.com

**Communications Audit UK Limited**
www.commsaudit.com

**Completer.net**
www.completer.net

**ComSearch**
www.comsearch.com

**COMSEC LLC**
www.comsecllc.com

**Comtech PST**
www.comtechpst.com

**Concurrent Technologies**
www.ctc.com

**Conduant Corp.**
www.conduant.com

**Corvus**
www.corvusgroup.org

**Crane Aerospace & Electronics**
www.craneae.com

**CRFS**
www.crfs.com

**CSIR – DPSS**
www.csir.co.za

**CTL SystemWare**
www.sysware.com

**CTS Technology Co. Ltd.**
www.ctstechnologys.com

**CTT, Inc.**
www.cttinc.com

**Cubic Global Defense**
www.cubic.com

**Cubic Nuvotronics**
www.nuvotronics.com

**Cuming Microwave Corp.**
www.cumingmicrowave.com

**Curtiss-Wright Defense Solutions**
www.cwcdefense.com

**Custom Cable Assemblies, Inc.**
www.customcableinc.com

**Custom MMIC**
www.custommmic.com

**CyberRadio Solutions**
www.cyberradiosolutions.com

## D

**D-Fend Solutions A.D. Ltd.**
www.d-fendsolutions.com

**DAICO Industries**
www.daico.com

**DaqScribe Solutions, LLC**
www.daqscribe.com

**DARE Electronics, Inc.**
www.dareelectronics.com

**Darkblade Systems Corp.**
www.darkbladesystems.com

**Dayton-Granger**
www.daytongranger.com

**dB Control**
www.dBControl.com

**DCS Corp**
www.dcscorp.com

**Decodio AG**
www.decodio.com

**DeDrone**
www.dedrone.com

**Deepwave Digital**
www.deepwavedigital.com

**Defence Research and Development Canada**
www.drdc-rddc.gc.ca

**Défense Conseil International (DCI)**
www.groupedci.com

**Defense Engineering Corp.**
www.defengcorp.com

**Defense Research Associates, Inc.**
www.dra-engineering.com

**Delphi Engineering Group**
www.delphieng.com

**Department 13**
www.department13.com

**DeTect Inc.**
www.detect-inc.com

**DHPC Technologies**
www.dhpctech.com

**Diamond Microwave**
www.diamondmw.com

**Diehl Defence**
www.diehl.com

**Digital Receiver Technology, A Boeing Company (DRT)**
www.drti.com

**DILAS Diodenlaser GmbH**
www.dilas.com

**diminuSys**
www.diminusys.com

**Dow-Key Microwave**
www.dowkey.com

**Dr. EW (Johnny Heikell)**
www.heikell.fi

**Dragoon ITCN**
www.dragoonitcn.com

**Dreamlab Technologies AG**
www.dreamlab.net

**DroneShield**
www.droneshield.com

**DRS Daylight Solutions**
www.daylightsolutions.com

**DSE International**
www.dseinternational.com

**D-TA Systems**
www.d-ta.com

**Ducommun Technologies**
www.ducommun.com

**Dynamic Analytics & Test, Inc.**
www.dat-inc.com

**Dynamic Signals LLC.**
www.dynamicsignals.com

**DynaWave Inc.**
www.dynawave.com

**Dynetics Inc.**
www.dynetics.com

## E

**Ecrin Systems**
www.ecrin.com

**ECS, LLC**
www.ecs-federal.com

**Elbit Systems**
www.elbitsystems.com

## COMPANY LISTINGS

**ELDES S.r.l.**
www.eldesradar.com

**Electro-Metrics Corp.**
www.electro-metrics.com

**Electronic Warfare Studying Group, Korean Institute of Electromagnetic Engineering & Science**
www.kiees.or.kr/english

**Electronic Warfare Tactical/ Training Support**
www.ewtsllc.com

**Elektrobit**
www.elektrobit.com

**Elettronica SpA**
www.elt-roma.com

**Elite RF**
www.eliterfllc.com

**ELTA Systems Ltd.**
www.iai.co.il

**EM Research**
www.emresearch.com

**Emhiser Research, Inc.**
www.emhiser.com

**Empower RF Systems**
www.EmpowerRF.com

**Enablia S.R.L.**
www.enablia.com

**Enterprise Control Systems**
www.enterprisecontrol.co.uk

**Epiq Solutions**
www.epiqsolutions.com

**Erzia**
www.erzia.com

**Espy Corp.**
www.espy.com

**ESROE**
www.esroe.com

**Esterline Defense Technologies**
www.esterline.com

**ET Industries**
www.etiworld.com

**ETL Systems**
www.etlsystems.com

**ETM Electromatic Inc.**
www.etm-inc.com

**ETS-Lindgren**
www.ets-lindgren.com

**Evans Capacitor Company**
www.evanscap.com

**EWA – Electronic Warfare Associates**
www.ewa.com

**Excelitas Technologies**
www.excelitas.com

**Exodus Advanced Communications**
www.exoduscomm.com

**Extant Aerospace**
www.extantaerospace.com

**Extreme Engineering Solutions (X-ES)**
www.xes-inc.com

## F

**Fairview Microwave**
www.fairviewmicrowave.com

**FEI-Elcom Tech**
www.fei-elcomtech.com

**FEI-Zyfer**
www.zyfer.com

**First RF Corp.**
www.firstrf.com

**Flann Microwave**
www.flann.com

**FLEXCO Microwave**
www.flexcomw.com

**Fractal Antenna Systems**
www.fractenna.com

**FS Antennentechnik GmbH**
www.fsant.de

## G

**Galleon Embedded Computing**
www.galleonembedded.com

**General Atomics**
www.ga.com

**General Dynamics Mission Systems**
www.gdmissionsystems.com

**Georgia Tech Research Institute**
www.gtri.gatech.edu

**GEW Technologies (Pty) Ltd.**
www.gew.co.za

**Giga-tronics Inc.**
https://go-asg.gigatronics.com

**Good Will Instrument Co. Ltd**
www.gwinstek.com

**Gowanda Components Group**
www.gowanda componentsgroup.com

## H

**HARP**
www.harparge.com

**Hascall-Denke**
www.hascall-denke.com

**HawkEye 360**
www.he360.com

**HAVELSAN**
www.havelsan.com.tr

**Hegarty Research LLC**
www.hegartyresearch.com

**Hensoldt**
www.hensoldt.net

**Hensoldt South Africa**
www.herotek.com

**Hermetic Solutions**
www.hermeticsolutions.com

**Herotek, Inc.**
www.herotek.com

**Herrick Technology Labs**
www.herricktechlabs.com

**High + Mighty International**
www.anti-drones.net

**HIK Vision**
www.en.hikrobotics.com

**Honeywell Aerospace**
www.aerospace.honeywell.com

**Horizon Technologies**
www.horizontechnologies.eu

**HP Marketing and Consulting Wüst GmbH**
www.hp-jammer.de

**HUBER+SUHNER AG**
www.hubersuhner.com

**Hunan NovaSky Electronic Technology**
www.novasky.cn

## I

**IACIT**
**http://iacit.com.br**

**IDSI LLC**
www.idsillc.com

**I.F. Engineering Corp.**
www.ifengineering.com

**IFI – Instruments for Industry Inc.**
www.ifi.com

**IKHANA Aircraft Services**
www.ikhanagroup.com

**IMI Systems**
www.imisystems.com

**INDRA**
www.indracompany.com

**Innovative Integration**
www.innovative-dsp.com

**Intel Product Solutions Group**
www.altera.com

**Intelligent Automation Inc.**
www.i-a-i.com

**Intelligent RF Solutions – iRF**
www.irf-solutions.com

**Interface Concept**
www.interfaceconcept.com

**Invisible Interdiction**
http://invisidiction.com

**ISPAS AS**
www.ispas.biz

**iVeia, LLC**
www.iveia.com

**IW Microwave**
www.iw-microwave.com

**IZT GmbH**
www.izt-labs.de

## J

**Jabil Defense and Aerospace Services**
www.jabil.com

**Jackson Labs Technologies, Inc.**
www.jackson-labs.com

**JEM Engineering**
www.jemengineering.com

**Jenkins Engineering Defence Systems**
www.jeds.com.au

**Jersey Microwave**
www.jerseymicrowave.com

**JFW Industries**
www.jfwindustries.com

**JMC Defence Ltd.**

**Jordan Electronic Logistic Support – Electronic Warfare**
www.jels-tech.com

**JT4 LLC**
www.jt4llc.com

## K

**K&L Microwave, Inc.**
www.klmicrowave.com

**Kerberos International**
www.kerberosinc.com

**Keysight Technologies**
www.keysight.com

**Kihomac, Inc.**
www.kihomac.com

**Kirintec**
www.kirintec.com

**KMIC Technology, Inc.**
www.kmictech.com

**Knowles Precision Devices**
www.knowlescapacitors.com

**Kranze Technology Solutions, Inc. (KTS)**
www.kranzetech.com

**Kratos**
www.kratosdefense.com

**Krytar Inc.**
www.krytar.com

## L

**L3 Harris**
www.l3harris.com

**L3 Harris Narda-Miteq**
www.nardamiteq.com

**Lacroix**
www.lacroixds.com

**Laird Technologies**
www.lairdtech.com

**LCR Embedded Systems**
www.lcrembeddedsystems.com

**Leidos, Inc.**
www.leidos.com

**Leonardo**
www.leonardocompany.com

**Lexatys**
www.lexatys.com

**Link Microtek**
www.linkmicrotek.com

**Linwave Technology**
www.linwave.co.uk

**Liteye Systems, Inc.**
www.liteye.com

**Littelfuse**
www.littelfuse.com

**Lockheed Martin**
www.lockheedmartin.com

**LOG.IN Srl**
www.loginshowroom.com

**Logus Microwave**
www.logus.com

**LS Telcom**
www.lstelcom.com

## M

**MacAulay-Brown – Alion Science**
www.macb.com

**MACOM**
www.macom.com

**MagiQ Technologies, Inc.**
www.magiqtech.com

**ManTech International Corp.**
www.mantech.com

**MarServices GmbH**
www.marservices.de

**MASS Consultants Limited**
www.mass.co.uk

**MBDA**
www.mbda-systems.com

**MC Countermeasures Inc.**
www.mc-cm.com

**MCTech**
www.mctech-jammers.com

**MECA Electronics**
www.e-meca.com

**MegaPhase**
www.megaphase.com

**Meggitt**
www.meggitt.com

**MEMtroncs Corp.**
www.memtronics.com

**Mercer Engineering Research Center**
www.merc-mercer.org

**Mercury Electronic Warfare Ltd**
www.mercuryew.com

**Mercury Systems**
www.mrcy.com

**Meritis Group**
www.meritis.ch

**MES S.p.A.**
www.mesroma.it

**MESL Microwave**
www.meslmicrowave.com

**Metamagnetics**
www.mtmgx.com

**Metis Aerospace Ltd**
www.metisaerospace.com

**Micro Lambda Wireless, Inc.**
www.microlambdawireless.com

**Micronetixx, P.A.**
www.micronetixx.com

**Microphase Corp.**
www.microphase.com

## COMPANY LISTINGS

**Microwave Amplifiers Ltd.**
www.microwaveamps.co.uk

**Microwave Communications Laboratories**
www.mcli.com

**Microwave Dynamics**
www.microwave-dynamics.com

**Microwave Engineering Corp.**
www.microwaveeng.com

**Microwave Filter Company**
www.microwavefilter.com

**Microwave Specialty Company**
www.microwavespecialty.com

**Mid-Atlantic RF Systems**
www.midatlanticrf.com

**Midwest Microwave Solutions Inc.**
www.mms-rf.com

**Military Optical RF Equipment Ltd.**
www.eimore.co.il

**MILMEGA, a Teseq Company**
www.milmega.co.uk

**Milso AB**
www.milso.se

**Mini-Circuits**
www.minicircuits.com

**Mission Microwave Technologies**
www.missionmicrowave.com

**The Mitre Corporation**
www.mitre.org

**Mitsubishi Electric Corp.**
www.mitsubishielectric.com

**Modern Technology Solutions, Inc.**
www.mtsi-va.com

**Momentive Performance Materials**
www.momentive.com

**Montena Technology sa**
www.montena.com

**Motorola Solutions**
www.motorolasolutions.com

**MRSL**
www.mrsl.com

**Multiconsult SRL**
www.multi-consult.com

**mWave Industries, LLC**
www.mwavellc.com

**My-konsult**
www.mykonsult.com

**MyDefence Communication**
http://mydefence.dk

## N

**N-Ask Incorporated**
www.nask.world

**Nallatech, Inc., a subsidiary of Interconnect Systems Inc.**
www.nallatech.com

**Narda Safety Test Solutions**
www.narda-sts.com

**National Instruments Corp.**
www.ni.com

**NEC Network and Sensor Systems, Ltd.**
www.necnets.co.jp

**NEL Frequency Controls, Inc.**
www.nelfc.com

**Netline Communications Technologies**
www.netlinetech.com

**Norden Millimeter, Inc.**
www.nordengroup.com

**Northeast Information Discovery, Inc.**
www.neidinc.com

**Northrop Grumman Corp.**
www.northropgrumman.com

**Nova Systems**
www.novadefence.com.au

**Novatech Instruments**
www.novatech-instr.com

**NovAtel**
www.novatel.com

**Novator Solutions AB**
www.novatorsolutions.com

**NuWaves Engineering**
www.nuwaves.com

**NXP Semiconductors**
www.nxp.com

## O

**Ocean Microwave Corp.**
www.oceanmicrowave.com

**Octane Wireless**
www.octanewireless.com

**OEwaves**
www.oewaves.com

**OPHIR RF**
www.ophirrf.com

**Orad**
www.orad.cc

**Overlook Systems Technologies, Inc.**
www.overlooksys.com

## P

**Parker Aerospace**
www.parker.com

**Parry Labs**
www.parrylabs.com

**Parsec**
www.parsec.co.za

**Parsons**
www.parsons.com

**Pascall Electronics Limited**
www.pascall.co.uk

**Pasternack Enterprises**
www..com

**Patria**
www.patria.fi

**PCTEL Inc. – Antenna Products**
antenna.pctel.com

**Pendar Technologies**
www.pendartechnologies.com

**Pentek**
www.pentek.com

**Peralex**
www.peralex.com

**Per Vices Corp.**
www.pervices.com

**Petards Group**
www.petards.com

**Phantom Technologies Ltd.**
www.phantomtechnologies.com

**Phase II Staffing and Contracting LLC**
www.p2sc.net

**Phase Matrix**
www.phasematrix.net

**Phasor Innovation**
www.phasorinnovation.com

**Phoenix Air**
www.phoenixair.com

**Photonis**
www.photonis.com

**Physical Optics Corp.**
www.poc.com

**PKI Electronic Intelligence**
www.pki-electronic.com

**Planar Monolithics Industries, Inc.**
www.pmi-rf.com

**PLATH AG**
www.plath-ag.ch

**PLATH GmbH**
www.plath.de

**Plexsa Manufacturing**
www.plexsa.com

**Plextek Consulting**
www.plextek.com

**Pole/Zero Corp.**
www.polezero.com

**Pranalytica**
www.pranalytica.com

**Precision Connector, Inc.**
www.precisionconnector.com

**Precision Display Technologies**
www.pdt-usa.com

**PROCITEC GmbH**
www.procitec.com

**Professional Development TSCM Group**
www.pdtg.ca

## Q

**Q Microwave, Inc.**
www.qmicrowave.com

**QinetiQ Ltd.**
www.QinetiQ.com

**Qnion Co., Ltd**
www.qnion.com

**Qorvo**
www.qorvo.vom

**QRC Technologies**
www.qrctech.com

**QuantiTech**
www.quantitech.com

**Quarterwave Corp.**
www.quarterwave.com

**QuinStar Technology, Inc.**
www.quinstar.com

## R

**R.A. Wood Associates**
www.rawood.com

**RADA Technologies LLC**
www.rada.com

**Radiall**
www.radiall.com

**Radio Reconnaissance Technologies**
www.radiorecon.com

**Radixon**
www.radixon.com

**RADX Technologies**
www.radxtech.com

**Rafael**
www.rafael.co.il

**Rantelon**
www.rantelon.ee

**Raytheon**
www.raytheon.com

**Red Rapids**
www.redrapids.com

**Renaissance Electronics Corp.**
www.rec-usa.com

**Research Associates of Syracuse (RAS)**
www.ras.com

**Research Electronics International (REI)**
www.reiusa.net

**Reut Systems & Technologies (RST)**
www.rst-tech.co.il

**RF COM Sistemas Ltda.**
www.rf.com.br

**RF Engines Ltd.**
www.rfel.com

**RF Industries**
www.rfindustries.com

**RF Logic**
www.rflogic.net

**RFcore Co, Ltd.**
www.rfcore.com

**RFHIC USA**
www.rfhic.com

**RH Laboratories**
www.rh-labs.com

**Rheinmetall Defence**
www.rheinmetall-defence.com

**Rincon Research Corporation**
www.rincon.com

**Rising Edge Technologies**
www.risingedge.com

**Riverside Research Institute**
www.riversideresearch.org

**Rodale Electronics Inc.**
www.rodaleelectronics.com

**Rodelco Electronics Corp.**
www.rodelco-usa.com

**Rohde & Schwarz GmbH & Co. KG**
www.rohde-schwarz.com

**Rotating Precision Mechanisms, Inc.**
www.rpm-psi.com

**RT Logic, Inc., a Kratos Company**
www.rtlogic.com

**RUAG – Aerospace**
www.ruag.com

**Rubisoft**
www.rubisoft.fr

## S

**S2 Corp.**
www.s2corporation.com

**Saab**
www.saabgroup.com

**Safran Electronics and Defense**
www.safran-electronics-defense.com

**Sagax Communications**
www.sagaxcommunications.com

**Sage Millimeter**
www.sagemillimeter.com

**SAIC**
www.saic.com

**Samel 90**
www.samel90.com

**Santa Barbara Infrared Inc.**
www.sbir.com

**SAT Corp., a Kratos Company**
www.sat.com

**SATIMO**
www.satimo.com

**Schaefer Electronics**
www.schaeferpower.com

**Scientific Research Corp**
www.scires.com

**SEA**
www.sea.co.uk

## COMPANY LISTINGS

**Sechan Electronics Inc.**
www.sechan.com

**Select Fabricators**
www.select-fabricators.com

**Selex Galileo, Inc. (a Leonardo-Finmeccanica Company)**
www.selexgalileo.com

**Sensofusion**
www.sensofusion.com

**SensorCom Inc.**
www.sensorcominc.com

**Seqtor ApS**
www.seqtor.com

**Serpikom**
www.serpikom.eu

**SESP Group**
www.sesp.com

**Seven Technologies Group**
www.7techgroup.com

**Shakespeare Military Products**
www.shakespeare-military.com

**Shoghi Communications Ltd.**
www.shoghi.co.in

**Sierra Nevada Corp.**
www.sncorp.com

**Signal Antenna Systems Inc.**
www.signalantenna.com

**Signal Hound**
www.signalhound.com

**SignalCore Inc.**
www.signalcore.com

**Silentium Defence**
www.silentiumdefence.com.au

**Silver Palm Technologies**
www.silverpalmtech.com

**Simulation Technologies**
www.simtechinc.com

**SimVentions**
www.simventions.com

**SINTIS Technology Ltd.**
www.sintistechnology.com

**Sivers IMA AB**
www.siversima.com

**SkySafe**
www.skysafe.io

**Skyworks Solutions**
www.skyworksinc.com

**SMAG Mobile Antenna Masts GmbH**
www.smam.de

**Smiths Interconnect**
www.smithsinterconnect.com

**Solid State Devices, Inc.**
www.ssdi-power.com

**Southwest Antennas**
www.southwestantennas.com

**Southwest Microwave**
www.southwestmicrowave.com

**Southwest Research Institute (SwRI)**
www.swri.org

**Spatial and Spectral Research**
www.ssrllc.us

**Spectra Research**
www.spectra-research.com

**Spectranetix Inc.**
www.spectranetix.com

**Spherea GmbH**
www.spherea.de

**Spirent Communications**
www.spirent.com

**SRI International**
www.sri.com

**SRC**
www.srcinc.com

**Steatite Antennas**
www.steatite-antennas.co.uk

**SteelRock Technologies**
www.sruav.co.uk

**SunCastle Microwave, LLC**
www.suncastlemicrowave.com

**Sundance DSP**
www.sundancedsp.com

**SURVICE Engineering Co.**
www.survice.com

**Swedish Defence Materiel Administration T&E Directorate (FMV T&E)**
www.defence-and-security.com

**Syncopated**
www.syncopatedproducts.com

**Syncopated Engineering**
www.syncopatedengr.com

**Syntonic Microwave Corp.**
www.syntonicmicrowave.com

**Sypris Solutions**
www.sypris.com

**Systematic**
www.systematic.com

**Systems & Processes Engineering Corp. (SPEC)**
www.spec.com

## T

**TACO Antenna**
www.tacoantenna.com

**Tabor Electronics Ltd**
www.taborelec.com

**Tampa Microwave, a subsidiary of Thales Defense and Security**
www.tampamicrowave.com

**Tata Advanced Systems Limited (TASL)**
www.tataadvancedsystems.com

**Tata Power Strategic Electronics Division**
www.tatapowersed.com

**TCI International, Inc., an SPX Company**
www.tcibr.com

**TE Connectivity**
www.te.com

**TechComm**
www.techcommdf.com

**Tech Resources, Inc. (TRI)**
www.trimilford.com

**TEK Microsystems, Inc.**
www.tekmicro.com

**Tektronix**
www.tek.com

**Teledyne Technologies**
www.teledynesolutions.com

**Teleplan Globe Defence**
www.teleplanglobe.no/defence

**TeleRadio Engineering Pte Ltd**
www.skydroner.com

**Ten-Tec**
www.tentec.com

**Terma AS**
www.terma.com

**Terra Hexen Group**
www.terrahexen.com

**Texas Instruments**
www.ti.com

**Textron Systems**
www.textronsystems.com

**Thales**
www.thalesgroup.com

**Thermacore**
www.thermacore.com

**ThinkRF**
www.thinkrf.com

**Times Microwave Systems**
www.timesmicrowave.com

**TINEX AS**
www.tinex.no

**TJR Global**
www.trjglobal.com

**TMC Design Corp.**
www.tmcdesign.com

**TMD Technologies Ltd.**
www.tmd.co.uk

**Top Aces**
www.topaces.com

**Toyon Research Corp.**
www.toyon.com

**Transformational Security LLC**
www.powerfulsecurity.com

**TRD Consultancy Pte Ltd**
www.trd.com

**Tri Star Engineering, Inc.**
www.star3.com

**Triad RF Systems Inc.**
www.triadrf.com

**TriaSys Technologies Corp.**
www.triasys.us

**Trident Systems Inc.**
www.tridsys.com

**Trival Antene**
www.trivalantene.si

**TrustComm**
www.trustcomm.com

**TSF5**
www.tsf5.com

**TTE Filters**
www.tte.com

**TUALCOM, Inc.**
www.tualcom.com

**TÜV SÜD**
www.tuv-sud.com

## U

**U B Corp.**
www.ubcorp.com

**Ultra Electronics – Australia**
www.ultra-electronics.com.au

**Ultra Electronics – Herley**
www.ultra-herley.com

**Ultra Electronics Limited – EWST**
www.ultra-cis.com

**Ultra Electronics TCS**
www.ultra-tcs.com

**Ultraview Corp.**
www.ultraviewcorp.com

**United Monolithic Semiconductor**
www.ums-gaas.com

**URC Systems**
www.urc-systems.cz

**US Dynamics Corp.**
www.usdynamicscorp.com

**US Technologies-Aldetec**
www.ust-aldetec.com

**UTC Aerospace Systems**
www.utcaerospacesystems.com

## V

**VadaTech, Inc.**
www.vadatech.com

**Vadum Inc.**
www.vaduminc.com

**Valkyrie Enterprises LLC**
www.valkyrie.com

**Varilog Research, Inc.**
www.varilog.com

**Vecicma Networks**
www.vecima.com

**Verint**
www.verint.com

**ViaSat, Inc.**
www.viasat.com

**VIAVI Solutions, Inc.**
www.viavisolutions.com

**Vicor Corp.**
www.vicorpower.com

**Virtualabs srl**
www.virtualabs.it

## W

**W.L. Gore and Associates**
www.gore.com

**Wang Electro-Opto Corp.**
www.weo.com

**Warfare Solutions LLC**
www.warfaresolutions.com

**Wavepoint Research, Inc.**
www.wavepointresearch.com

**Wenteq Microwave Corporation**
www.wenteq.com

**Werlatone, Inc.**
www.werlatone.com

**WGS Systems, Inc.**
www.wgssystems.com

**WhiteFox Defense Technologies, Inc.**
www.whitefoxdefense.com

**Wide Band Systems Inc.**
www.widebandsystems.com

**Wideband Systems, Inc.**
www.wideband-sys.com

**Winchester Interconnect**
www.winconn.com

**Windfreak Technologies, LLC**
www.windfreaktech.com

**Wolfspeed**
www.wolfspeed.com

**Wright Technologies Inc.**
www.wrighttec.com

**Wyle Laboratories, Inc.**
www.wyle.com

## Z

**Z Microsystems, Inc.**
www.zmicro.com

# 2019 EW/SIGINT Resource Guide

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ISTOCK.COM/DANI3315

## RF MICROWAVE COMPONENTS & SUBSYSTEMS

### Antennas/Arrays

Aero Telemetry
Alaris Antennas
AMT Microwave Corp.
Antenna Authority
Antenna Experts
Antenna Research Associates
API Technologies
Applied EM Inc.
ARA, Inc.
CAL-AV Labs Inc.
CEA Technologies
Cobham
COJOT
Communications & Power Industries, Inc (CPI)
Comtech PST
Cubic Nuvotronics
Dayton-Granger
Defence Research and Development Canada
Electro-Metrics
ET Industries
ETS-Lindgren
European Antennas
First RF Corp.
Flann Microwave
Fractal Antenna Systems
FS Antennentechnik GmbH
Hascall-Denke
HUBER+SUHNER AG
IFI – Instruments for Industry Inc.
JEM Engineering
Jenkins Engineering Defence Systems
L3 Harris – Linkabit
L3 Harris – Randtron Antenna Systems
L3 Harris – US
Leonardo
Link Microtek
MEDAV GmbH
Micronetixx, P.A.
Mercury Systems
Microwave Engineering Corp.
Microwave Specialty Company
Microwave Technologies Inc.
Montena Technology sa
mWave Industries, LLC
NovAtel
Ocean Microwave Corp.
Octane Wireless
PCTEL Inc.
PLATH GmbH
QuinStar Technology, Inc.
Radio Reconnaissance Technologies
Rantelon
Rincon Research Corporation
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
Rubisoft
Saab
SATIMO
Seqtor ApS
Shakespeare Military Antenna Products
Signal Antenna Systems Inc.
SMAG Mobile Antenna Masts GmbH
Southwest Antennas
Southwest Research Institute
Steatite Antennas
SunCastle Microwave LLC
TACO Antenna
TCI
TechComm
TECOM Industries, Inc.
Transformational Security LLC
Trival Antene
U B Corp.
Ultra Electronics – Herley
Wang Electro-Opto Corp.

### Antenna Mounts/ Support Structures

Cobham
IKHANA Aircraft Services
Hascall-Denke
L3 Harris – Randtron Antenna Systems
Rotating Precision Mechanisms, Inc.
SMAG Mobile Antenna Masts GmbH
Steatite Antennas
TECOM Industries, Inc.

### Antenna Radomes

API Technologies
CEA Technologies
Cobham
HUBER+SUHNER AG
IKHANA Aircraft Services
L3 Harris – Randtron Antenna Systems
L3 Harris – US
Meggitt
PLATH GmbH
Steatite Antennas
TECOM Industries, Inc.

### Active RF Components

Analog Devices Inc.
Anaren, Inc.
API Technologies
Applied Thin Film Products
Cobham
Crane Aerospace & Electronics
EM Research
ET Industries
I.F. Engineering Corp.
IZT GmbH
Jabil Defense and Aerospace Services
Jersey Microwave
L3 Harris – Electron Device Division
L3 Harris – Narda-Miteq
MACOM
Mercury Systems
Micro Lambda Wireless, Inc.
Pole/Zero Corp.
Rodelco Electronics Corp.
Tektronix
Teledyne Technologies
Times Microwave Systems
TRAK Microwave
US Dynamics Corp.
Wolfspeed

### Analog-to-Digital Converter Boards

Abaco Systems
ApisSys
Analog Devices Inc.
Annapolis Micro Systems
API Technologies
Avalon Electronics, Inc.
Bittware, Inc.
CEA Technologies
Cobham
Curtiss-Wright Defense Solutions
Delphi Engineering Group
Dynamic Signals LLC
Innovative Integration
Intersil
iVeia, LLC
Mercury Systems
Pentek
Protium Technologies, Inc.
Red Rapids
Rockwell Collins
Spectrum Signal Processing
Sundance DSP
TEK Microsystems, Inc.
Tektronix
Teledyne Technologies
Texas Instruments
Themis
Ultraview Corp.
VadaTech, Inc.
X-COM Systems, LLC

### Digital-to-Analog Converter Boards

Analog Devices Inc.
Annapolis Micro Systems
API Technologies
Bittware, Inc.
Cobham
Curtiss-Wright Defense Solutions
Delphi Engineering Group
Innovative Integration
Intersil
iVeia, LLC
MACOM
Mercury Systems
Pentek
Red Rapids
Tektronix
Teledyne Technologies
X-COM Systems, LLC

### Semiconductor Integrated Circuits

Cobham Sensor Systems
Hittite Microwave
Intersil
MACOM
Tektronix
Teledyne Technologies

### Digital Signal Processors

Analog Devices Inc.
Annapolis Micro Systems, Inc.
API Technologies
BAE Systems
BittWare
Curtiss-Wright Defense Solutions
Dynamic Signals LLC
Intel Product Solutions Group
iVeia, LLC
Mercury Systems
Pentek
Protium Technologies, Inc.
RFEL LTd.
Rockwell Collins

### ASICs

Cobham
Mercury Systems
Tektronix
Teledyne Technologies

### FPGAs and FPGA Boards

Abaco Systems
Annapolis Micro Systems, Inc.
ApisSys
Applied Radar Inc.
BAE Systems
BittWare
Colorado Engineering Inc.
Curtiss-Wright Defense Solutions
Extreme Engineering Solutions
Delphi Engineering Group
Dynamic Signals LLC
Galleon Embedded Computing
Innovative Integration
Interface Concept
Intel Product Solutions Group
iVeia, LLC
Mercury Systems
Nallatech, Inc.
Parsec
Red Rapids
Rincon Research Corporation
Spectranetix, Inc.
TEK Microsystems, Inc.
Ultraview Corp.

### Frequency Converters

AKON, Inc.
Analog Devices Inc.
Anaren, Inc.
API Technologies
Applied Radar Inc.
Cobham
Crane Aerospace & Electronics
CTT, Inc.
EM Research
FEI-Elcom Tech
I.F. Engineering Corp.
Jersey Microwave
K&L Microwave, Inc.
KMIC Technology, Inc.
Kratos
L3 Harris
Mercury Systems
Norden Millimeter
NuWaves Engineering
Planar Monolithics Industries, Inc.
Red Rapids
Renaissance Electronics Corp.
SignalCore
TRAK Microwave
Ultra Electronics – Herley
Wright Technologies, Inc.

## Frequency Synthesizers

AKON, Inc.
Analog Devices
Anritsu
API Technologies
Berkley Nucleonics
Cobham
Crane Aerospace and Electronics
EM Research
FEI-Elcom Tech
L3 Harris – Narda-Miteq
L3 Harris – US
MagiQ Technologies Inc.
Mercury Systems
Micro Lambda Wireless, Inc.
National Instruments Corp.
Novatech Instruments
Phase Matrix
Planar Monolithics Industries, Inc.
Renaissance Electronics Corp.
RFcore Co, Ltd.
Rodelco Electronics Corp.
SignalCore
Sivers IMA AB
Teledyne Technologies
Textron Systems
TRAK Microwave
Ultra Electronics – Herley
Ultraview Corp.
Wide Band Systems Inc.

## Oscillators

Analog Devices Inc.
API Technologies
Cobham
EM Research
FEI-Elcom Tech
Jackson Labs Technologies Inc.
Jersey Microwave
L3 Harris
L3 Harris – Narda-Miteq
MACOM
Mercury Systems
Micro Lambda Wireless, Inc.
Microwave Dynamics
National Instruments Corp.
NEL Frequency Controls, Inc.
Norden Millimeter
Pascall Electronics Limited
Phase Matrix
Qorvo
QuinStar Technology, Inc.
Renaissance Electronics Corp.
Sivers IMA AB
Skyworks Solutions
Syntonic Microwave
TRAK Microwave
Ultra Electronics – Herley
Vectron International

## Low Noise Amplifiers

Aethercomm, Inc.
Amplifier Solutions Corp.
AmpliTech
Analog Devices
API Technologies
ARS Products
Atlanta Micro
Ciao Wireless, Inc.
Cobham
CTT, Inc.
Custom MMIC
Elite RF
Endwave Corp.
Herotek, Inc.
Jersey Microwave
K&L Microwave, Inc.
Keragis
KMIC Technology, Inc.
L3 Harris
MACOM
Mercury Systems
Microwave Communications Laboratories
Microwave Dynamics
Norden Millimeter
NuWaves Engineering
Pascall Electronics Limited
Pasternak
Planar Monolithics Industries, Inc.
Pole/Zero Corp.
Qorvo
QuinStar Technology, Inc.
Renaissance Electronics Corp.
RFHIC
Rodelco Electronics Corp.
Sage Millimeter
Smiths Interconnect
Teledyne Technologies
TRAK Microwave
Triad RF Systems Inc.
Ultra Electronics – Herley
US Dynamics Corp.
US Technologies-Aldetec
Wenteq Microwave Corporation
Wolfspeed
Wright Technologies, Inc.

## Passive RF Components

American Microwave Corp.
Analog Devices Inc.
Anaren, Inc.
Anritsu
API Technologies
Applied Thin Film Products
Bird Technologies
Cobham
Coleman Microwave Company
Crane Aerospace & Electronics
Cubic Nuvotronics
Dielectric Labs
Dow-Key Microwave
Ducommun Technologies
Emhiser Research, Inc.
Endwave Corp.
ET Industries
Herotek, Inc.
Honeywell Aerospace
HUBER+SUHNER AG
I.F. Engineering Corp.
Jabil Defense and Aerospace Services
JFW Industries
K&L Microwave, Inc.
Kratos
Krytar, Inc.
L3 Harris – Narda-Miteq
Lexatys
Link Microtek

Logus Microwave
Lorch Microwave
MACOM
MECA Electronics
Mercury Systems
Microphase Corp.
Microwave Communications Laboratories
Microwave Engineering Corp.
Pascall Electronics Limited
Picosecond Pulse Labs
Planar Monolithics Industries, Inc.
Q Microwave, Inc.
Qorvo
QuinStar Technology, Inc.
Radiall
Renaissance Electronics Corp.
RH Laboratories
Rodelco Electronics Corp.
Skyworks Solutions
Smiths Interconnect
Solid State Devices, Inc.
Teledyne Technologies
TRU Corp.
TTE Filters

## Converters and Mixers

Advanced Microwave Inc.
Anaren, Inc.
Anritsu
API Technologies
Cobham
EM Research
FEI-Elcom Tech
I.F. Engineering Corp.
Jersey Microwave
KMIC Technology, Inc.
L3 Harris – Narda-Miteq
Mercury Systems
QuinStar Technology, Inc.
RH Laboratories
Rodelco Electronics Corp.
Teledyne Technologies
US Technologies-Aldetec

## Couplers

Anaren, Inc.
API Technologies
ARS Products
Atlanta Micro
BJG Electronics
Cobham
Cubic Nuvotronics
DynaWave Inc.
ET Industries
Ferrite Microwave Technologies
Honeywell Aerospace
HUBER+SUHNER AG
I.F. Engineering Corp.
K&L Microwave, Inc.
Krytar Inc.
L3 Harris – Narda-Miteq
MECA Electronics
Mercury Systems
Microwave Communications Laboratories
Microwave Engineering Corp.
Planar Monolithics Industries, Inc.
Precision Connector
Qorvo
Radiall
RF Industries
Rohde & Schwarz GmbH & Co. KG
Southwest Microwave
TE Connectivity
Werlatone, Inc.
Winreak Technologies, LLC

## Fiber-Optic Cable

Alker Optical Equipment
Assemblies, Inc.
HUBER+SUHNER AG
Meggitt Defense Systems

## Fiber-Optic Connectors

Assemblies, Inc.
BJG Electronics
HUBER+SUHNER AG
Meggitt Defense Systems

## Filters and Diplexers

AKON, Inc.
Anatech Electronics
API Technologies
Atlanta Micro
BSC Filters
Cobham
Coleman Microwave Company
Cubic Nuvotronics
Endwave Corp.
ET Industries
Ferrite Microwave Technologies
Gowanda Components Group
Honeywell Aerospace
HUBER+SUHNER AG
KMIC Technology, Inc.
L3 Harris
Lexatys
Link Microtek
Lorch Microwave
MECA Electronics
MEMtroncs Corp.
Mercury Systems
Metamagnetics
Micro Lambda Wireless, Inc.
Micronetixx, P.A.
Microphase Corp.
Microwave Communications Laboratories
Microwave Engineering Corp.
Microwave Filter Company
OEwaves
Physical Optics Corp.
Picosecond Pulse Labs
Plexsa Manufacturing
Pole/Zero Corp.
Q Microwave, Inc.
Syntonic Microwave

## Power Dividers/Combiners

Anatech Electronics
Anaren, Inc.
API Technologies
Cobham
Comtech PST
Cubic Nuvotronics
EMS Technologies, Inc.
ET Industries
HUBER+SUHNER
I.F. Engineering Corp.
JFW Industries
K&L Microwave, Inc.
Krytar, Inc.
L3 Harris – Narda
MECA Electronics
Mercury Systems
Micronetixx, P.A.
Microwave Communications Laboratories
Microwave Engineering Corp.
Planar Monolithics Industries, Inc.
QuinStar Technology, Inc.
Renaissance Electronics Corp.
Rodelco Electronics Corp.
Rohde & Schwarz GmbH & Co. KG
Teledyne Technologies
TTE Filters
Werlatone, Inc.

## RF Switches

Analog Devices
API Technologies
Atlanta Micro
Cobham
Dow-Key Microwave
JFW Industries
Kratos
L3 Harris
MACOM
Mini-Circuits
National Instruments
Pasternack Enterprises
Rohde & Schwarz GmbH & Co. KG
Skyworks Solutions

## RF Absorptive Materials/ Shielding

ARC Technologies
Boyd Corporation
Cuming Microwave Corp.
ETS-Lindgren
Select Fabricators

## RF Cables/Cable Assemblies

Anatech Electronics
Assemblies Inc.
Cablex PTY Ltd
Carlisle Interconnect Technologies
CDM Electronics
Cobham
Custom Cable Assemblies, Inc.
FLEXCO Microwave
HUBER+SUHNER AG
Insulated Wire (IW)
MECA Electronics
MegaPhase
Micro-Coax, Inc.
Molex
Montena Technology sa
Radiall
RF Industries
RF Logic
TE Connectivity
Teledyne Technologies
Times Microwave Systems
TRU Corp.
W.L. Gore

## RF Connectors and Adapters

Amphenol RF
Acewavetech
BJG Electronics
BTC Electronics
Cinch Connectivity Solutions
Cobham
Custom Cable Assemblies
Delta Electronics Mfg. Corp.
Digi-Key
Dynawave Inc.
Fairview Microwave
Gigalane
Hermetic Solutions
Huber + Suhner
Insulated Wire (IW)
JFW Industries
Krytar
Maury Microwave
Meca Electronics
Megaphase
Microwave Communications Laboratories Inc.
Molex
Pasternack
Radiall
Sage Millimeter
Santron
Smiths Interconnect
Southwest Microwave
Spectrum Elektrotechnik GmbH
TE Connectivity
Times Microwave Systems

## Waveguides

Anatech Electronics
API Technologies
Cobham
Dow-Key Microwave
Ferrite Microwave Technologies
Honeywell Aerospace
K&L Microwave, Inc.
Keragis
Link Microtek
Micronetixx, P.A.
Microwave Communications Laboratories
Microwave Engineering Corp.
Montena Technology sa
Q Microwave, Inc.
Smiths Interconnect
Steatite Antennas
Teledyne Technologies
Ultra Electronics – Herley

## Digital Frequency Discriminators

AKON, Inc.
Anaren, Inc.
API Technologies
CSIR – DPSS
L3 Harris – Narda-Miteq
Mercury Systems
Systems & Processes Engineering Corp.
Teledyne Technologies
Triasys
TUALCOM, Inc.
Wide Band Systems Inc.

## Digital RF Memories

Anaren, Inc.
CSIR – DPSS
Curtiss-Wright Defense Solutions
L3 Harris
MC Countermeasures Inc.
Mercury Systems

Reut Systems and Technologies (RST)
Saab
Systems & Processes Engineering Corp.
TEK Microsystems, Inc.
Ultra Electronics – Herley

## Integrated Microwave Assemblies

Aethercomm
AKON, Inc.
American Microwave Corp.
Anaren, Inc.
API Technologies
ARS Products
Cobham
Comtech PST
Crane Aerospace & Electronics
CTT Inc.
Dow-Key Microwave
FEI-Elcom Tech
Jabil Defense and Aerospace Services
L3 Harris
LaBarge, Inc.
Lexatys
Lorch Microwave
Mercury Systems
Microphase Corp.
National Instruments
Planar Monolithics Industries, Inc.
Quarterwave Corp.
Renaissance Electronics Corp.
RFcore Co, Ltd.
Rockwell Collins
Rodelco Electronics Corp.
Spectranetix, Inc.
Tektronix
Teledyne Technologies
Ultra Electronics – Herley
US Dynamics Corp.

## RF Receivers

Abaco Systems
Anaren, Inc.
API Technologies
Argon ST
Atos
BAE Systems
Chemring Technology Solutions
Clearbox Systems
Cobham
Communications & Power Industries, Inc (CPI)
Communications Audit UK
Curtiss-Wright Defense Solutions
Digital Receiver Technology
D-TA Systems
Epiq Solutions
Emhiser Research Inc.
FEI-Elcom Tech
IZT GmbH
Jersey Microwave
Kratos
L3 Harris – Linkabit
Leonardo DRS
MEDAV GmbH
Mercury Systems
Mid-Atlantic RF Systems
Norden Millimeter
PLATH GmbH
Plextek Consulting
Radio Reconnaissance Technologies
Raytheon
RFEL Ltd.
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
RT Logic, Inc., a Kratos Company
Spectranetix, Inc.
Spectrum Signal Processing
Tampa Microwave
TCI
Teledyne Technologies
Ten-Tec
Triasys
Trident Systems Inc.
Ultra Electronics – Herley

## RF Tuners

AKON, Inc.
API Technologies
ASELSAN
Atlanta Micro
Chemring Technology Solutions
Cobham
Communications Audit UK
CyberRadio Solutions
Digital Receiver Technology
diminuSys
D-TA Systems Inc.
Elektrobit
FEI-Elcom Tech
FS Antennentechnik GmbH
Intelligent RF Solutions
IZT GmbH
Leonardo DRS
Mercury Systems
Mid-Atlantic RF Systems
Midwest Microwave Solutions Inc.
Norden Millimeter, Inc.
NuWaves Engineering
PLATH GmbH
R.A. Wood Associates
Radixon
Rockwell Collins
Rohde & Schwarz GmbH Ko KG
Saab Medav
Silver Palm Technologies
Spectranetix, Inc.
Syntonic Microwave Corp.
Teledyne Technologies
Ultra Electronics TCS
Zeta Associates

## Signal Conditioners

ARS Products
Cobham
Pole/Zero Corp.
Rantelon
RFEL Ltd.
Teledyne Technologies

### Displays

Aeromaoz
Astronautics C.A. Ltd
BARCO
Curtiss-Wright Defense Solutions
Ecrin Systems
L3 Harris
Lockheed Martin
Meggitt Defense Systems
Precision Display Technologies
Z Microsystems, Inc.

### Solid-State Power Amplifiers

Aero Telemetry
Aethercomm, Inc.
API Technologies
Applied Systems Engineering Inc.
AR RF/Microwave Instrumentation
BC Systems
Cobham
Communication Power Corporation
Comtech PST
CTT, Inc.
dB Control
Diamond Microwave
Elite RF
Emhiser Research, Inc.
Empower RF Systems
ETL Systems
ETM Electromatic Inc.
Exodus Advanced Communications
IFI – Instruments for Industry Inc.
Keragis
KMIC Technology, Inc.
Kratos Microwave Electronic Devices
L3 Harris
Linwave Technology
MACOM
Mercury Systems
Microwave Amplifiers Ltd.
Microwave Dynamics
Mid-Atlantic RF Systems
MILMEGA, a Teseq Company
Mission Microwave Technologies
NEC Network and Sensor Systems, Ltd.
NuWaves Engineering
OPHIR RF
Pole/Zero Corp.
Protium Technologies, Inc.
Qorvo
Quarterwave Corp.
Rantelon
RFHIC
Rodelco Electronics Corp.
Rohde & Schwarz GmbH & Co. KG
Smiths Interconnect
Teledyne Technologies
Thales Electron Devices
TMD Technologies Ltd.
Triad RF Systems Inc.
Triton Services Inc.
US Technologies-Aldetec

### GaN/GaAs Transistors

Analog Devices Inc.
MACOM
Mercury Systems
Northrop Grumman
NXP
Qorvo
United Monolithic Semiconductor
Wolfspeed

### TWTs

Communications & Power Industries, Inc (CPI)
Comtech PST
dB Control
L3 Harris – Electron Devices Division
NEC Network and Sensor Systems, Ltd.
Photonis
Teledyne Technologies
Thales Electron Devices
TMD Technologies Ltd.

### TWT Assemblies

Applied Systems Engineering Inc.
Cobham
Communications & Power Industries, Inc (CPI)
Comtech PST
dB Control
ETM Electromatic Inc.
IFI – Instruments for Industry Inc.
L3 Harris – Electron Technologies, Inc.
L3 Harris – Narda-Miteq
NEC Network and Sensor Systems, Ltd.
Photonis
Quarterwave Corp.
Teledyne Technologies
Thales Electron Devices
TMD Technologies Ltd.

### Microwave Power Modules (MPMs)

Communications & Power Industries, Inc (CPI)
dB Control
L3 Harris – Electron Devices Division
NEC Network and Sensor Systems, Ltd.
Photonis
Teledyne Technologies
Thales Electron Devices
TMD Technologies Ltd.

### Power Supplies

API Technologies
BC Systems
Behlman Electronics
Communications & Power Industries, Inc (CPI)
Crane Aerospace & Electronics
ETM Electromatic, Inc.
Schaefer Electronics
Vicor Corp.

### Data Recorders

Abaco Systems
Ampex
Annapolis Micro Systems, Inc.
Avalon Electronics, Inc.
Conduant Corp.
Curtiss-Wright Defense Solutions
Delphi Engineering Group
DSPCon, Inc.
D-TA Systems Inc.
Dynamic Signals LLC
Galleon Embedded Computing
IZT GmbH
Keysight Technologies
L3 Harris
Leonardo DRS
Mercury Systems
Novator Solutions AB
PLATH GmbH
PLATH AG
PROCITEC GmbH
Rincon Research Corporation
Rising Edge Technologies
Rohde & Schwarz GmbH & Co. KG
Scientific Research Corp.
Serpikom
Shoghi Communications Ltd.
Signami-DCS – EW/Range
Sypris Solutions
Systems & Processes Engineering Corp.
TEK Microsystems
Wideband Systems Inc.
X-COM Systems, LLC

### Signal Analysis Systems

Annapolis Micro Systems, Inc.
Berkley Nucleonics
Cobham
Hensoldt South Africa
Innovative Signals Technology (ISigTech)
ITAS A/S
IZT GmbH
Mercury Systems
Novator Solutions AB
Patria
PLATH GmbH
PROCITEC GmbH
Rantelon
Rincon Research Corporation
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
Serpikom
Southwest Research Institute
X-COM Systems, LLC

## TEST EQUIPMENT

### Oscilloscopes

B&K Precision Corp.
Berkley Nucleonics
Dynamic Signals LLC
Keysight Technologies
National Instruments Corp.
Rohde & Schwarz GmbH & Co. KG
Tektronix Inc.
Teledyne Technologies

### Signal Generators

Anritsu
B&K Precision Corp.
Berkley Nucleonics
Cobham
Dynamic Signals LLC
FEI-Elcom Tech
ISPAS AS
IZT GmbH
Keysight Technologies
Mercury Systems
National Instruments Corp.
Novatech Instruments
Phase Matrix
Rohde & Schwarz GmbH & Co. KG
Tabor Electronics Ltd
Tektronix Inc.
Varilog Research, Inc.

### Spectrum Analyzers

Aaronia AG
Anritsu
B&K Precision Corp.
Berkley Nucleonics
Cobham
COMSEC LLC
Good Will Instrument Co., Ltd.
Keysight Technologies
National Instruments Corp.
RADX Technologies
Research Electronics International (REI)
Rohde & Schwarz GmbH & Co. KG
Signal Hound
Tektronix Inc.
ThinkRF
WhiteFox Defense Technologies, Inc.

### Power Meters

Anritsu
Keysight Technologies
Krytar, Inc.
Mercury Systems
National Instruments Corp.
Rohde & Schwarz GmbH & Co. KG

### Network Analyzers

Anritsu
DaqScribe Solutions, LLC
Keysight Technologies
National Instruments Corp.
Rohde & Schwarz GmbH & Co. KG
Tektronix

### Automatic Test Equipment

Advanced Testing Technologies Inc.
ARS Products
Astronics
Berkley Nucleonics
Cobham
Dow Key Microwave Corp.
Electronic Systems
Empower RF Systems, Inc.
INDRA
Keysight Technologies
L3 Harris
Leonardo DRS
MASS Consultants Limited
MC Countermeasures
Meggitt Defense Systems

Mercer Engineering Research Center
MES S.p.A.
National Instruments Corp.
Rodale Electronics Inc.
RUAG – Aerospace
Spirent Communications
Textron Systems
TRU Corp.
ViaSat, Inc.
VIAVI Solutions, Inc.

## EO/IR COMPONENTS & SUBSYSTEMS

### IR Detectors

Defense Research Associates, Inc.
Leonardo DRS

### Fine-Track Sensors

BAE Systems
L3 Harris
Northrop Grumman
Teledyne Technologies

## EW & TEMS

### Radar Warning Receivers (RWRs) and ESM Systems

Aeronix, Inc.
Argon ST
ASELSAN
BAE Systems
BEL – Bharat Electronics Ltd.
Elbit Systems
Elettronica SpA
ELTA Systems Ltd.
HawkEye 360
Hensoldt
INDRA
L3 Harris
Leonardo
Lockheed Martin
Microwave Technologies Inc.
Northrop Grumman
Rafael
Raytheon
Saab
Sierra Nevada Corp.
Silentium Defence
Southwest Research Institute
Teledyne Technologies
Thales Airborne Systems
TINEX AS
Ultra Electronics – Australia
Ultra Electronics TCS

### RWR and ESM – Antennas

AMT Microwave Corp.
API Technologies
ASELSAN
BAE Systems
BEL – Bharat Electronics Ltd.
Cobham
Elbit Systems
Electro-Metrics
Fractal Antenna Systems
IFI – Instruments for Industry Inc.
JEM Engineering
L3 Harris – Randtron Antenna Systems
L3 Harris – US
Link Microtek
Rohde & Schwarz GmbH & Co. KG Saab – Electronic Defence Systems
Steatite Antennas

### RWR and ESM – Receivers

Abaco Systems
Aeronix
API Technologies
Argon ST
Atos
Cobham
Elettronica SpA
ELTA Systems Ltd.
ESROE
FEI-Elcom Tech
Leonardo
Lockheed Martin
Mercury Systems
Microwave Technologies Inc.
Northrop Grumman
Plextek Consulting
Saab
Sierra Nevada Corp.
Thales
Teledyne Technologies
Trident Systems Inc.
TUALCOM, Inc.
Ultra Electronics TCS

### Radar Jammers

ASELSAN
BAE Systems
BEL – Bharat Electronics Ltd.
Elbit Systems
Elettronica SpA
ELTA Systems Ltd.
INDRA
L3 Harris
Leonardo
MyKonsult
Northrop Grumman
QinetiQ Ltd.
Rafael
Raytheon
Rodale Electronics Inc.
Saab
Thales Airborne Systems
Ultra Electronics TCS

### Radar Jammers – Antennas

AMT Microwave Corp.
API Technologies
ASELSAN
BAE Systems
BEL – Bharat Electronics Ltd.
Cobham
Elbit Systems
Electro-Metrics
Fractal Antenna Systems
IFI – Instruments for Industry Inc.
JEM Engineering
L3 Harris – Randtron Antenna Systems
L3 Harris – US
Link Microtek
Steatite Antennas

### Radar Jammers – DRFMs

Anaren, Inc.
CSIR – DPSS
Curtiss-Wright Defense Solutions
L3 Harris
Leonardo
MC Countermeasures Inc.
Mercury Systems
Military Optical RF Equipment Ltd.
Saab
Systems & Processes Engineering Corp.
TEK Microsystems, Inc.
Ultra Electronics – Herley

### Radar Jammers – Exciters

API Technologies
Cobham
Elbit Systems
ELTA
L3 Harris
FEI-Elcom Tech
Mercury Systems
Northrop Grumman

### Radar Jammers – Power Amplifiers

Aethercomm Inc.
API Technologies
Applied Systems Engineering Inc.
Communications & Power Industries, Inc (CPI)
Comtech PST
dB Control
Empower RF Systems
L3 Harris – Electron Device Division
Leonardo
MACOM
Photonis
Qorvo
Teledyne Technologies
Thales Electron Devices
TMD Technologies Ltd.

## Airborne Active RF Decoys

BAE Systems
Hensoldt
Leonardo
Rafael
Raytheon
Reut Systems and Technologies (RST)
Thales Airborne Systems

## EW Suite Managers/ Controllers

BIRD Aerosystems
Leonardo
Northrop Grumman
Terma

## Passive Missile Warning Systems

BAE Systems
Elbit Systems
Hensoldt
Lockheed Martin
MBDA
Northrop Grumman
Orbital ATK
Rafael
Saab
Thales Airborne Systems

## Active (Pulse Doppler) Missile Warning Systems

ELTA Systems Ltd.
Leonardo – Airborne and Space Systems Division
Thales

## Laser Warning Systems

ELTA Systems Ltd.
Leonardo
Saab
UTC Aerospace Systems – ISR Systems

## Directed IR Countermeasures (DIRCM) Systems

BAE Systems
BIRD Aerosystems
Elbit Systems
Elettronica SpA
INDRA
Leonardo
Northrop Grumman

## DIRCM – Fine-Track Sensors

Defense Research Associates, Inc.
ElectroOptic Industries Ltd.
Leonardo DRS

## DIRCM – Lasers

BAE Systems
CILAS
Coherent Nufern
DILAS
Elbit Systems
Leonardo
Leonardo Daylight Solutions
Lockheed Martin
Northrop Grumman
Pendar Technologies
Pranalytica

## Airborne Decoy Dispensers

ASELSAN
BAE Systems
Cobham
Extant Aerospace
Hensoldt
IMI Systems
Leonardo
MBDA
Meggitt Defense Systems
MES SpA
Petards Group
Rodale Electronics Inc.
Saab
Terma
Thales Airborne Systems

## Airborne IR Decoys/ Countermeasures Flares

Chemring Countermeasures UK
Chemring Countermeasures USA
Esterline Defense Technologies
IMI Systems
Lacroix Defense and Security
MBDA
Rheinmetall Defence

## Airborne Chaff Countermeasures

Chemring Countermeasures UK
Cherming Countermeasures USA
Esterline Defense Technologies
IMI Systems
Lacroix Defense and Security

## Maneuvering Air-Launched Decoys

IMI Systems
Raytheon

## Anti-Radiation Homing Missiles

Lockheed Martin
Orbital ATK
Raytheon

## Naval Decoy Launchers

Lacroix Defense and Security
Lockheed Martin
Rheinmetall Defence
Safran Electronics and Defense SEA
Sechan Electronics
Lockheed Martin
Terma

## Naval IR Decoys

Chemring Countermeasures UK
Chemring Countermeasures USA
Lacroix Defense and Security
Rheinmetall Defence

## Naval Chaff Countermeasures

Chemring Countermeasures UK
Chemring Countermeasures USA
Lacroix Defense and Security
Rheinmetall Defence

## Naval RF Reflector Decoys

Airborne Systems Limited
Elbit Systems EW and SIGINT – Elisra
Rafael – Systems Division

## Active RF Naval Decoys

BAE SYSTEMS Australia
L3 Harris
Leonardo
Lockheed Martin
Rafael
Thales

## Multispectral Obscurants/ Smoke

Chemring Countermeasures UK
Chemring Countermeasures USA
L3 Harris
Lacroix Defense and Security
Rheinmetall Defense

## Communications ESM Systems

ASELSAN
BAE Systems
Chemring Technology Solutions
Comsearch
COMSEC LLC
CRFS
Decodio AG
Defence Research and Development Canada
Digital Receiver Technology
Elettronica SpA
ELTA Systems Ltd.
EWA Government Systems, Inc.
General Dynamics Mission Systems
Hensoldt South Africa
INDRA
IZT GmbH
Kerberos International
Kratos
L3 Harris Narda Safety Test Solutions
L3 Harris TRL Technology
L3 Harris – US
Leonardo DRS
Lockheed Martin
LS Telcom
Metis Aerospace Ltd
Motorola Solutions
N-Ask Incorporated
Netline Communications Technologies
Northrop Grumman Corp.
Peralex
PLATH GmbH
Professional Development TSCM Group
Radixon
Raytheon
Research Electronics International (REI)
Rincon Research Corporation
Rohde & Schwarz GmbH & Co. KG
RT Logic, Inc., a Kratos Company
Saab Medav
Seqtor ApS
Serpikom
Shoghi Communications Ltd.
Sierra Nevada Corp.
Southwest Research Institute
Spectranetix, Inc.
Tata Advanced Systems Limited (TASL)
Tata Power Strategic Electronics Division
Thales
ThinkRF
URC Systems

## Comms ESM – Antennas

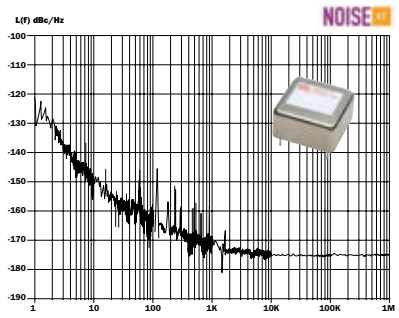
Alaris Antennas
AMT Microwave Corp.
Antenna Authority
Antenna Experts
Antenna Research Associates
Antenna Systems and Solutions
API Technologies
Applied EM Inc.
ARA, Inc.
CEA Technologies
Cobham
COJOT
Defence Research and Development Canada
Electro-Metrics
ET Industries
ETS-Lindgren
European Antennas
First RF Corp.
Flann Microwave
Fractal Antenna Systems
FS Antennentechnik GmbH
JEM Engineering
L3 Harris
Leonardo DRS
Link Microtek
Micronetixx, P.A.
Mercury Systems
Microwave Engineering Corp.
Microwave Technologies Inc.
Ocean Microwave Corp.
Octane Wireless
PCTEL Inc.
PLATH GmbH
QuinStar Technology, Inc.
Radio Reconnaissance Technologies
Rantelon
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
Rubisoft
Saab
SATIMO
Steatite Antennas

NEL FREQUENCY CONTROLS, INC.
*Your Silent Partner®*

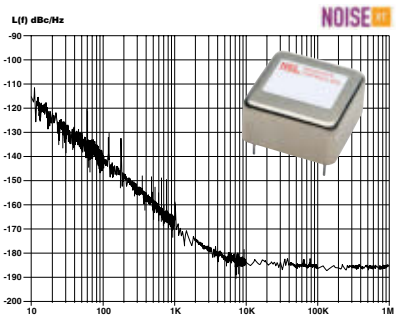
# Ultra Low Phase Noise Frequency Control Products

## Ultra Low Phase Noise OCXOs

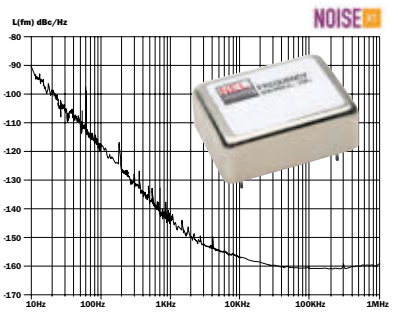
### 10 MHz Output Frequency



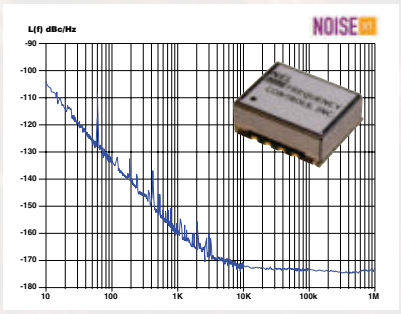

### 100 MHz Output Frequency




### 1 GHz Output Frequency

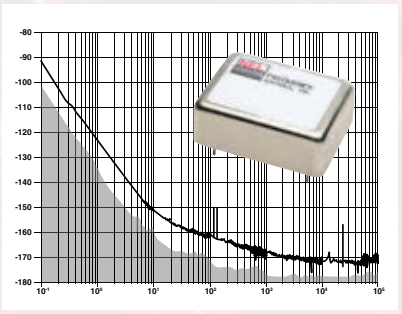



## ULPN TCXO @ 100 MHz with Low G Sensitivity



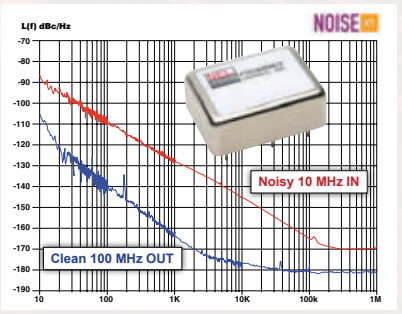

**0.2ppb/ G**

## Precision Europack ULPN OCXO



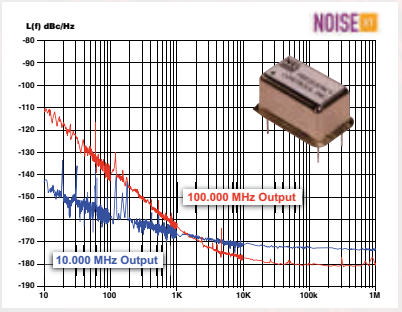
**Outstanding close to the carrier phase noise**

## Clean Up OCXO



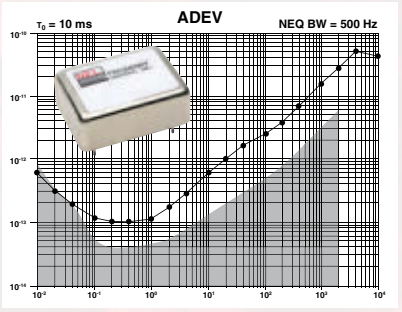

**Atomic clock stability with low phase noise**

## DIP 14 OCXO— 10 MHz or 100 MHz



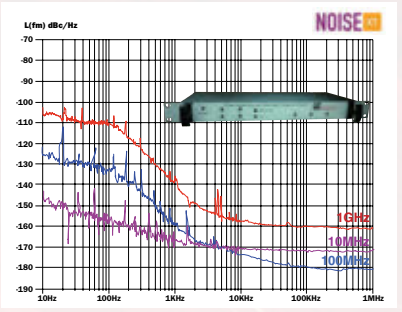

**Ultra low phase noise, low power consumption (250 – 350mW)**

## ULPN OCXO @ 10 MHz




**Outstanding short term stability**

## ULPN 10/100/1000 MHz Appliance




**Perfect for 5G applications**

Contact Us Today **www.nelfc.com** | **262.763.3591** | **sales@nelfc.com**

## Comms ESM – Receivers

Abaco Systems
API Technologies
Argon ST
Atos
BAE Systems
Chemring Technology Solutions
CommsAudit
Communications Audit UK
Curtiss-Wright Defense Solutions
Deepwave Digital
Digital Receiver Technology
D-TA Systems
Emhiser Research Inc.
Enablia S.R.L.
Epiq Solutions
FEI-Elcom Tech
Herrick Technologies
Intelligent RF Solutions
IZT GmbH
Jersey Microwave
L3 Harris
L3 Harris Narda Safety Test Solutions
Leonardo DRS
LOG.IN Srl
Mercury Systems
Mid-Atlantic RF Systems
Norden Millimeter
OEwaves
Per Vices Corp.
PLATH GmbH
Plextek Consulting
Radio Reconnaissance Technologies
Radixon
Raytheon
RFEL Ltd.
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
RT Logic, Inc., a Kratos Company
Saab Medav
Sagax Communications
SignalHound
Spectranetix, Inc.
Spectrum Signal Processing
Syncopated
Tampa Microwave
TCI
Teledyne Technologies
Ten-Tec
Triasys
Wide Band Systems Inc.

## Communications Jammers

Aegis Corea
Albrecht Telecommunications
Allen-Vanguard Corp.
ASELSAN
BAE Systems
Cobham
DSE International
Elbit Systems
Elettronica SpA
ELTA Systems Ltd.
Enterprise Control Systems
Hensoldt
Hensoldt South Africa
Honeywell Aerospace
HP Marketing and Consulting
INDRA
Kerberos International
L3 Harris TRL Technology
L3 Harris – US
Leonardo
Lockheed Martin
Mitsubishi Electric Corp.
Netline Communications Technologies
PKI Electronic Intelligence
PLATH AG
Radixon
Rantelon
Raytheon
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
Samel 90
SESP Group
Shoghi Communications Ltd.
Sierra Nevada Corp.
SRC
Tata Advanced Systems Limited
Tata Power
Thales
Ultra Electronics TCS
URC Systems

## Comms Jammer – Antennas

Alaris Antennas
API Technologies
Applied EM Inc.
CEA Technologies
Cobham
COJOT
Defence Research and Development Canada
Electro-Metrics
ET Industries
ETS-Lindgren
European Antennas
First RF Corp.
Flann Microwave
Fractal Antenna Systems
FS Antennentechnik GmbH
JEM Engineering
L3 Harris
Leonardo DRS
Link Microtek
Micronetixx, P.A.
Microwave Engineering Corp.
Microwave Technologies Inc.
Ocean Microwave Corp.
Octane Wireless
PCTEL Inc. – Antenna Products
PLATH GmbH
QuinStar Technology, Inc.
Radio Reconnaissance Technologies
Rantelon
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
Rubisoft
Saab
SATIMO
Seqtor ApS
Shakespeare Antennas
Steatite Antennas

## Comms Jammer – DRFMs

Anaren, Inc.
CSIR – DPSS
Curtiss-Wright Defense Solutions
L3 Harris
MC Countermeasures Inc.
Mercury Systems
Saab
Systems & Processes Engineering Corp.
TEK Microsystems, Inc.
Ultra Electronics – Herley

## Comms Jammer – Power Amplifiers

Aethercomm, Inc.
Amplifier Technology
API Technologies
Applied Systems Engineering Inc.
BC Systems
Comtech PST
CTT, Inc.
Emhiser Research, Inc.
Empower RF Systems
IFI – Instruments for Industry Inc.
Keragis
KMIC Technology, Inc.
L3 Harris
Linwave Technology
Mercury Systems
Microwave Amplifiers Ltd.
Mid-Atlantic RF Systems
MILMEGA, a Teseq Company
NEC Network and Sensor Systems, Ltd.
OPHIR RF
Qorvo
Quarterwave Corp.
Rantelon
RF Core Co, Ltd.
RFHIC
Rodelco Electronics Corp.
Smiths Interconnect

## Counter-UAS Systems (EW)

Aaronia AG
Advanced Protection Systems
Alion Science and Technology
Allen-Vanguard
Atos
AntiDrone
ApolloShield
ArtSYS360
Aselsan
BATS
Battelle
Blind Tiger
Broadfield Security Services
CACI
CellAntenna Corporation
CerbAir
Citadel Defense
CRFS
CTS Technology Co. Ltd.
D-Fend Solutions A.D. Ltd.
DeDrone
Department 13
DeTect Inc.
Diehl Defence
Drone Defence
DroneShield
Elbit Systems
Elettronica SpA
Elta Systems Ltd.
Enterprise Control Systems
HARP
Hensoldt
Hensoldt South Africa
High + Mighty International
HIK Vision
HP Marketing and Consulting
Hunan NovaSky Electronic Technology
IACIT
IMI Systems
Indra
Kirintec
L3 Technologies
Leonardo
Liteye Systems, Inc.
Lockheed Martin
LS Telcom
MCTech
Meritis Group
MyDefence Communication
National Instruments Corp.
Netline
Northrop Grumman
Orad
Phantom Technologies Ltd.
PKI Electronic Intelligence GmbH
Plath AG
Radio Hill Technologies
Rafael
Rantelon
Rohde & Schwarz
Samel 90 PLC
Sensofusion
Serpikom
SESP Group
Sierra Nevada Corp.
Silentium Defence
SINTIS Technology Ltd.
Skysafe
Syracuse Research Corp.
SteelRock Technologies
Teleradio Engineering
Terra Hexen
TCI
TRD Consultancy Pte Ltd

## GPS Jammers

Defence Research and Development Canada
Elbit Systems
L3 Harris
Scientific Research Corp.
Thales

## ELINT Systems

Aeronix, Inc.
Avalon Electronics, Inc.
BAE Systems
BEL – Bharat Electronics Ltd.
DaqScribe Solutions, LLC
Elbit Systems
Elettronica SpA
ELTA Systems Ltd.
INDRA
Intelligent RF Solutions
Jordan Electronic Logistic Support – Electronic Warfare
L3 Harris
Lockheed Martin
Microwave Technologies Inc.
National Instruments Corp.
Northrop Grumman
Patria
QinetiQ Ltd.

Rafael
Raytheon
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
Rubisoft
Saab
Sierra Nevada Corp.
Teledyne Technologies
Thales Airborne Systems
Ultra Electronics – Australia
Ultra Electronics TCS

## ELINT Systems – Antennas

Alaris Antennas
AMT Microwave Corp.
Antenna Authority
Antenna Research Associates
Antenna Systems and Solutions
API Technologies
Applied EM Inc.
Azure Summit Technology, Inc.
CAL-AV Labs Inc.
CEA Technologies
Cobham
Communications & Power Industries,Inc (CPI)
Comtech PST
Defence Research and Development Canada
Electro-Metrics
ET Industries
ETS-Lindgren
European Antennas
First RF Corp.
Flann Microwave
Fractal Antenna Systems
FS Antennentechnik GmbH
HUBER+SUHNER AG
IFI – Instruments for Industry Inc.
JEM Engineering
Jenkins Engineering Defence Systems
L3 Harris
Leonardo DRS
Link Microtek
Micronetixx, P.A.
Mercury Systems
Microwave Engineering Corp.
Microwave Technologies Inc.
Ocean Microwave Corp.
Octane Wireless
PCTEL Inc. – Antenna Products
PLATH GmbH
QuinStar Technology, Inc.
Radio Reconnaissance Technologies
Randtron Antenna Systems
Rohde & Schwarz GmbH & Co. KG
Steatite Antennas

## ELINT Systems – Tuners

AKON, Inc.
API Technologies
D-TA Systems Inc.
FEI-Elcom Tech
Intelligent RF Solutions
Leonardo DRS
Mercury Systems
Midwest Microwave
NuWaves Engineering
R. A. Wood Associates
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG

## ELINT Systems – Receivers

Argon ST
Atos
Chemring Technology Solutions
Cobham
Communications Audit UK
D-TA Systems
Elbit Systems
Elettronica SpA
ELTA Systems Ltd.
Emhiser Research Inc.
ESROE
FEI-Elcom Tech
Intelligent RF Solutions
IZT GmbH
Kratos
L3 Harris
Leonardo DRS
Lockheed Martin
Mercury Systems
Mid-Atlantic RF Systems
Patria
PLATH GmbH
Plextek Consulting
Raytheon
Rohde & Schwarz GmbH & Co. KG
RT Logic, Inc., a Kratos Company
Sierra Nevada Corp.
Teledyne Technologies
Thales
TUALCOM, Inc.
Ultra Electronics TCS
Wide Band Systems Inc.

## COMINT Systems

Argon ST
Avalon Electronics, Inc.
BAE Systems
Chemring Technology Solutions
COMSEC LLC
CRFS
Cubic Defense Systems
CyberRadio Solutions
DaqScribe Solutions, LLC
Decodio AG
Digital Receiver Technology
Elbit Systems
ELTA Systems Ltd.
ESPY Corp.
General Dynamics
Hensoldt
Hensoldt South Africa
Jordan Electronic Logistic Support – Electronic Warfare
L3 Harris
L3 Harris Narda Safety Test Solutions
Leonardo DRS
Lockheed Martin
LS Telcom
N-Ask Incorporated
Northrop Grumman
PLATH GmbH
PLATH AG
PROCITEC GmbH
QinetiQ Ltd.
Radio Reconnaissance Technologies
Radixon
Raytheon
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
Rubisoft
Saab Medav
Sierra Nevada Corp.
Southwest Research Institute
Spectranetix, Inc.
Tata Advanced Systems
TCI
Thales Defense and Security
Transformational Security LLC
Ultra Electronics TCS
WGS Systems, Inc.

## COMINT Systems – Antennas

Alaris Antennas
AMT Microwave Corp.
Antenna Authority
Antenna Research Associates
Antenna Systems and Solutions
API Technologies
Applied EM Inc.
ARA, Inc.
CAL-AV Labs Inc.
CEA Technologies
Cobham
Defence Research and Development Canada
Defence Systems
Electro-Metrics
ET Industries
ETS-Lindgren
European Antennas
First RF Corp.
Flann Microwave
Fractal Antenna Systems
FS Antennentechnik GmbH
HUBER+SUHNER AG
IFI – Instruments for Industry Inc.
JEM Engineering
Jenkins Engineering
L3 Harris
Leonardo DRS
Link Microtek
Micronetixx, P.A.
Mercury Systems
Microwave Engineering Corp.
Microwave Technologies Inc.
Ocean Microwave Corp.
Octane Wireless
PCTEL Inc. – Antenna Products
PLATH GmbH
QuinStar Technology, Inc.
Radio Reconnaissance Technologies
Rantelon
Rohde & Schwarz GmbH & Co. KG
Steatite Antennas

## COMINT Systems – Tuners

API Technologies
Communications Audit UK
Cyber Radio Solutions
D-TA Systems Inc.
FEI-Elcom Tech
Intelligent RF Solutions
IZT GmbH
Leonardo DRS
Mid-Atlantic RF Systems
Midwest Microwave Solutions Inc.
PLATH GmbH
Radixon
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
Saab Medav
Spectranetix, Inc.
URC Systems
Zeta Associates

## COMINT Systems – Receivers

Argon ST
Atos
Azure Summit Technology, Inc.
BAE Systems
CommsAudit
Communications Audit UK Limited
CRFS
Cubic Defense Systems
Curtiss-Wright Defense Solutions
Deepwave Digital
Digital Receiver Technology
D-TA Systems
Emhiser Research Inc.
Enablia S.R.L.
Epiq Solutions
FEI-Elcom Tech
Hensoldt South Africa
Herrick Technology Labs
Intelligent RF Solutions
IZT GmbH
Jersey Microwave
L3 Harris – Linkabit
L3 Harris Narda Safety Test Solutions
Leonardo DRS
MEDAV GmbH
Mercury Systems
Mid-Atlantic RF Systems
Norden Millimeter
OEwaves
Per Vices Corp.
PLATH GmbH
Plextek Consulting
Protium Technologies, Inc.
Radio Reconnaissance Technologies
Radixon
Raytheon
RFEL Ltd.
Rockwell Collins
Rohde & Schwarz GmbH & Co. KG
Roke Manor Research Ltd
RT Logic, Inc., a Kratos Company
Sagax Communications
Spectranetix, Inc.
Spectrum Signal Processing
Syncopated
Syncopated Engineering
Tampa Microwave
TCI
Ten-Tec
Wide Band Systems Inc.
X-COM Systems, LLC

## Direction Finding Systems

Argon ST
Azure Summit Technology, Inc.
BAE Systems
CEA Technologies
Communications Audit UK Limited
Cubic Defense Systems
DATONG plc
Elbit Systems EW and SIGINT – Elisra

Hensoldt South Africa
INDRA
IZT GmbH
Jenkins Engineering
Defence Systems
Kerberos International
L3 Harris – Linkabit
L3 Harris TRL Technology
Leonardo DRS
LS Telcom
MEDAV GmbH
Mitsubishi Electric Corp.
National Instruments Corp.
PLATH AG
PLATH GmbH
QinetiQ Ltd.
QRC Technologies
Radio Reconnaissance Technologies
Rantelon
Raytheon
Rohde & Schwarz GmbH & Co. KG
Roke Manor Research Ltd (Chemring Group)
Serpikom
Shoghi Communications Ltd.
Southwest Research Institute
Tata Advanced Systems Limited (TASL)
TCI
TechComm
Thales Defense and Security
Ultra Electronics TCS

### GPS Anti-Jam Receiver Systems

Boeing
Lockheed Martin MST
NovAtel
Raytheon

## EW SIMULATORS

### Field/Flightline RF EW Testers

Dragoon ITCN
ELDES srl – Radar Division
L3 Harris
Leonardo DRS
Spherea GmbH
Textron Systems – Electronic Systems
Ultra Electronics Limited – EWST

### EW Antenna Couplers

L3 Harris
Leonardo DRS
Rohde & Schwarz GmbH & Co. KG
Tech Resources, Inc.
Textron Systems – Electronic Systems

### EO/IR Simulators

CI Systems (Israel) Ltd.
Defense Research Associates, Inc.
Rohde & Schwarz GmbH & Co. KG
RUAG – Aerospace
Textron Systems – Electronic Systems
Ultra Electronics Limited – EWST

### Laboratory EW Simulators

CSIR – DPSS
ELDES srl – Radar Division
EW Simulation Technology Ltd.
DaqScribe Solutions, LLC
FEI-Elcom Tech
Giga-tronics
Hensoldt South Africa
Herrick Technology Labs
ITT Test and Support Systems
IZT GmbH
Lockheed Martin – Aeronautics
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Mercury Systems
National Instruments Corp.
Northrop Grumman Mission Systems
Rafael – Systems Division
Reut Systems and Technologies (RST)
Scientific Research Corp.
Tactical Technologies Inc. a Leonardo Company
Textron Systems – Electronic Systems
Thales Airborne Systems
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Ultra Electronics Limited – EWST
Varilog Research Inc.
ViaSat, Inc. – RF Simulation Group

### RF Range Threat Simulators

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D-TA Systems
Leonardo DRS
National Instruments Corp.
Northrop Grumman Amherst Systems
Reut Systems and Technologies (RST)
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Ultra Electronics Limited – EWST

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Cobham AvComm
Corvus
CSIR – DPSS
Défense Conseil International
Defense Engineering Corp.
Defense Research Associates, Inc.
DePriest Associates, Inc.
DEWC Pty Ltd
DHPC Technologies
Dr. EW (Johnny Heikell)
Dynamic Analytics & Test, Inc.
Dynetics Inc.
ECS
Electronic Warfare Studying Group, Korean Institute of Electromagnetic Engineering & Science
Engineering Corp.
ETL Technologies Ltd.
EWA – Electronic Warfare Associates
EWTS
Georgia Tech Research Institute
JMC Defence Ltd.
Kihomac, Inc.
Kranze Technology Solutions, Inc. (KTS)
L3 Harris
Leidos
LS telcom
MacAulay-Brown – Alion Science
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Development Canada
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Dynetics Inc.
ECS.
EMS Technologies, Inc. – Defense and Space
Georgia Tech Research Institute
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MacAulay-Brown – Alion Science
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General Dynamics Mission Systems
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ThinkRF
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IZT GmbH
Jenkins Engineering Defence Systems
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L3 Harris – Linkabit
L3 Harris – US
L3 Harris Integrated Systems
L3 Harris TRL Technology
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Lockheed Martin – IS&GS – Littleton
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Peralex
PLATH GmbH
Professional Development TSCM Group
QinetiQ Ltd.
QRC Technologies
Radio Reconnaissance Technologies
Raytheon – Space and Airborne Systems
Research Associates of Syracuse (RAS)
Research Electronics International (REI)
RF Engines Ltd.
Rising Edge Technologies
Rohde & Schwarz GmbH & Co. KG
Rubisoft
SAIC
Scientific Research Corp.
SensorCom Inc.
Shoghi Communications Ltd.
Signami-DCS – EW/Range
SimVentions
Spatial and Spectral Research
Spectrum Signal Processing
SRI International
SRC
TCI
TechComm
Teleplan AS
Thales Defense and Security
ThinkRF
Transformational Security LLC
TriaSys Technologies Corp.
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NAYLOR
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## New EA Techniques (Part 11)

# Impact of Leading Edge Tracking

**By Dave Adamy**

### RANGE-GATE PULL-OFF

Range-gate pull-off (RGPO) is a deceptive jamming technique to counter the range tracking capability of a radar. Radar signals travel at the speed of light, so time-of-arrival of a radar pulse at a target (which is also the location of a self-protection jammer) is a function of the square of the distance from the radar to the target. The round trip of the skin return takes twice that time. The threat radar has a pair of time gates in its processing. An early gate leads the time of arrival of the skin return pulse and a late gate follows it. The early gate ends just as the late gate begins. When the radar is acquiring the target, these gates are several times as long as the radar pulse; but when the radar is locked onto the target, they are about the duration of the pulse. These two time gates move during the engagement so that their received energy levels are equal. If the target is moving away from the radar, the late gate has more energy, so the pair of gates is delayed until they have equal energy. The timing of these gates allows the radar to track its target in range.

As shown in **Figure 1,** a self-protection jammer on the target using RGPO transmits a pulse on top of the threat radar pulse. The jamming signal is also stronger than the radar skin return signal to create a jamming-to-signal (J/S) advantage. The jammer then sequentially delays each pulse, changing the pulse interval non-linearly (either exponentially or parabolically) to simulate the pulse time-of-arrival pattern that would occur if the target-to-radar range were increasing faster or decreasing slower than it actually is. The reason the rate of delay is non-linear is that it simulates the situation in which the target is turning away from the radar.

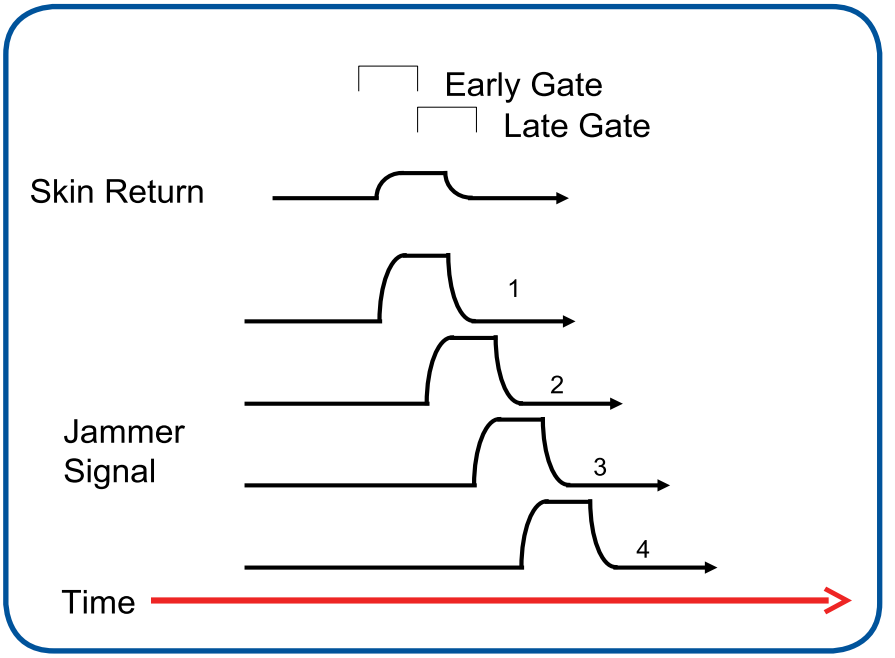


*Fig. 1: Range-gate pull-off involves sequential delay of a jamming pulse that is initially synchronous with the radar's skin return. This causes the energy in the radar's late gate to increase, so the radar falsely assumes that the target is moving farther away from the radar.*

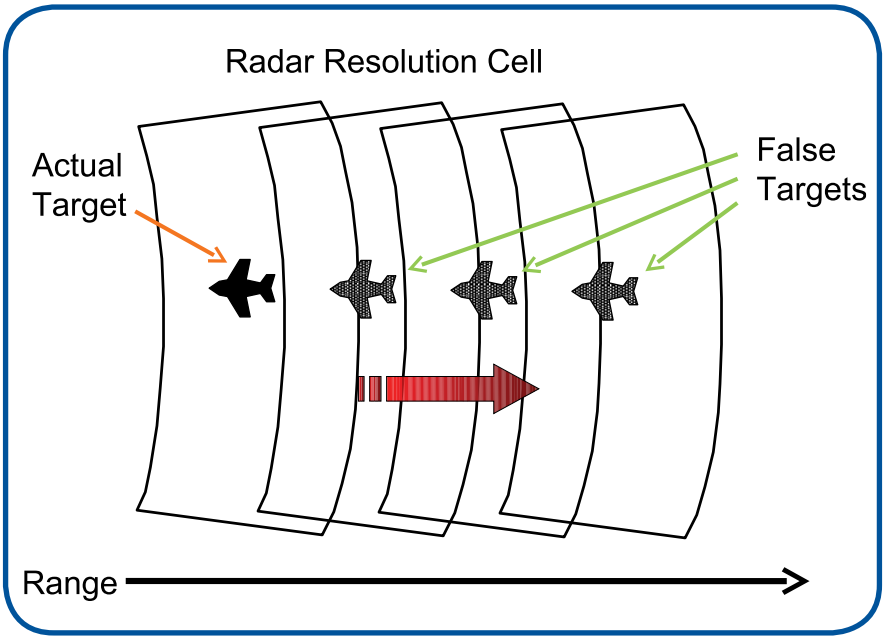


*Fig. 2: Loading up the late gate causes the radar's resolution cell to move farther away from the target, breaking the radar's range lock on the target.*

Because the jamming pulse has more energy than the skin-return pulse, it artificially loads up the late gate. Note that the rate of change of the time of arrival must simulate a turning rate that is not faster than the turning ability of the target aircraft.

As shown in **Figure 2,** the radar's resolution cell is centered on the perceived location of the target. The jammer's range gate pull-off technique causes the radar to look for the target at the wrong range. The jamming waveform moves out in time, and then snaps back to the actual time of arrival of the radar pulse before moving out again. When delayed, the resolution cell contains no target, so the radar returns to its range acquisition mode. The threat system will not fire its missile without a valid range track, so the missile stays on its rail.

## LATENCY IN LEGACY JAMMERS

The jammer sets the timing of its jamming pulse based on the time at which the threat radar's pulse is received, so there is a processing delay between the actual pulse arrival and the beginning of the jamming pulse. This processing throughput latency is typically more than 100 nanoseconds in legacy jammers. However, it can be shorter in modern jammers which include a Digital RF Memory (DRFM) capability.

## LEADING-EDGE TRACKING

The threat radar would normally track on the full energy of the skin return from a target to maximize the effective radar range. If RGPO jamming is suspected, however, the radar can switch to leading-edge tracking. As shown in **Figure 3,** the latency in the jammer can cause the jamming pulse to be delayed long enough that the jamming pulse cannot capture the range tracking function. This means that the radar's range-tracking function continues to follow the actual radar pulse rather than the delayed jamming pulse, which means the radar's range tracking remains accurate and the RGPO jamming fails to protect the target.

The leading edge of the radar's pulse has less energy than the full pulse, so the effective radar range will be reduced, but the radar will be protected from the RGPO jamming over this reduced range.

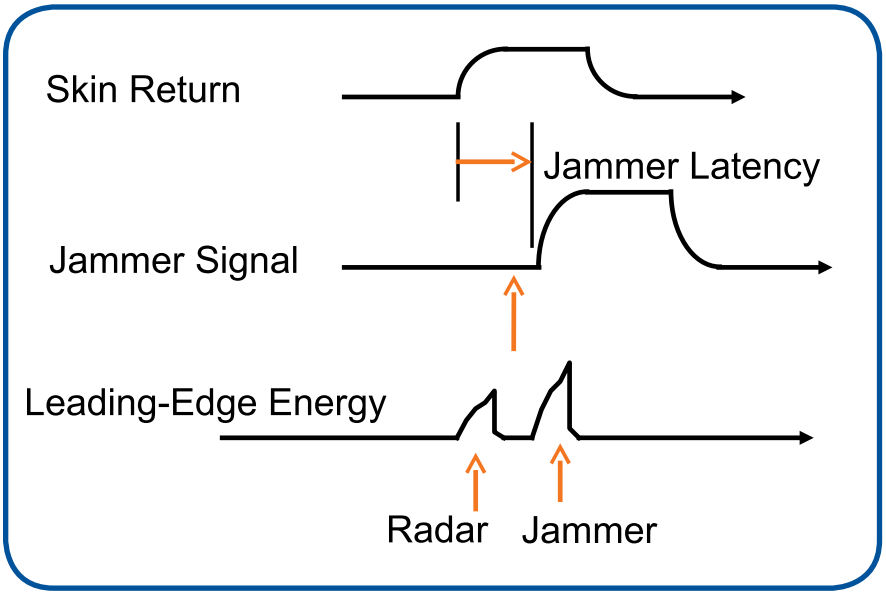


*Fig. 3: When a radar uses leading-edge tracking, the latency in the jammer allows the radar to continue to track its own leading edge rather than that of the jamming pulse, unless the latency period is very small.*

## RANGE GATE PULL-IN JAMMING

In legacy jammers, there is a second jamming technique, as shown in **Figure 4.** This is "Inbound Range Gate Pull-off" or "Range Gate Pull-In" (RGPI). In this technique the jammer uses a "pulse repetition frequency tracker" to predict the time arrival of the next pulse. The jammer then transmits a larger artificial pulse to cover the next pulse. As shown in the figure, this pulse starts at the time of the actual pulse and then moves earlier on each subsequent pulse. This causes the energy in the radar's early gate to be larger than that in the late gate. Thus, the radar assumes that the target is moving closer to the radar than is actually the case. This makes the ra-

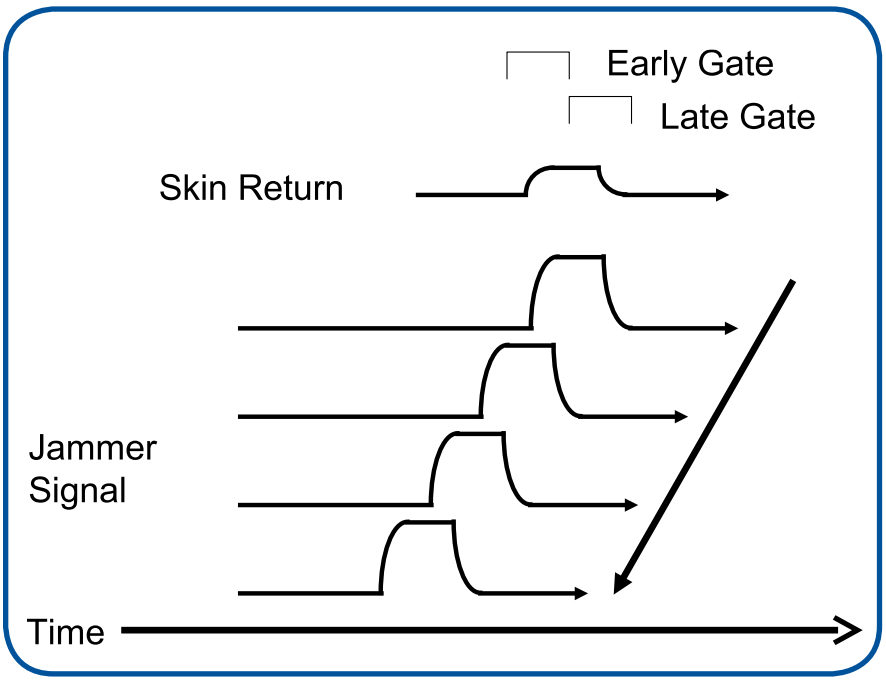


*Fig. 4: Range gate pull-in involves sequentially increased anticipation of the return pulse, which loads up the radar's early gate.*

dar's tracking inaccurate and the radar's resolution cell moves closer to the radar as shown in **Figure 5.** The jamming pulse moves earlier for several pulses and then snaps back to the actual pulse arrival time. As in the RGPO case, the RGPI technique causes the radar resolution cell to move to a location in which there is no target, so the radar cannot cue a missile to be fired at the target.

While RGPI jamming can be very effective against a radar with a fixed pulse repetition rate and can be made effective against a radar with a low-order staggered PRF, the PRF tracker will not work against a radar with a randomly jittered PRF. In these cases, some other jamming technique must be employed.

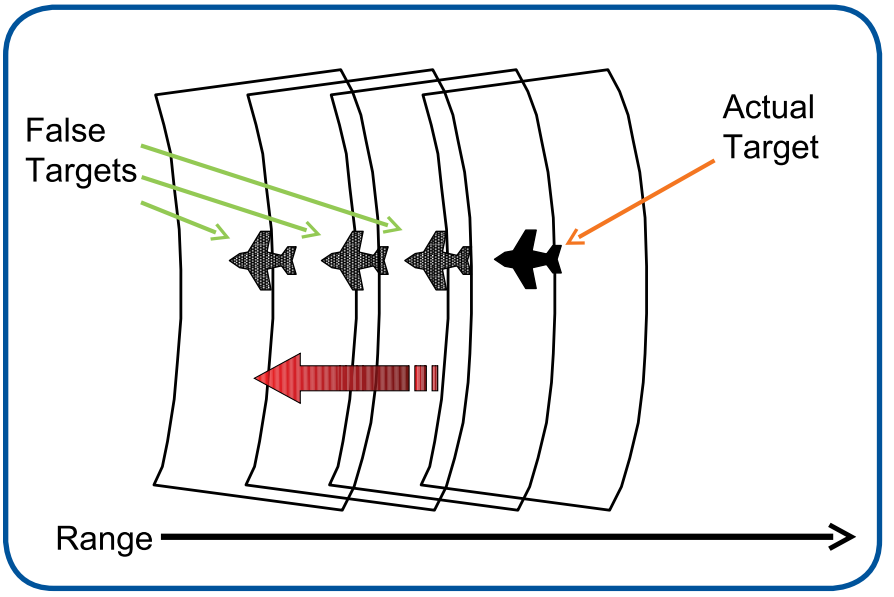


*Fig. 5: Loading up the early gate causes the radar's resolution cell to move closer to the radar, breaking the radar's range lock on the target.*

## A MODERN JAMMER WITH A DRFM

The latency in a DRFM is much shorter than that in a legacy radar jammer. EW literature indicates that current DRFMs have latency (i.e., the time between receiving a pulse and transmitting a jamming pulse) of the order of 50 nanoseconds. This reduced latency should be short enough for the jammer to capture the leading edge of the radar pulse, and thus make RGPO effective even when leading-edge tracking is employed. Apparently (from EW literature), DRFM designers hope to reduce this latency to the order of 25 nanoseconds, so future jammers should be even more effective against staggered or jittered-pulse radars.

## WHAT'S NEXT

Next month, we will continue our coverage of the impact of electronic protection techniques in radars by discussing the effects of the "Dicke fix." For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

# Priority

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### 6U AND 3U SWITCHES

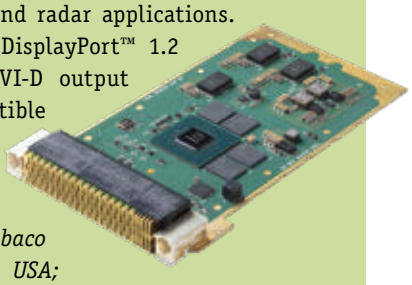
Annapolis Micro Systems has introduced two new products to their Wild100 EcoSystem portfolio, the WILDSTAR 100GbE 6E10 6U Open VPX Switch and the WILDSTAR 3E10 3U Open VPX Switch. Both switches are SOSA-aligned, compatible with SOSA-aligned 6U and 3U VPX systems, or deployed with Annapolis' WILD100 EcoSystem Open VPX systems. The 6E10 switch offers seven optional 40/100 Gb Ethernet (GbE) optical interfaces to VITA 66 and 4 optional 40/100GbE optical interfaces to the front panel. The 3E10 switch features eight 40/100GbE ports or 32 1/10/25 GbE ports. *Annapolis Micro Systems, Inc.; Annapolis, MD, USA; +1 410-841-2514;* www.annapmicro.com.

### GAN AMPLIFIER

Empower RF has announced the release of a new GaN solid state high power amplifier, model 2226, designed for GPS denial, jamming, threat simulation, multipaction, HIRF and automotive EMC applications. The model 2226 operates within a frequency range of 900-1600 MHz and offers 2,000W of output power. *Empower RF Systems, Inc.; Inglewood, CA, USA; +1 310-412-8100; www.EmpowerRF.com.*

### 3U VPX VIDEO/GRAPHICS GPGPU CARD

Abaco Systems has released the GR5 3U VPX video/graphics and GPGPU card, based on the NVIDIA® Pascal™ Quadro P2000 GPU and intended for SIGINT, ISR, situational awareness and radar applications. The GR5 supports two DisplayPort™ 1.2 and two single-link DVI-D output ports, making it compatible with Abaco's GRA112D and GRA113D 3U VPX graphics boards for upgraded performance. *Abaco Systems; Huntsville, AL, USA; +1 866-652-2226; www.abacosystems.com.*



### INTERFERENCE CANCELLER

L3 Harris has introduced the HalcyonLink, an interference cancellation solution intended to protect communication links from radio frequency (RF) interference during EW missions. This product allows for the unencumbered use of both EW systems and communications systems simultaneously by counteracting interference, canceling undesired in-band signals by more than 80 dB and out-of-band signals by more than 140 dB. *L3 Harris Technologies; Melbourne, FL, USA; +1 321-727-9100; www.l3harris.com.*


### DIGITIZATION TRANSCEIVER

Mercury Systems has released the DCM6112 open architecture digitization transceiver, offering low-latency and wide bandwidth for EW applications. The DCM6112 features four 12-bit analog-to-digital converter (ADC) channels and four 12-bit digital-to-analog (DAC) channels, with all channels supporting a sample rate up to 3.2 GSPS. *Mercury Systems, Inc.; Andover, MA, USA; +1 978-256-1300; www.mrcy.com.*

### MULTI-CHANNEL RADAR SIGNAL EMULATORS

D-TA Systems has introduced the Multi-Channel Radar Signal Emulator (MRSE) family of products, including the portable MRSE-1000S and MRSE-1000W, as well as the MRSE-2000 and MRSE-5000, two rack-mount or user specified packaging MRSE options. The portable MRSE-1000S and MRSE-1000W feature a 1 MHz-8 GHz frequency tuning range, as well as frequency range extension up to 18 GHz. The 8-kg MRSE-1000S offers up to two RF channels and an operating bandwidth up to 40 MHz, while the 12-kg MRSE-1000W offers up to four RF channels and an operating bandwidth up to 10 MHz.

Both the MRSE-2000 and 5000 operate from 0.5-18 GHz with a frequency extension up to 40 GHz. The MRSE-2000 features up to four RF channels and an operating bandwidth up to 200 MHz, whereas the MRSE-5000 features up to two RF channels and an operating bandwidth up to 500 MHz. *D-TA Systems Corp.; Arlington, VA, USA; +1 571-775-8924; www.d-ta.com.*

# MULTI-CHANNEL SOFTWARE DEFINED RADIOS

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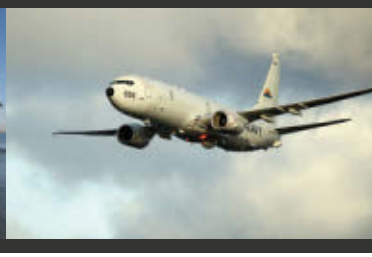

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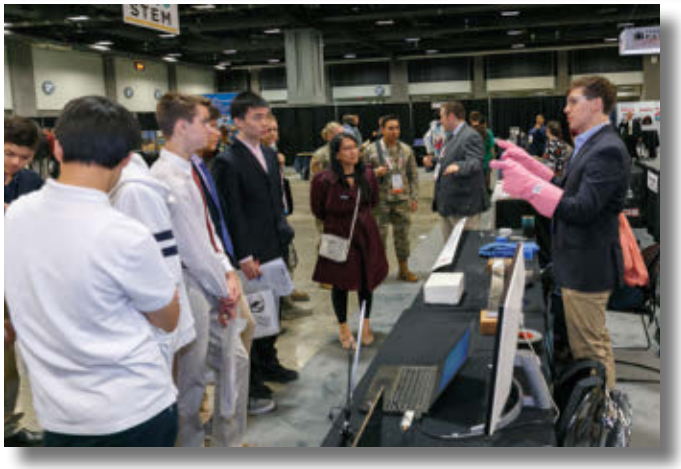
# Views from the 56th Annual AOC Inte







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# AOC JAPAN CHAPTER HOSTS 8TH EW RESEARCH GROUP CONFERENCE


The AOC Japan Chapter hosted the 8th EW Research Group Conference on April 16 in National Defense Academy, Yokosuka. The event was co-sponsored by the IEICE (The Institute of Electronics, Information and Communication Engineers) Japan, Technical Committee on Space, Aeronautical and Navigational Electronics (SANE).

The EW Research Group of the AOC Japan Chapter holds this annual conference to promote the exchange of new ideas and information in the fields of EW and related areas.

At the conference, AOC Japan Chapter President Mr. Shigeo Kazama, an AOC Lifetime Service Award recipient, welcomed the more than 110 attendants from Japanese industries, academia and government, and promoted AOC membership.

The keynote speeches were on EW circumstance and our challenges, and stealth technology in EW. They were preceded by the technical session presentations of researchers, engineers and students.


AOC JAPAN CHAPTER PRESIDENT SHIGEO KAZAMA

# AOC PAST PRESIDENTS DINNER

At the 56th Annual AOC International Convention & Symposium, the AOC hosted the Past Presidents Dinner. General Robert Elder (RET); Powder Carlson, AOC president-elect; Chris Glaze; Lisa Fruge Cirilli; Kermit Quick, Dave Adamy and Muddy Watters, current AOC president were in attendance.

# FEATURED LIVE COURSES

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

*Dr. Clayton Stewart*

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

## EW Against a New Generation of Threats

*Dave Adamy*

Mondays, Wednesdays & Fridays
**13:00 – 16:00 EDT | April 13 – 29, 2020**
This is a practical, hands-on course which covers Spectrum Warfare and current EW approaches, and moves on to discuss the new equipment capabilities and Tactics that are required to meet the new threat challenges.

## Intermediate Electronic Warfare
***EW EUROPE 2020***

*Dr. Clayton Stewart*

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

## Electronic Warfare Signal Processing

*Kyle Davidson*

Mondays, Wednesdays, & Fridays
**13:00 – 16:00 EDT | September 14 – 30, 2020**
This course introduces students to Electronic Warfare (EW) signal processing systems and their implementation, providing a foundation in learning to solve modern EW problems.

## EW Modeling and Simulation

*Dave Adamy*

Mondays & Wednesdays
**13:00 – 16:00 EST | March 2 – 25, 2020**
This is a practical course in which the basic concepts and techniques of Electronic Warfare modeling and simulation are presented and applied to practical problems.

## RF Theory for ES Operations

*Dr. Patrick Ford*

Mondays & Wednesdays
**13:00 – 16:00 EDT | June 1 – 17, 2020**
This course will include a thorough overview of key electromagnetic spectrum (EMS) concepts, with an emphasis on the RF spectrum and commensurate propagation mechanisms and environmental impacts.

## Missile Design, Development, and System Engineering

*Eugene Fleeman*

Mondays, Wednesdays, & Fridays
**13:00 – 16:00 EDT | July 13 – 31, 2020**
Missiles provide the essential accuracy and standoff range capabilities that are required in modern warfare. Technologies for missiles are rapidly emerging, resulting in the frequent introduction of new missile systems.

## Electro-Optical/Infrared Sensor Engineering

*Dr. Phillip Pace*

Mondays & Wednesdays
**13:00 – 16:00 EDT | October 5 – 28, 2020**
This course presents the fundamentals of electro-optical (EO) & infrared (IR) sensor technology, its analysis and its application to military search, track and imaging systems. Electronic warfare (electronic attack and electronic protection) are emphasized.

***= Web Course, no travel required!***

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