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The AOC Electronic Warfare Publication
www.crows.org

JED
The Journal of Electronic Defense

EW, the EMS Domain and Air Superiority

Also in this issue:
Developing Critical EW Technologies
Technology Survey: RF Power Sources for IED/Comms Jammers

Cover photo courtesy Lockheed Martin.

the view from here

EW AND AIR WARFARE

This month's cover story by Lt Col Jeffrey "Fisch" Fischer, USAF, offers an insightful look into the evolving relationship between EW and air warfare. While the traditional contest between threat systems and EW capabilities continues to evolve, some of the most significant challenges to air warfare are occurring across the electromagnetic spectrum (EMS). For the past 70 years, aircraft have operated in an increasingly "contested" EMS, facing enemy radars, missile threats, DRFM-based RF jammers, FLIRs, and (more recently) directed energy weapons, to name a few of the challenges to air power. Today, however, aircraft must increasingly contend with a "congested" spectrum (populated by blue force, government and civilian users), which can severely affect the performance of onboard sensors and systems that depend on the EMS.

A congested spectrum is problematic in a place such as Iraq or Afghanistan. But at least our adversaries in those theaters possess a limited set of options to challenge air power. However, a heavily congested and contested spectrum in a place like the Taiwan Strait significantly increases the risk to air operations. In the next war, joint or coalition air forces may enter the conflict with the assumption that they will have free and constant access to the EMS, only to discover (too late) that they do not. They may find their radars are vulnerable to DRFMs, the GPS signal is unavailable and their digital data links are suffering from a combination of interference and jamming. This may sound unlikely only because it hasn't happened before. But didn't the US Army and US Marine Corps operate under these same assumptions in Iraq back in 2003-2004 – until RCIEDs began to appear in the midst of an increasingly congested EMS environment?

The good news is that the emerging EM vulnerabilities facing today's air forces can be addressed. However, the solution must be holistic, constant and enduring – not a working group or ad hoc committee that meets once every three months to think about the problem for a day. This brings me back to Fisch's article. The central point Fisch makes is that the EMS is a warfigthing domain, right up there with Air, Land, Sea, Space and Cyberspace. Military and government leaders need to recognize that they must organize, equip and train their forces to fight in the EMS the same way they organize, equip and train their forces to fight in the Air, Land, Sea, Space and Cyberspace domains. Until this happens, however, the vulnerabilities mentioned above will continue to grow.

Over the past year, *JED* has devoted several pages to the concept of the EMS as a domain. But Fisch, a pioneer of this concept (he originally presented it at an AOC EW conference back in 2008), brings his own perspective to the discussion. He looks at the problem and the solution from several angles (operational, political, manpower, etc.) and makes some extremely valuable observations. I hope you will take time to read the article and tell us what you think.

– John Knowles

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SEPTEMBER

AFA Annual Air and Space Conference
September 13-15
Washington, DC
www.afa.org

RF Directed Energy Weapons Conference
September 13-17
Shrivenham, UK
Clearance: Secret UK/US Only
www.deps.org

Africa Aerospace & Defence
September 21-25
Cape Town, South Africa
www.aadexpo.co.za

Modern Day Marine
September 28-30
Quantico, VA
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OCTOBER

AOC 47th Annual Convention
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October 19-21
Virginia Beach, VA
www.crows.org

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October 25-27
Washington, DC
www.ausa.org

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October 25-29
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www.euronaval.fr

MILCOM 2010
October 31-November 3
San Jose, CA
www.milcom.org

NOVEMBER

Spectrum Modeling and Simulation Conference
November 2-4
Las Vegas, NV
www.crows.org

Aircraft Survivability Symposium 2010
November 2-5
Monterey, CA
www.ndia.org

Aircraft Survivability Equipment Symposium
November 15-17
Nashville, TN
www.quad-a.org

13th Annual Directed Energy Symposium
November 15-19
Bethesda, MD
www.deps.org

I/ITSEC
November 29-December 2
Orlando, FL
www.iitsec.org

Information Operations & Cyber Capabilities in 21st Century Warfare
November 30-December 2
Charleston, SC
www.crows.org

Exponaval 2010
November 30-December 2
Valpariso, Chile
www.exponaval.cl

DECEMBER

Electronic Warfare Symposium
December 1-2
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Alexandria, VA
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DRFM Technology
September 21-22
Atlanta, GA
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Advanced RF EW Principles
September 27-October 1
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Fundamental Principles of EW
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OCTOBER

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October 7-8
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www.crows.org

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October 12
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NOVEMBER

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November 8-12
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Cyber Warfare – The Weaponry and Strategies of Digital Conflict
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November 22-December 3
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IR Countermeasures
November 30
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www.pe.gatech.edu

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message from the president

THE JOINT EW CBA AND DOD'S EFFICIENCY INITIATIVES

Many of us within the greater EW community await the final decisions surrounding the leadership and organizational aspects of the Joint EW Capabilities Based Assessment (EW CBA). Decisions in these two key areas will impact the strategic direction of EW for many years. How Joint EW is organized and who leads DOD's EW efforts in the future will shape our national security priorities in the area of Electromagnetic Spectrum Warfare throughout the next century. However, these types of policy and leadership decisions are never made in a vacuum and we can expect the final outcome to be shaped by a number of issues such as DOD's ongoing efficiency initiatives.

Last month, Secretary of Defense Gates accelerated the DOD's efficiency initiatives using a four-track approach to reduce excess overhead costs and apply savings to force structure and modernization. The four track approach addressed the following:

1. The military services were tasked to find more than $100 billion in overhead savings by 2015, with the promise they could keep any of the savings they generate to invest in higher priority warfighting needs.
2. DOD is soliciting ideas, suggestions and proposals from outside experts.
3. A comprehensive assessment of how DOD is organized and operated to inform the FY12 budget request is underway.
4. Eight initiatives and decisions were announced to deal with a number of areas within the budgeting and program cycle.

These initiatives and decisions are designed to reduce duplication, overhead and excess in the defense enterprise. Varying in size and levels of savings achieved, they will act as initial down payment on a department-wide efficiency and savings campaign tied to the FY12 budget request.

Four of these eight initiatives may have significant impact on the EW CBA decisions. First, a comprehensive re-baselining of OSD, defense agency and COCOM staffing and organization will impact the number of civilian senior executive and general/flag officer billets over the next two years. This may affect any senior EW billet sought by the EW CBA. Second, SECDEF directed a zero-based review of all of the department's intelligence missions, organizations, relationships and contracts, with the goal to eliminate needless duplication. Completed by 1 November 2010, this review could impact an intelligence structure, which is a core support function to EW. Finally, over the next six to 12 months, DOD will eliminate two organizations and recommend the closure of another. Within that decision, DOD intends to close Joint Forces Command (JFCOM), believing it has created an unneeded extra layer and step in the force management process.

These initiatives can have a positive impact on EW if our senior leaders take into consideration the critical impact of the EMS and EW on 21st-century warfighting. We shall see...

– Chris "Bulldog" Glaze


innovation
integrity
quality
Photo courtesy of Defenseimagery.mil

JED welcomes and publishes letters to the editor when we're lucky enough to receive them. Please send letters to John Knowles, knowles@naylor.com or to JEDeditor@naylor.com.

ISR FOR TURBOPROPS NOT NEW

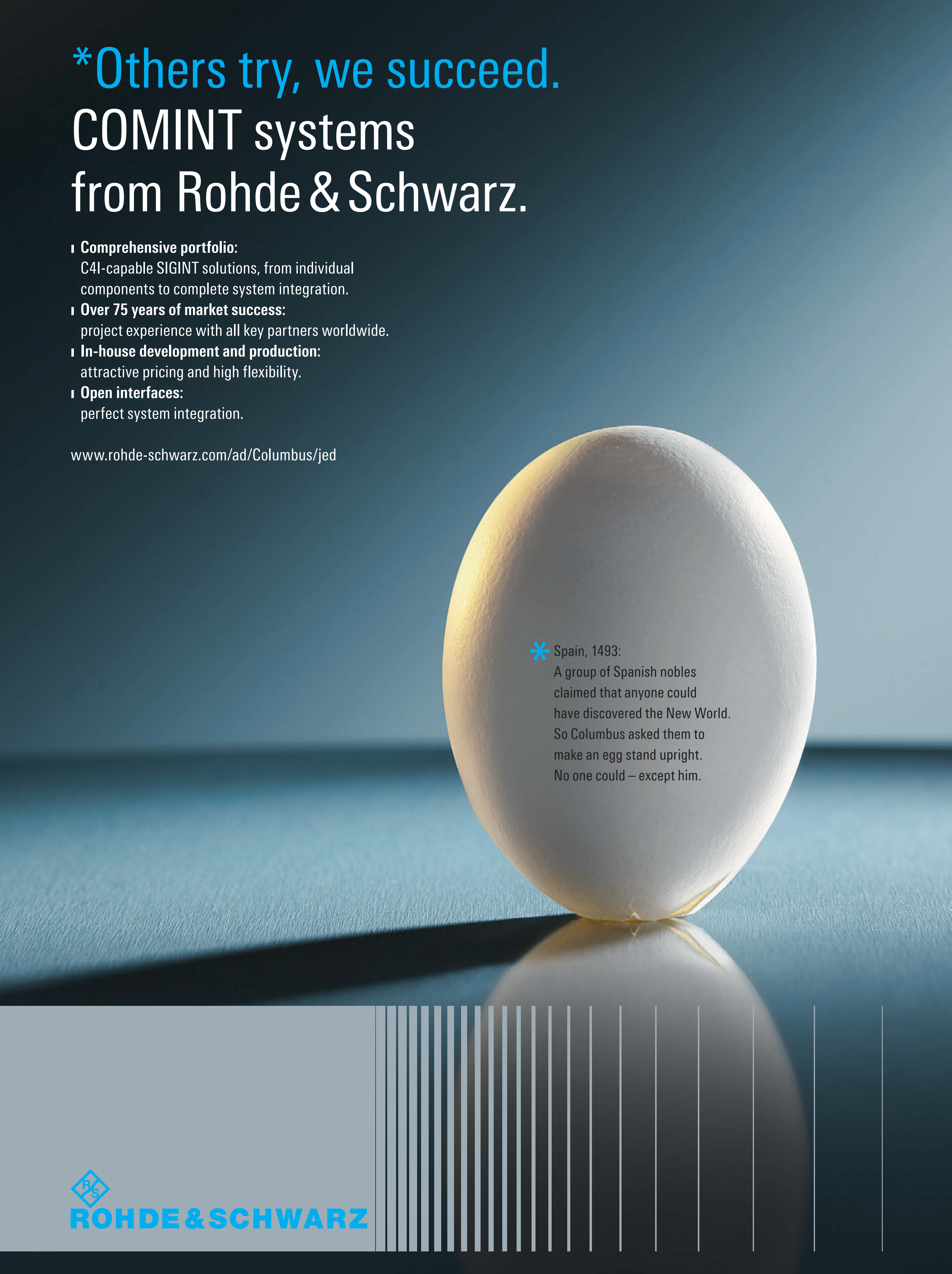
With respect to Glenn Goodman's article in this month's *JED* magazine ("SIGINT for Special Mission Aircraft," July 2010), using small turboprops for ISR was not started this decade or even this century. The US Army has been using small prop planes for ISR before there was even an Air Force; just read the *History of US Electronic Warfare* from the AOC.

Even way before there were Guardrail Common Sensors and ARL there were Mohawks, Crazy Horse, Left Jab, Cafe Girl, Wine Bottle, etc. A good history can be found at http://www.nasaa-home.org/asa/buley2/. Many of these systems were installed on Beechcraft prop aircraft like the U-8, the U-21 and the C-12.

During the Vietnam War the Army flew large numbers of U-6 Beaver fixed-wing aircraft with ARD-15 HF DF systems (which worked exceptionally well) and they even had integrated fixed-wing intercept and jamming aircraft like Cefirm Leader in CEWI BNs (imagine that a G2 and G3 function in the same platform).

As to the quote about these small planes being good for tactical ISR, that has been known for at least 50 years, as the Army did multiple studies throughout the '70s, '80s and '90s that justified the "HI-LO" mix and using fixed-wing props for ISR. It was clear their low cost, slow loiter speeds and antenna-friendly installations were perfect for surveillance. Even the OSD SIGINT Mix study, which tried to kill the use of turboprops (especially Guardrail) in the early 1990s in favor of UAVs and other systems, didn't succeed when the facts were laid out.

Steve Pizzo
Toms River, NJ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the monitor news

US ARMY RAMPING UP HOSTILE FIRE DETECTION SYSTEM PROGRAM

The US Army is developing the acquisition strategy for a new Hostile Fore Detection System (HFDS) that will enable its helicopter crews to detect and respond to enemy fire from small arms and rocket propelled grenades. The Army's Project Manager for Aircraft Survivability Equipment (PM ASE) has issued a request for information, and program officials were scheduled to hold an industry day at Redstone Arsenal (Hunstville, AL) late last month.

The HFDS effort calls for adding new acoustic and IR sensor capabilities to the AAR-57 Common Missile Warning System (CMWS), which currently uses an ultraviolet-based sensor to detect and declare approaching IR-guided missile threats. By adding acoustic and IR sensors and fusing their information with existing UV and laser warning sensor data (via the AVR-2B), the helicopter's self-protection suite will be able to detect small arms fire and rocket-propelled grenades (RPGs), which have been the primary threat to coalition helicopters throughout operations in Iraq and Afghanistan.

The Army plans to develop the HFDS capability in three increments in parallel with development of an ASE modular open system architecture (MOSA) and an integrated ASE suite. HFDS Increment 1 is expected to provide a baseline capability to "detect, declare and provide a line of bearing to the threat. The second increment would expand the threat detection and classification capabilities. Increment 3 would fully integrate the hostile fire detection capability into the ASE, provide threat geolocation and provide a countermeasure response to the threat. The ability for helicopters to automatically detect, identify, locate and respond to small arms fire would be a major milestone in ASE development.

The PM ASE office will evaluate industry input over the next several months as it develops its acquisition strategy for this effort. The Army is expected to initiate a two-year HFDS technology development phase in the second half of FY2011. The technical point of contact for the HFDS program is Ms. Suzanne Birdsong, (256) 425-6047, e-mail Suzanne.birdsong@us.army.mil. – *J. Knowles*

JATAS COMPETITION OPENS UP

The US Navy has decided to open up the competition for the engineering and manufacturing development (EMD) phase of its next-generation missile warning program. Currently, two teams are under contract for the technology Development (TD) phase of the Joint Allied Threat Awareness System (JATAS) program, which aims to develop a new IR-based missile warning sensor for fixed- and rotary-wing aircraft.

Alliant Techsystems and teammate BAE Systems are competing under the JATAS TD program against another team led by Lockheed Martin Missiles and Fire Control. A third major player in the missile warning market, Northrop Grumman, was not selected for the TD phase. The company is currently supplying a two-color IR missile warning system to the Navy under the Department of Navy Large Aircraft IR Countermeasures (DoN LAIRCM) program (see related story in this month's "Monitor"). It is also producing a similar capability for the Air Force under the NexGen Missile Warning System program.

The Navy's initial plan for the JATAS TD program was to select two TD contractors who would be the only companies qualified to bid for the follow-on EMD

phase of the program. However, the Navy has outlined plans to conduct a full and open competition for the EMD phase of the program, clearing the way for Northrop Grumman to re-enter the competition for the EMD phase of the program. The Navy plans to select a single contractor for the JATAS EMD effort.

Naval Air Systems Command (NAVAIR), which is managing the JATAS program, will allow companies to bid for the EMD phase if they pass certain systems engineering and technical reviews, including a system requirements review, a systems functional review and a preliminary design review. JATAS EMD bidders will also be required to provide additional documentation, such as various design specifications, interface control documents, and test plans. These documents are due to NAVAIR by October 15. Potential bidders were required to register their interest with NAVAIR last month.

The JATAS EMD Phase is scheduled to begin in 2011. – *J. Knowles*

USMC COMPLETES LAIRCM BUY

The US Marine Corps completed its planned buy of a laser-based, directional infrared countermeasures (DIRCM) system for its medium- and heavy-lift helicopters with the award of a $77.7 million contract to Northrop Grumman last month by Naval Air Systems Command (NAVAIR). The system has been in service on CH-53E Super Stallion helicopters in Iraq and Afghanistan since early 2009 and is in line for CH-53D and CH-46E aircraft deploying overseas as well. The DIRCM system protects the "low-and-slow" flying aircraft against IR-guided man-portable air defense systems (MANPADS).

The Navy and Marine Corps call their system, produced by Northrop Grumman's Land and Self-Protection Systems Division (Rolling Meadows, IL), the AAQ-24(V)25 Department of the Navy Large Aircraft IRCM (DoN LAIRCM) system. The Air Force began using its earlier version of the AAQ-24 LAIRCM on its C-17 and C-130 transports in 2003.

The AAQ-24, with no action required by the aircrew, automatically detects and tracks an incoming threat missile. It then directs a high-intensity modulated laser beam – from a swiveling pointer-tracker turret – at the missile's guidance seeker to defeat it.

In addition to the turret (laser transmitter assembly or LTA), the AAQ-24 includes a passive missile warning system (MWS) and a processor. Each of the Marine helicopters uses two LTAs, one on each side of the aircraft, and five MWS sensors spread externally around the aircraft's fuselage, to provide full spatial coverage. The MWS cues the LTAs to the direction of arrival of the IR missile.

The Air Force began replacing the AAQ-24's original Small LTA (SLTA) in 2008 with the smaller and lighter

Guardian turret, which is used on the USMC helicopters. Those aircraft were the first to be outfitted with a more advanced two-color IR MWS, developed by Northrop Grumman, to replace its ultraviolet-based AAR-54 Passive Missile Warning System on the Air Force's AAQ-24s. The two-color IR MWS provides faster and longer-range detection than a UV sensor and much lower false alarm rates because it compares the IR energy levels of a potential threat in two separate frequency bands.

The AAQ-24 comprises an A kit and a B kit. The A kit consists of the wiring and structural modifications to the aircraft that allow it to be outfitted with the B kit (LTAs, MWS and processor). The B kit installation is not permanent; the equipment can be moved from one aircraft to another.

The Marine Corps plans to install the A-kits on all of its CH-53Es and on some portion of its CH-53D and CH-46E fleets to ensure that enough of the modified helicopters can be outfitted with B kits to meet overseas commitments. Under this latest $77 million DoN LAIRCM contract awarded to Northrop Grumman, the company will deliver 121 Guardian LTAs to the Navy at a rate of about 10 per month beginning in August 2011 and finishing in August 2012.

Navy CAPT Paul Overstreet, who heads the Advanced Tactical Aircraft Protection Systems Office (PMA-272) at NAVAIR, NAS Patuxent River, MD, told *JED* that about half of the Marine Corps' CH-53Es have received the A kit modifications. The CH-46E's DoN LAIRCM system passed its formal Operational Evaluation (OPEVAL) in July, so A kit modifications to CH-46Es only began recently, he said, and the CH-53D DoN LAIRCM system was undergoing OPEVAL as of late August.

"We expect to have enough CH-46Es modified by the end of the year to support a deployment of 12 aircraft and enough CH-53Ds modified by next spring to support their planned deployment," Overstreet said.

Northrop Grumman's August 6 contract covered the production of a final 103 Guardian LTAs for the Marine Corps helicopters as well as 18 of the LTAs for use on Air Force Special Operations Command CV-22 tilt-rotor aircraft. – *G. Goodman*

SOCOM SEEKS "DARK" IR COUNTERMEASURES FLARE

US Special Operations Command (SOCOM) is seeking information from companies capable of developing and manufacturing a new low-visible flare to protect its aircraft from IR-guided threats. SOCOM's fixed and rotary-wing aircraft often must fly missions deep into enemy airspace at low altitudes while remaining undetected. A covert countermeasures flare that does not emit significant visible light would provide a major operational benefit.

SOCOM currently uses covert, Special Materials Decoys, such as the M211 manufactured by Alloy Surfaces Company (Chester Township, PA) for its helicopters. These flares burn at much lower temperatures than magnesium-teflon-viton flares, and this property makes them very difficult to detect with the visible eye, even at night. SOCOM is now interested in developing a new generation of covert flares and it is requesting information that will help it plan


Never saw us coming.

the new program. SOCOM will consider candidate solutions in terms of airworthiness, effectiveness, reliability, interface and interoperability and shelf life, according to a request for information (RFI) issued by the Joint Munitions and Lethality Contracting Center (Picatinny Arsenal, NJ).

The development phase of the potential flare program would run approximately 18 months, covering design, fabrication, assembly, packaging, testing and analysis. As part of this effort, selected contractor(s) would deliver a small quantity of "dark" flares for testing and evaluation. Pending successful test results, the contractor may be awarded an option for limited-rate initial production.

Aside from Alloy, other companies that may respond to the RFI include Alloy's sister division in the UK, Chemring Countermeasures, and Israel Military Industries (IMI).

Responses to the RFI were due in late August. After viewing the information, SOCOM could follow up with a formal solicitation in FY2011. The point of contact at the Joint Munitions and Lethality Contracting Center is Kristen Kachur, (973) 724-3217, Kristen.Kachur@us.army.mil. – *J. Knowles*

US ARMY PLANNING DUKE JAMMER UPGRADE

The US Army's Program Manager for Electronic Warfare (Aberdeen Proving Ground, MD) has issued a request for information (RFI) to provide upgrades to the mounted AN/VLQ-12(V)2, also known as the Duke V3 system. According to the RFI, the Army wants to upgrade the Duke V3 with a variety of technology insertions to ensure that it remains effective against new and emerging IED threats.

The Duke comprises a "two box" (primary unit and secondary unit) solution. The primary unit cover IED threats in "Bands A and B." The secondary unit handles "Band C" threats. The desired upgrades would be implemented on the primary unit.

According to the RFI, the Army is seeking companies that can provide the following types of upgrades:

- Provide waveform reprogramming to address emerging threats,
- Demonstrate compatibility with Blue Force communications and interoperability with other mounted and dismounted CREW systems,

US NAVY, AIR FORCE SEEK CLOSED-LOOP RF THREAT SIMULATOR

The Naval Air Warfare Center Weapons Division (NAWCWD) in China Lake, CA is seeking information from companies that can deliver a portable closed-loop test system. Known as the Portable Closed-Loop Operational RFCM Evaluation System (PCORES), it would represent a new generation of RF simulation and test equipment capable of evaluating advanced EW systems, such as the Next Generation Jammer (NGJ) and the Integrated Defensive Electronic Countermeasures (IDECM) System Block 5.

NAWCWD's Threat Target Systems Division is studying the requirement, as well as the acquisition strategy, for the PCORES. Currently, the Navy relies on open-loop simulators, such as the CEESIM and AMES equipment from Northrop Grumman Amherst Systems, as well as other non-programmable systems. In order to test new EW systems, however, the Navy may determine that it requires a programmable, closed-loop simulation capability to emulate advanced threats.

If the Navy opts to develop PCORES, it would likely seek a common simulator for multiple facilities, such as the ground-based hardware-in-the-loop labs at NAWS Point Mugu, CA, installed system test facilities at the Air Combat Environment Test and Evaluation Facility (ACETEF) and open-air ranges such as the China Lake Electronic Combat Range (ECR). (The open-air range version of the system would require the addition of high-power transmit components and antennas.) Aside from being a "common" system for the Navy, the PCORES program may also be a joint acquisition, as the US Air Force has a similar need for an advanced RF threat simulation capability.

The NAWCWD study and the results of the RFI will be used to help the Navy determine what is available in terms of advanced RF threat simulation technology and to plot an acquisition strategy. Northrop Grumman, AAI Corp. and DRS Defense Solutions are among the companies likely to pursue a PCORES acquisition program. Responses to the RFI are due September 8. The program point of contact is Craig Matheny, (760) 939-4280, e-mail craig.matheny@navy.mil – *J. Knowles*

- Provide programmability to support operation with various timing protocols,
- Provide programmability to support complex waveform generation for advanced jamming techniques,
- Provide full frequency coverage of Bands A and B in the primary unit,
- An ability to address multiple threats at operationally effective distances,
- Provide open high-speed interfaces to allow integration with specialized EW modules and user interface devices,
- Support Common Timing Protocol-compliant CREW-to-CREW networking,
- Use the existing primary unit of the Duke V3 system to accomplish the technology insertion efforts; and maintain existing size, weight and power limits (as defined in a classified performance specification),
- Full system built-in test (BIT) with fault isolation to the line-replaceable unit,
- Provide an event logging capability for post mission analysis and for future emerging applications. (The event log will also record BIT results.),
- Provide Selective Availability/Anti-Spoofing Module (SAASM) Global Positioning System-compliant design,
- Provide level 3 anti-tamper capabilities, and
- Utilize existing Duke V3 antenna system to minimize integration impact with US Army vehicles.

The Army does not own the technical data package for the Duke V3 system. Aside from the Duke V3 manufacturer, SRCTec (Syracuse, NY), it is not clear if any other company will pursue the upgrade on a competitive basis. The Army expects to award a contract for the Duke V3 system technology insertion in the third quarter of FY2011. The technical point of contact for this effort is John Masco, (732) 532-4350, e-mail: john.masco@us.army.mil. – *JED Staff*

NULKA GOES VERTICAL

The first vertical launch of the US Navy's Nulka offboard electronic countermeasures rocket occurred on August 12 at Eglin AFB, FL. Two Nulka test rounds were fired from Lockheed Martin MS2-Baltimore's new Extensible Launching System (ExLS). The latter is an insert developed by the company that snaps into its existing Mk-41Vertical Launching System (VLS) cell, allowing a variety of missiles to be integrated and launched vertically for the first time.

Nulka is an active decoy, developed jointly by the Navy and Australia's Department of Defence. The 6.5-foot-long, 8-inch-diameter Nulka employs a broadband RF repeater decoy payload mounted atop a hovering rocket. In the US Navy configuration, it is deployed from the deck-mounted Mk-53 decoy launching system. Once launched, the decoy moves away from the ship and its receiver detects and processes RF signals from incoming anti-ship missiles while rejecting RF emissions from friendly systems. It lures the incoming missile away from the ship by radiating high-power RF signals that mimic the radar return from a target.

The MK 41 VLS, installed below deck on US Navy Aegis destroyers and cruisers, eliminates the need for separate topside Nulka launchers, such as the Mk 53, according to the company. The Mk 41 currently launches Tomahawk and Standard missiles, which emerge from the top deck. The MK 41 VLS is deployed in 13 different configurations, ranging from a single module with 8 cells to 16 modules with 122 cells. The launcher has completed integration or is currently being integrated with 18 different ship classes and 11 different weapon control systems for 12 different navies.

Nulka is installed on all US Navy surface combatants, as well as Royal Australian Navy. BAE Systems Australia (Edinburgh, South Australia) developed the hovering rocket, while Lockheed Martin Sippican (Marion, MA) developed the decoy payload and fire control system. Lockheed recently delivered the 1,000th payload for assembly in Australia.

The ExLS test was conducted with support from the Naval Surface Warfare Centers at Dahlgren, VA, and Crane, IN, as well as BAE Systems Australia. – *G. Goodman*

IN BRIEF

The **US Air Force EW** training community will mark two significant events this month. On September 17, the Air Froce is retiring its T-43 "Gator" training aircraft during a ceremony at Randolph AFB, TX. The T-43 was used by the 562nd and 563rd Flying Training Squadrons for Combat Systems Officer (and previously for Electronic Warfare Officer) training. On September 30, the last EWO class will graduate (soft winging) from the 563rd FTS, with a formal ceremony scheduled for October 1.

✪ ✪ ✪

Alloy Surfaces Company, Inc. (Chester Township, PA) has been awarded a three-year, $38 million indefinite-delivery/indefinite-quantity (IDIQ) contract to manufacture MJU-49/B decoy devices for US Navy aircraft. Deliveries are scheduled through December 2013.

✪ ✪ ✪

Lockheed Martin (Syracuse, NY) has successfully completed a preliminary design for the US Navy's Surface Electronic Warfare Improvement (SEWIP) Block 2 upgrade program. The initial $9.9 million design contract for SEWIP Block 2 was awarded to the company in November 2009 and includes options totaling nearly $167 million. Under the SEWIP program, the Navy is pursuing a succession of enhancements to its AN/SLQ-32 EW system.

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ITT Advanced Engineering & Sciences (Annapolis Junction, MD) received a $455 million contract from Naval Sea Systems Command (NAVSEA) for production of up to 5,000 Joint Counter Radio-Controlled Improvised Explosive Device Electronic Warfare (JCREW) 3.2 mounted systems. The contract is for the procurement and support of JCREW to be used by forces across all US military services. Most of the work will be performed in Thousand Oaks, CA, and is expected to be completed by September 2014. ITT's Force Protection business also received an $18 million contract option for the production and support of 260 CREW 2.1 systems. The systems will include the Band C upgrade to support forces in Operation Enduring Freedom. Work on the contract will be carried out in Thousand Oaks and is expected to be completed by April 2011.

washington report

DOD RELEASES SMALL BUSINESS RESEARCH SOLICITATION

The DOD has listed its final (of three) Small Business Innovative Research (SBIR) solicitations for FY2010. The SBIR solicitation lists several EW topics.

The Air Force portion of the solicitation includes Topic AF103-023, titled "Rapid Reprogramming Technologies for Electronic Warfare Training," which will focus on defining, developing and demonstrating "innovative technologies that allow training systems to rapidly and accurately represent agile, reactive, and adaptable threats." The solutions will be used in systems, such as "high fidelity flight simulators, constructive threat simulations, computer generated forces, and embedded training capabilities in actual systems." Phase 1 work entails developing a system design concept, and Phase 2 calls for a prototype demonstration and conducting "an end-to-end demonstration of a US electronic warfare system reacting to a rapidly changing threat."

Another Air Force effort, "Sensor Network Data Management for Distributed Electronic Warfare," (Topic AF103-189) seeks to "develop algorithms for optimal data re-routing/fusion in sensor networks supporting distributed electronic warfare assets when they encounter network disruption due to random malfunction or malicious attack." Phase 1 entails studying data communications requirements for sensor networks supporting distributed EW missions. During Phase 2, the contractor will develop "fast mathematical algorithms" to re-route sensor data during network disruption.

The Navy listed several EW topics in its portion of the solicitation. NAVAIR's Advanced Tactical Aircraft Protection Systems Program Office (PMA-272) sponsored several topics related to ultra-short pulsed lasers for IR countermeasures applications. Under Topic N103-201, "Fiber Delivery Systems for Ultrashort Pulse Lasers," the Navy wants to design and develop "an innovative process using fiber-based delivery of high peak power ultra-short pulsed laser radiation," for use in future directed IR countermeasures systems. Phase 1 calls for developing an concept and a basic design. The second phase entails completing the design and building the fiber delivery subsystem. "Notional delivery system specifications should meet or exceed 1+ mJ per pulse, <1 ps pulse duration, and 1 kHz repetition rate," according to the topic description. Two other topics, "Novel Amplifier Materials and Technology for Ultrashort Pulse Lasers," (Topic N103-210) and "Automated Ultrashort Pulsed Laser Tailoring Technology," (Topic N103-211) also focus on future DIRCM technology.

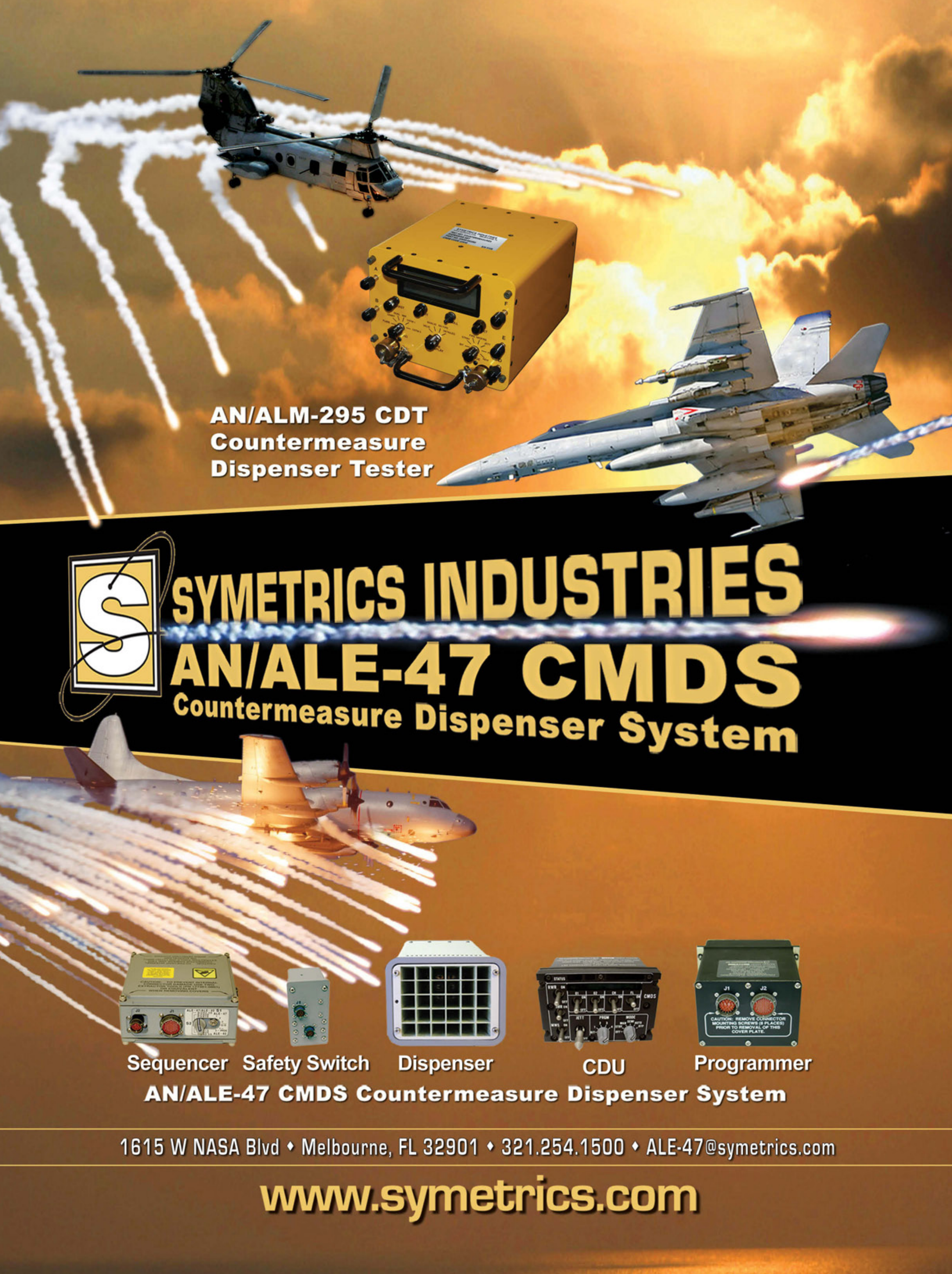
Another PMA-272 topic (N103-209) seeks solutions for a new "AN/ALE-47 Dispenser Assembly Retaining System." This addresses a deficiency in the ALE-47 in which the magazine attachments can wear down and fail without warning. This topic calls for designing and developing "a reliable, maintainable and safe dispenser retaining system with positive locking indications for the US Navy configuration (round expendables) AN/ALE-47 dispenser assembly that allows for efficient removal and replacement of the on-aircraft magazine."

NAVAIR's EA-18G program office (PMA-265) is sponsoring a topic titled "Radio Frequency (RF) System Performance and Electromagnetic Interference (EMI) in Dynamic Environments," (Topic N103-202). Under this research effort, the Navy seeks to develop a tool that allows analysts to accurately assess RF system performance over a time window where physical conditions change. Phase 1 work calls for demonstration of "proof of concept prototype algorithms for solving the problems of EMI, installed antenna pattern, and other RF-system-level metrics under dynamic conditions of moving parts on platforms and also one or more platforms in complex maneuvers." During Phase 2, the contractor will further develop the algorithms and "demonstrate their accuracy, robustness and speed."

NAVAIR's Direct and Time Sensitive Strike Weapons Program Office (PMA-242) is sponsoring a topic titled, "Ultra Wideband Conformal Antennas for Network Enabled Weapons," (Topic N103-204). The objective of this research is to "develop and demonstrate conformal antennas suitable for a number of existing missile airframes, which are capable of transmitting and receiving an ultra wide bandwidth of frequencies." The ultimate goal is to develop an engineering model of a conformal antenna and integrate it with a missile, such as the Advanced Anti-Radiation Guided Missile (AARGM), for flight demonstration. The point of contact for all of the previously described NAVAIR topics is Janet McGovern, e-mail navair.sbir@navy.mil.

Naval Sea Systems Command (NAVSEA) is seeking research into "Adaptive Data Fusion for Real-time Threat Assessment" (Topic N103-224) for the Navy's shipboard EW systems. The objective of this work is to enable naval EW systems, such as the BLQ-10 and Integrated Topside, to perform against modern radars in the dense signal environments associated with littoral operations. The point of contact is Dean Putnam, e-mail dean.r.putnam@navy.mil.

SBIR proposals are due on September 15. The detailed topics and additional information can be accessed on the Web at www.dodsbir.net. – *JED Staff*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world report

ISRAEL BUYS F-35, AGREES TO "EW COMPROMISE"

After years of negotiations between the Israeli and US governments, Israel's Defense Minister, Ehud Barak, approved a deal to buy F-35 fighters for the Israeli Air Force. While there were several aspects of the deal that caused delay, one of the most contentious issues was the aircraft's electronic warfare (EW) suite.

When buying foreign weapon systems, the Israeli government typically follows a policy of customizing the platforms for its unique requirements and buying domestically manufactured systems and technology. This usually includes installation of Israeli-manufactured (and supported) EW systems on its platforms. This policy became an issue when the DOD insisted that Israel accept the F-35's standard EW suite, the AN/ASQ-239 Barracuda RF EW system, which is manufactured by BAE Systems (Nashua, NH).

Throughout two years of contract negotiations, the Israeli government resisted the US position on F-35 EW. In the end, according to informed sources, the US and Israeli government struck a compromise on the EW suite. Israel will buy its first batch of 20 F-35s (valued at approximately $2.7 billion and paid for with Foreign Military Funding from the US) equipped with the ASQ-239, which includes ESM and RF countermeasures subsystems. In order to meet some of its unique requirements, the Israeli F-35s will receive several ASQ-239 EW upgrades, which coincide with improvements the US wants for its F-35s, as well.

Israel's 20-aircraft order will be part of the initial batch of full-rate production aircraft, slated for delivery in 2015. The Israeli Air Force still maintains a requirement for 75 F-35s, and it is expected to buy more aircraft in future production lots. In these future buys, according to informed sources, the DOD has created an option for the Israeli government to pay for the installation of Israeli-made EW systems into the aircraft. The cost of integrating a new EW system into the highly integrated JSF avionics suite will be considerable. But it would fulfill Israel's need to tailor the aircraft according to its own requirements and invest in its defense industry. Within the Israeli defense industry, Elbit's Elisra subsidiary is widely believed to be the company that would provide the JSF EW suite.

The Cabinet of Israeli Prime Minister Benjamin Netanyahu must formally approve the F-35 buy. However, the sale is not expected to run into significant political opposition. In July, the Canadian government announced that it would buy 65 F-35s. – *J. Knowles*

CHEMRING TO BUY ROKE

Chemring plc (Fareham, Hampshire, UK) announced last month that it will buy Roke Manor Research Ltd. (Romsey, Hampshire, UK) from Siemens Holdings plc for £55 million (US$85 million).

Roke manufactures electronic systems and provides consulting services for a variety of markets. In the defense sector, the company makes radars and communications-band EW and SIGINT systems, including its "Locate" direction finding and receiver family and its "Resolve" communications ESM systems. Last year, Roke won a major EW contract from the UK Ministry of Defense for Project SEER. Under that program, the company is supplying 58 man-pack communications EW (ESM and EA) systems for British land forces.

For Chemring, which until a few years ago was primarily a countermeasure flare and pyrotechnics company, the acquisition of Roke further diversifies its portfolio in the defense electronics and homeland security markets. According to Chemring, the existing management team at Roke will remain in place after the acquisition is completed. – *J. Knowles*

IN BRIEF

- **Indra Sistemas** (Madrid, Spain) has been tapped to supply radar ESM systems for the Italian Navy's U212 submarines. The company will supply ESM systems similar to those it provided to German Navy U212 boats. The contract was awarded by Fincantieri, which is building the submarines for the Italian Navy.
- The government of **Oman** has requested the purchase of 18 F-16 Block 50/52 aircraft from the US via Foreign Military Sales channels. The proposed deal includes 24 APG-68(V)9 radars and 18 AN/AAQ-33 Sniper Pods. Oman is being offered two EW options: the ALQ-211 Advanced Integrated Defensive EW System (AIDEWS) from ITT or the Advanced Countermeasures Electronic System (ACES) – comprising the ALR-93 RWR and ALQ-187 jammer – from Raytheon. Either option will be integrated with ALE-47 countermeasures dispensers. The proposed sale also includes 35 ALE-50 towed decoys. This is the first known sale of the standard ALE-50 to the Gulf region. The UAE is believed to fly a fiber-optic version of the ALE-50 (FO-50) on its F-16 Block 60 fighters.) The deal also includes unspecified upgrades for 12 F-16s already in service with the Royal Air Force of Oman.
- **Terma A/S** (Lystrup, Denmark) and **L-3 Link Simulation & Training** (Arlington, TX) have agreed to jointly develop a fighter aircraft simulation solution that incorporates Terma's Electronic Warfare Management System (EWMS). The EWMS simulation initially will be integrated on two Royal Danish Air Force (RDAF) F-16 Unit Level Trainers and two F-16 Part Task Trainers. L-3 Link and Terma will deliver this solution to the RDAF in 2011.


TAKING YOUR MISSION TO
THE PEAK OF SUCCESS

EW, the EMS Domain and Air Superiority

By Lt Col Jeffrey H. Fischer

The EMS Domain.

There, I said it. What are you going to do about it?

Every now and then, I sit around with friends and banter back and forth on a myriad of electronic warfare (EW) topics. On occasion, the discussion evolves into whether or not the electromagnetic spectrum (EMS) is a medium or domain. To frame the discussion, a medium has intrinsic military value but is not decisive to operations or strategy. A domain is critical to military employment from tactical to strategic levels – i.e., land, sea, space, and air. Each is undeniably reliant on others for successful operations. In these debates, I am always the EMS domain advocate, and recently something interesting has been happening – my arguments and positions are getting stronger. While I wish I could attribute the increases of success on my ever-improving oratory skills, I don't believe that's the case. I believe, as every day goes by and the US military becomes increasingly dependent on the EMS, eventually, the EMS will gain its rightful place as a warfare domain alongside air, land, sea, space and cyber.

HISTORIC TRANSITIONS OF MEDIUMS INTO WARFARE DOMAINS

Just as the sea was initially a medium for many, many years (even before the creation of seaworthy vessels), man viewed waterways as logistical avenues for transporting personnel and goods over water. That application progressed to controlling those routes by building war ships. Eventually, the ability of sea battles to impact warfare at strategic levels proved the sea was no longer just a medium; it had become a full-fledged domain. A similar argument can be applied to the air domain. During the American Civil War, air (think reconnaissance balloons) was just a medium. It was not until well after Orville and Wilbur harnessed flight that militaries gained the opportunity to consider air as a domain. Interestingly, even after the technological leap into the air (no pun intended), it took years for the air medium to become a domain. This most likely happened sometime after Gen Billy Mitchell's sinking of the *Ostfriesland*. The important point is not *when* air turned from a medium to a domain; rather that air *did* transition, given new technologies. Technology (manned flight) facilitated new military capabilities with profound operational and strategic impacts on the other domains (land and sea). The three domains (air, land and sea) became intrinsically reliant and interdependent on each other for military actions – tactical to strategic.

Realizing that it was new technologies which transitioned sea and air (and space, as well) from mediums to domains, it is not hard to envision that the EMS – given technological development – will also someday become a domain. The military has increasingly leveraged the EMS medium over the years. From radios, radars, data link systems, video feeds, millimeter wave systems and others, EMS usage and reliance exponentially grows.

EMS reliance arguments are becoming increasingly easy. As an aviator, let me provide an example: an aviator's primary tasks are to "aviate, navigate, and communicate." Years ago, the EMS only enabled *communication* via VHF/UHF radios. Soon thereafter, radars, navigational aids and Doppler enabled *navigation*. In the 1990s, RF signals from the satellite-based global positioning system (GPS) solidified reliance on the EMS to *navigate* (not just aircraft, but also weaponry). And today, the evolution to radio frequency-controlled remotely piloted vehicles has forced some aviators into complete reliance on the EMS to "aviate, navigate and communicate." Similar arguments can be made for other domains' (land, sea, space and cyber) EMS dependencies. Given this continually increasing reliance, at some point, DOD must realize a full and utter dependence on the EMS, and it is at that point the EMS will become a domain. Soon thereafter, DOD will realize the value of EMS supremacy, much like air supremacy and sea supremacy. More importantly, it will become apparent if a future adversary was to gain EMS supremacy, because the US and its allies would suffer a significant strategic disadvantage across all other domains.

OTHER EMERGING DOMAINS IN THE MILITARY

Efforts to validate other military operational domains are not new, and today the DOD is moving forward with the cyber domain. I must confess, I'm not sold. While cyber does follow the aforementioned domain interdependency theory, like the air domain, I am leery to give cyberspace the domain nod for one reason: cyber did not start as a natural medium – it is man-made. Just as man has become increasingly dependent on cyber and the Internet, man still has (and will always have) the ability to cease information processing and "turn off" the Internet – as scary as that might be. (A humorous side note here: For over a year, I've debated an Internet "off switch," and the response is always, "Fisch, there is NO WAY to turn off the Internet or cyber. It's just too big." I chuckle knowing the US Congress is working on legislation that would give the President of the United States that very capability – a cyber "kill switch." Given an ability to turn off a domain, I'm willing to bet during WWII when London was being bombed frequently, the British seriously wished they had an air domain ON/OFF switch.)

Anyway, I digress. The point is, the domains of air, sea, land, space and EMS naturally occur in the environment. Because of this, they are bound by laws of physics – gravity, Archimedes's principles, Newton's Laws, Bernoulli's principles, aerodynamics, hydrodynamics, speed of light, line of sight, propagation, attenuation, vacuums, etc. While humans can choose not to fly, sail, march, orbit or transmit, that will not stop flying birds, swimming fish, roaming animals, orbiting planets, and electromagnetic disturbances. Because of this, I firmly believe a true warfighting domain must first exist in nature whether man exists or not.

While I don't think senior leaders will reverse course on the creation of the cyber domain, I do provide words of caution. Two serious dilemmas face DOD and policy makers: emerging man-made domains and an "unbounded" cyber domain. First, creating a man-made domain opens future doors for additional man-made domains. In the Capitol Beltway, air, land and sea services cringe at "emerging new domains," as it directly correlates to a loss of budgetary strength (the DOD top line is most likely not going to increase). Limiting domains to physical entities might have been a better approach, as the EMS was the last known natural domain. Man-made domains will continually emerge (maybe the "artificial intelligence" domain is next) which will continually spur "domain debates." Additionally, the Internet (what most people equate to the cyber domain) is an ever-evolving entity, and therefore the domain's definition will also continually evolve (as stated earlier, cyber is not bound by natural physical laws). Can you imagine an Air Force defining policy, strategy, operations and tactics for the "air" domain if Bernoulli's principle, gravity, and other bounding natural laws continually changed?

Usually, at this point, many of my verbal sparring partners try to encompass the EMS into cyber domain. Additionally, I hear cyber is more than the Internet. I don't dispute that and I also do not dispute that the United States' reliance on cyber is massive. However, I do argue that cyber is *not* the EMS and the EMS is *not* cyber. EMS systems (radar, comms, targeting systems, EW, navigation, IFF, etc.) resident in aircraft, satellites, ships or land vehicles in *no way* make the EMS a part of the air, space, sea and land domains. Similarly, cyber's reliance on EMS systems also does not provide linkages to make EMS part of the cyber domain.

WHAT'S STOPPING THE EMS FROM GAINING DOMAIN STATUS?

While I argue the US should have already made the EMS a domain, the more important question is, "Why hasn't the US established the EMS domain already?" Three reasons are readily apparent: organizational issues, the invisibility of the EMS and a limited pool of advocates. The US military machine is organized in a "domain-based" construct. As air (and space), land and sea domains exist, so do their respective domain departments – Air Force, Army and Navy. Given the DOD's fiscal constraints, services hesitate to champion the creation of new domains (and potentially new departments). Case in point – the fight and consternation over the recent creation of cyber. Historically, services aggressively challenge any program or idea that threatens service (domain)-related funding. (Think about the space domain and the Rand Report, for instance). Another organizational problem is pre-existing EMS reliance and a fear of oversight and control. Encompassing intelligence collection, command and


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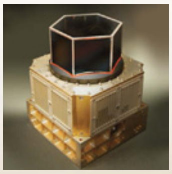
control, bandwidth congestion, sister services and other governmental agencies usage, industry stakeholders, FCC oversight and many more organizations, the stakes involved in surrendering established EMS footholds to a "domain manager" are many. It is most likely an idea very few senior leaders in DOD or other agencies are willing to consider.

Another potential reason the EMS is not already a domain is its "invisibility" and relative mystery to the average human. Unlike air, land, sea and space, we cannot see, touch, or feel the EMS. To many, it is an enigma and poorly understood. For those who use cell phones, watch TV, listen to satellite radio, connect to WiFi hotspots or navigate their automobiles with GPS, the EMS is likened to a heart pacemaker. People might not notice when it is working, but they sure know when it isn't. Additionally, people have little idea of the inner-workings of a pacemaker – just as very few understand the EMS. Because of this, gaining support to transition the EMS from medium to domain is difficult. On the other hand, EMS experts usually attempt to explain it to decision makers with words like," frequency, pulse width, PRF, PRI, monopulse, right-hand circular polarization, etc." From my experiences, this is where most of the decision makers fall victim to the medical condition known as the "EMS-induced coma."

The final reason the EMS has yet to achieve domain status is a significant lack of manpower (think advocacy) across the services. Just as aviators advocate air issues and space operators advocated space issues, it is the EW specialists who must champion and advocate EMS issues. Today, three services have advocates – Air Force Electronic Warfare Officers (EWO) and Navy/Marine Electronic Counter Measures Officers (ECMO). The US Army recently established a new EW Military Occupational Specialty (MOS), and it will eventually stand up a significant number of trained electronic warfare specialists. But today, the Army currently lacks EW specialists. Operations in Afghanistan and Iraq exacerbate the limited USAF, USN, and USMC EW specialist pool, as EWOs and ECMOs from stateside critical billets fill ground combat EW positions.

Another problem is the shortage of EMS advocates available to generate the horsepower needed to adequately push EW agendas. Within the US Air Force, few EWOs rise to the ranks required to champion EW. And if they do, too few O-6 EWO billets exist, causing the Colonel's Group problems for assignment matching. The Air Force personnel system categorizes EWOs the following way: aviator first, navigator second, type airframe (heavy or fighter) third and EWO is fourth. Case in point: a recent EWO whose past includes weapons officer graduate, Air Staff EWO and Electronic Warfare Deputy Group Commander graduated from the Industrial College of the Armed Forces (he received the CJCS strategic paper award writing on information ops), was assignment matched to a foreign country's air attaché assignment as he was an aviator (assignment match requirement) and had studied two years of that country's language in college (desired). His EWO knowledge was most likely not considered.

"Corporate culture" hurdles within the services exacerbate the manpower problem. In the Air Force, few EWOs man weapon systems in which the primary mission is offensive airborne electronic attack. The majority of EWOs fly kinetic strike (B-52, B-1, F-15E) and collection (RC-135) platforms. In no way is this statement derogatory; these EWOs are awesome at what they do – be it protecting their airframe or intelligence exploitation. But these assignments cultivate a mindset in line with the platform's mission, rather than EMS dominance. In the Navy/USMC, a large pool of EMS-dominance trained ECMOs exist. However, EA-6Bs will soon be replaced with EA-18Gs, reducing ECMO manning by 66 percent. Similarly, the USMC eventually plans to transition from EA-6Bs to the single-seat (pilot only) F-35 – further re-



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ducing EMS corporate knowledge. Today, the only service increasing EW manpower capacity is the Army.

The services' limited EW personnel and thin "corporate knowledge" amplify the problem of too few EMS advocates in DOD. Given this manpower limitation, it is not a stretch to say that today's EMS advocates are nearly nonexistent, especially when compared to aviation personnel of the 1930-40s who advocated the creation of a separate air service or the number of space personnel in the 1970-80s who advocated its domain establishment.

Finally, the last advocacy problem is the lack of industry backing. Within the scope of the DOD budget, EMS-related programs represent a relatively small portion of industry dollars and quite often are subcontracts or subcomponents on much larger military programs. It is large-dollar programs that influence DOD and Congress.

NEVER FORGET: FUTURE POTENTIAL ADVERSARIES ALWAYS GET A VOTE

Given the hurdles that hinder the growth of EMS into a domain, it is interesting to investigate what other nations are doing with their EMS programs. Over our nation's past wars, the world witnessed the US dominate both the Iraqi and Yugoslavian air defense systems during Operations Desert Storm, Iraqi Freedom and Allied Force. The world quietly learned the undeniable value of EMS dominance. One of these countries is the People's Republic of China. Over the past few years, the Chinese have created a high-level office in charge of information operations and electronic warfare. This office is on par in level to the Chinese Army, Navy and Air Force, reporting directly to the Ministry of National Defense. A four-star general oversees EW in China. A colonel oversees it in the USAF. There is no question China's placement of electronic warfare in its national defense system is much higher than the United States.

APPLICATION OF AIR EW OPS – TODAY'S RELEVANCE AND RELIANCE

As stated earlier, cyberspace has become a domain due to the continual increasing reliance by other domains; cyber assets are critical components to how the US fights wars in land, sea, air and space. Interestingly, the components that comprise the cyber domain – computers, the Internet, SiPRnet, PDAs, open and closed networks, information feeds from JTIDS and Blue Force Tracker, etc. – are all physical entities that exist. While the EMS is "invisible," today's warfighter is no less reliant on it than cyber. From command and control (C2) nets, GPS, MTI, SAR, and Doppler radars, to tactical datalinks, wideband reachback capabilities, all these systems are critical to the way we fight wars. Suffice it to say, until the US military hardwires every satellite, aircraft, surface vehicle, ship, soldier, sailor, airman or Marine, it will be enslaved to the EMS.

To put into context, a US versus near-peer large-scale conflict where the US and coalition lose EMS superiority might look like this: First, Air Operations Center (AOC) command and control efforts would be at a minimum degraded, if not denied. Air Tasking Order generation and distribution would be difficult and senior-level control of Time-Sensitive Targeting / Time-Critical Targeting would be impossible. Datalink and voice communications between control assets, fighters, bombers, tankers and other aircraft would most likely be hindered, denied or even deceived. GPS navigation for aircraft/munitions could be denied, especially around strategic targets,

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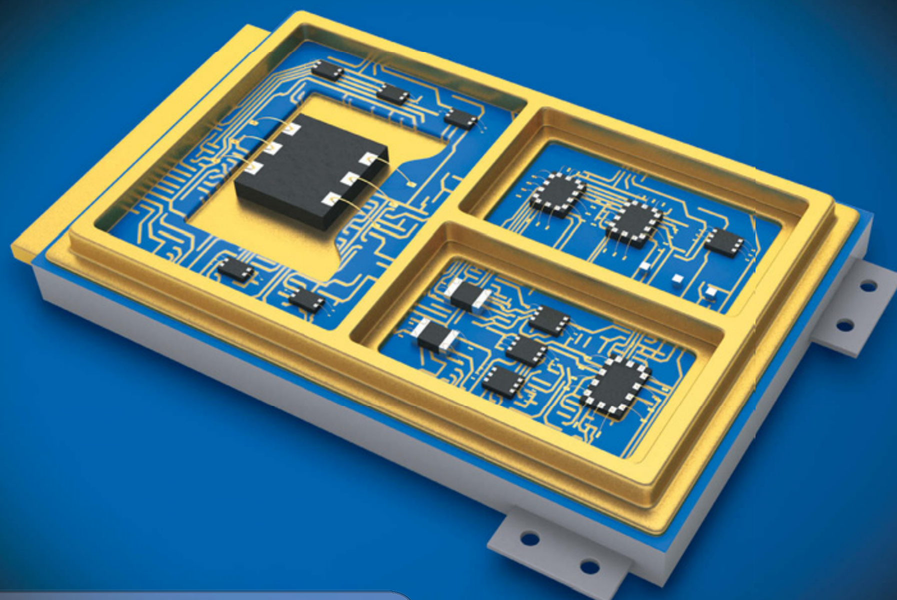

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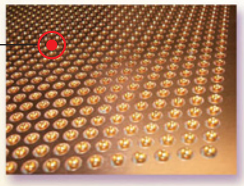

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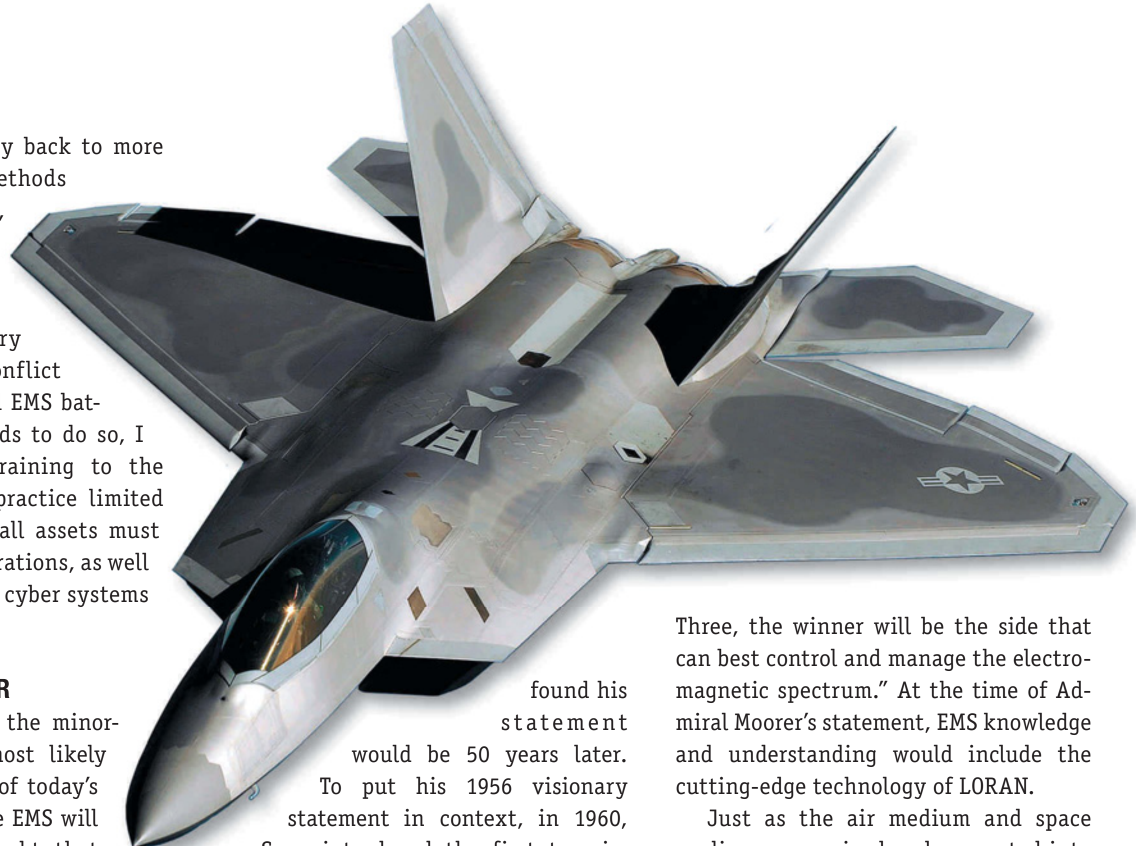

forcing weapons delivery back to more traditional guidance methods such as laser. Obviously, it's an ominous position to consider. To be fair, all is not lost. I do believe the US military can still fight a major conflict while losing a contested EMS battlespace, but if it intends to do so, I recommend it begin training to the scenario. AOCs should practice limited ability to control, and all assets must rehearse comms-out operations, as well as placing their GPS and cyber systems in the "OFF" position.

WINNING THE NEXT WAR

While I might be in the minority – and my belief most likely isn't shared with many of today's US military leaders – the EMS will become a domain. I doubt that Admiral Sergei Gorschkov, former Commander of the Soviet Navy, 1956, who once said, "Whoever controls the electromagnetic spectrum on the battlefield will win the next war," realized how profound his statement would be 50 years later. To put his 1956 visionary statement in context, in 1960, Sony introduced the first transistorized radio. Interestingly, he wasn't alone in his vision. Twenty years later, ADM Thomas H. Moorer, former Chairman of the Joint Chiefs of Staff (1970-1974), also commented, "If there is a World War Three, the winner will be the side that can best control and manage the electromagnetic spectrum." At the time of Admiral Moorer's statement, EMS knowledge and understanding would include the cutting-edge technology of LORAN.

Just as the air medium and space medium were seized and converted into revolutionary military operational domains, an opportunity exists again to leverage a new domain into operational and strategic advantages in future wars. Unfortunately, this opportunity exists not just for the United States. It's up for the taking. Earlier, I referenced Gen Billy Mitchell. As we know from history, his career was tumultuous. But without question, his efforts proved the air domain's worthiness and shaped the Air Force we know today. I don't know if the EMS needs a Billy Mitchell to push it into domain status, but I must confess, the tactic is proven.

Photos courtesy US Deparment of Defense, US Air Force and Lockheed Martin.

Lt Col Jeffrey "Fisch" Fischer, USAF, has spent the past 20 years as an EWO, flying on EC-130H and EA-6B aircraft. He served in the 41st and 43rd Electronic Combat Squadrons during Operations Deny Flight, Enduring Freedom and Iraqi Freedom and also served in VAQ-131 during Operations Southern Watch and Allied Force. For the past two years, he has been the Electronic Attack Branch Chief within the EW Requirements Office, (A5RE) at Headquarters, US Air Force. This month, he begins his master's studies at the Industrial College of the Armed Forces at National Defense University.

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Developing Critical EW Technologies

A View From the Labs

By Barry Manz

The Journal of Electronic Defense | September 2010

Mad Magazine's "Spy Versus Spy", which made its debut in 1961, is about as good a depiction of the electronic warfare (EW) environment as any that has ever appeared in print. The black spy and the white spy were constantly working to outwit each other's latest ploy. And its originator, Cuban refugee Antonio Prohias, did it all without words. So it is today, as EW systems devour virtually every technology available, from materials through analog, digital, microwave and optical semiconductors to cooling schemes, packaging, communications buses and an array of complex signal processing software, to name just a few. These projects yearly consume the efforts of thousands of engineers and scientists in government laboratories, private industry and academia.

To sort all this out, *JED* will be running multiple articles over the next few years in order to examine the development of EW from the perspectives of government and industry. This first article discusses some of the technologies driving EW forward, including the viewpoints of scientists at the Office of Naval Research and the Army's Research and Development Command. Any effort to cover all of the drivers of EW advancements would fill several issues of *JED*. This feature story targets just a few, all of which will have major impact in the years ahead.

THE MOVING TARGET OF EW

The challenge of finding new electronic methods of outwitting the enemy was difficult to start with and has grown to extraordinary proportions, thanks to increasing threat sophistication. The various elements of EW range from wired communications to RF, microwave, and millimeter-wave systems, as well as free-space and lightwave optical networks and even directed energy and anti-radiation threats. Obviously, the "to-do list" of the Army, Navy and Air Force laboratories, as well as the Defense Advanced Research Projects Agency (DARPA) is a long one.

No list of key EW technologies would be complete without a discussion of analog-to-digital converters (ADCs) and digital-to-analog converters (DACs), as conversion of received analog signals into digital form with the highest resolution and at the highest speed is a critical function of every EW system. The challenges presented by this task grow continuously as the frequency range of threats creeps higher into the electromagnetic spectrum and radar processing systems can rapidly discriminate between real targets and those created by digital RF memories (DRFMs), as well as other signals and noise.

From their inception through about 1990, the sampling rate of converters was very low and bandwidth very narrow, but they could still perform some low-speed signal processing. With a sampling rate up to only a few megahertz, they could be used in low-frequency SIGINT systems, but high-frequency applications were beyond their capabilities. This changed for the better with the introduction of the 8-bit ADC that had a sampling speed


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of 1 GHz, which gave them entry into replacing analog receiver signal processing functions with a single digital device for the first time.

Sampling rates of 1 GHz and faster allowed bandwidths of up to 500 MHz (always half the sampling rate) to be processed and the greater number of bits increased a system's dynamic range. That is, the span from the weakest to the strongest detectable signal the system can handle. Today's high-resolution ADCs can sample at around 200 MS/s (million samples per second) and soon will reach 250 MS/s with 16-bit (rather than today's 14-bit) resolution. They can dramatically enhance the capabilities of wideband receivers by increasing their sensitivity and selectivity, which affects the system's ability to intercept and characterize captured signals. Fortunately, the increase in speed of high-speed converters has not resulted in increased power consumption, which is typically about 2 W per converter with an FMC-based, quad-channel solution consuming less than 10 W. Lower-speed, dual-channel versions consume even less power.

The systems in which these converters are embedded today typically can be based on industry standards rather than the more traditional custom designs, reducing risk, cost, and deployment time. Current embedded computing standards can meet the rigorous demands of these environments, so it is now possible to use a COTS approach for the first time. Specifically, industry-standard board form factors such as FMC and XMC on standard VPX host cards are readily available. In the case of FMC, its combination of simplicity and high performance allows for very fast development times.

These standard-based systems also have the ability to provide sensor I/O capability – processing of data into a useable form along with the high-speed infrastructure that allows the information to be most effectively used. These COTS solutions can even address the low-jitter reference clocks required by the digitization synchronization process. As an alternative to an I/O card, an FMC mezzanine card coupled with an existing VPX host allows the deployment of a high-speed ADC and, using an appropriate software and firmware interface, rapid technology insertion using a FMC/VPX combination can be achieved.

THE RISE OF GaN

In the world of compound semiconductor devices for RF and microwave applications, Gallium-Arsenide (GaAs) has risen from a promising new technology to the de facto device for both small signal and RF power amplification. It has replaced silicon-based devices in a wide array of applications with the exclusion of base-station transceiver RF power amplifiers, where silicon LDMOS (laterally diffused metal oxide semiconductor) reigns supreme. However, in the last few years, a competitor has appeared whose unique capabilities and characteristics make it an excellent choice in many applications. These capabilities include exceptional power density (more power per square millimeter of die), higher power level at higher frequencies, and higher efficiency.

The first significant adoption of Gallium Arsenide (GaN) technology has been in defense systems, where its characteristics have driven it from experimental status to deployment in IED jammers and a few other applications at astonishing speed. This trend is evolving rapidly, and researchers in the Army, Navy, and Air Force, along with those at DARPA (whose joint government/industry efforts are largely responsible GaN's rapid advancement from lab to systems). It is more than likely that GaN will find its way into communications and radar systems in the not-too-distant future as well.

Of course, GaAs has an enormous advantage over any new disruptive technology such as GaN, thanks to a quarter century of development, which has dramatically reduced the cost of GaAs devices and MMICs (monolithic microwave integrated circuits) and resulted in thousands of different commercially-available GaAs devices over wide frequency and power ranges. However, this has not stopped industry prophets from projecting that GaN will significantly penetrate the GaAs market. While there is no question that GaN will have a major impact on the GaAs market, its major application will likely continue to be in EW and other defense systems, with its widespread use in commercial systems yet to come.

"GaAs has its role, especially high-voltage GaAs, as risk mitigation for some of the things we are doing with GaN," said Dr. Peter Craig, EW Science and Technology Program Manager in the C4ISR Department of the Office of Naval Research. "We'll use GaN when power is required, but GaAs also plays a part in some of the lower-power applications at the edge of arrays where you are shaping the beam."

The speed at which GaN rose from novelty to fielded technology is dramatic, especially since its initial champion and potential market is the defense industry. However, the DOD has long demonstrated its ability to ram development efforts into high gear, "cost be damned," when a clear need was apparent. That need was first revealed in the urgent requirement for IED jammers in Iraq and Afghanistan. This speed was depicted in a March 2009 *Microwave Military Digest* article quoting Dr. Mark Rosker, former program manager for DARPA's Wide Bandgap Semiconductor Technology Initiative (WBGS-RF) and now deputy director of DARPA's Microsystems Technology Office. At the beginning of the program in 2001, said Dr. Rosker, "you could measure performance of the (GaN) transistor and literally watch it degrade in front of you". However in only a few years, he said, "We made a 10^{10} improvement in operating lifetime from minutes to 107 hours."

ONR has worked hand-in-hand with DARPA during GaN's development and remains a committed supporter. "We are trying to take advantage of GaN, looking at airborne decoys, surface ship EW, and – where power-efficient – to put RF into environments in which a broad band is very critical," said Dr. Craig. "I see it a key enabler for what we want to do. We're heading into a world where EW is not a single jammer on a single aircraft, but is distributed across the entire battle force. This requires power, efficiency and smaller, lighter components and systems so they can be employed on unmanned aerial surveillance platforms". GaN has the ability to deliver on all four counts.

In addition to the inherent superiority of GaN in several key areas of performance, its rapid adoption was also driven by another significant factor: once DoD recognized the need for its performance, cost became a secondary issue, as it was needed in EW systems – and fast. A typical GaN RF power transistor currently costs considerably more than a comparable GaAs device – a problem that is offset somewhat by the fact that fewer GaN transistors are needed to produce a specific power level. For this reason, the cost of GaN devices remains problematic in the commercial sector (although less so every year), where a specific level of performance is assumed and cost is the top priority. In short, of all the compound semiconductor technologies in the RF and microwave designer's toolkit, GaN is the most likely to get DOD attention in the coming years. GaN has a fair number of hurdles to overcome before it can realize its full potential, but at the rate its proponents are progressing, the timeline is years, not decades.

SEMICONDUCTOR POWER CLOSES IN ON TUBES

Many EW systems require high RF power levels to get the job done. Since the earliest days of EW, that job has fallen to the vacuum tube, and more specifically to the traveling-wave tube amplifier (TWTA), for the simple reason that no semiconductor technology can come close to delivering the TWT's very high power levels over broad bandwidths from high microwave frequencies to 100 GHz.

For this reason, there are at least 300,000 TWTs and other vacuum tube-based amplifiers in more than 300 different US defense systems, of which EW makes up a large number. Thus, while the death of the vacuum tube has been forecast seemingly forever, that simply will not happen (in this decade at the very least). In fact, development work is continuing throughout the world and at DARPA to make microwave power modules (MPMs), which are essentially small versions of larger TWTAs, deliver more power at higher frequencies in smaller form factors.

That said, advances in RF power transistors are sure to make inroads into larger EW systems, in addition to the IED jammers (and no doubt other systems) in which they are currently employed. LDMOS and even "ancient" bipolar transistors can generate 1 kW of power or more, although at narrow bandwidths. However, the real deal breaker will be GaN, which has the potential to deliver the same power levels or more, at reasonably high frequencies, over broader bandwidths, in a smaller form factor. This could begin the encroachment of semiconductors into the TWT's domain, at least at lower power levels.

"There's been an ongoing debate about solid-state versus TWTs," said ONR's Dr. Craig, "putting solid-state components into a phased array. It gives you flexibility for beam steering, modulation, and multibeam capabilities that TWTAs do not do as well. Raw power is not as strong an emphasis as it used to be, and while there will always be a need for it, the ability to use power selectively and with the precision that you get from solid-state components and an array is very appealing."

FROM ONR CONCEPT TO DEPLOYMENT

A good example of a technology that ONR developed and saw through to its exit as a deployable subsystem is two-color IR missile warning capability, which was pioneered at NRL in the 1990s. ONR developed multicolor focal planes and invested in stacked-diode arrays to eliminate background sources of noise, increase sensitivity as high as possible, and achieve a two-band structure without crosstalk between the bands. As the focal planes are cryogenically cooled, the issue arose of cooling subsystem reliability, which was problematic. However, cryocooler reliability has improved markedly over the years, and a closed-cycle Stirling engine cooler was chosen. "We realized that if we invested in increasing the operating temperature of these focal planes from 70 [degrees] K to 110 K and 120 K, it would increase efficiency, limit the power you have to use to cool them, and enable more flexibility in terms of deployment," said Dr. Craig. "You don't want to put a missile warning sensor on an airplane that needs a 50 lb. metal plate to dissipate the heat."

The system uses a mercury cadmium telluride (HgCdTe) detector, which has been employed in the past for basic midband and longwave IR sensing. However, the idea of using a stacked diode array was new. There are a lot of approaches for achieving a two-color design, such as taking incoming light and using a prism to separate different spectra, but registration of the two scenes was always a problem. Misregistration defeats the benefit of high clutter rejection and good registration allows the system to recognize objects that are not a "point in space" like a missile, so any distributed object will be something other than a missile.

"We wanted an image in which each pixel could be read with different spectral bands to get exact registration," Dr. Craig continues. "When implementing the sensor on the skid of a helicopter there is no robust skin to use for dissipating heat, so the only way to cool it is to build something in or use air cooling. Raising the operating temperature allowed power handling to be lowered, with a reduction in heat." Having achieved its intended goals, the technology is now in the acquisition phase at Naval Air Systems Command.

UNIQUE ARMY CHALLENGES

Anthony Lisuzzo, Director of the Army's Intelligence and Information Warfare Directorate (I2WD) at Ft. Monmouth, NJ, sets out four major EW challenges among the many being worked on. If all four share anything in common, it is their relationship to the increasing density of signals throughout the spectrum. The first challenge noted by Lisuzzo is how to identify, locate or disrupt the right target set without causing collateral electromagnetic damage. "Surgically pursuing one signal set, identifying it and mitigating the complexity of doing so is the focus of several programs," he explained. "It's very computationally intensive, so you need significant computer and processing power to increase EW capabilities. Compared to 20 years ago, we have a three-fold increase in signal density, but with the appropriate signal identity algorithms, we can effectively put countermeasures on signals of interest."

The second challenge is keeping pace with the rapid development and deployment of commercial over-the-air systems, which change regularly in terms of modulation techniques, frequency ranges and many other factors. Lisuzzo says that while the most challenging is in the RF domain, there are also millimeter-wave, infrared and optical systems that have to be addressed.

An even more vexing problem is limiting fratricide when employing EW systems across a battlefield, or more specifically, "how do you keep friendly forces operational while we are doing EW effects on the enemy," said Lisuzzo. "Situational awareness is critical in terms of where friendlies are and maybe where the foes are. If you analyze the environment, you can make a deterministic decision about what you can employ as a countermeasure."

The answer to these challenges, said Lisuzzo, lies within the processing capability of a system to differentiate between signal sets. If there is a specific signal present but not being used, that's an indication of something, a differentiator. We work on different ways to look at different signal sets. "The day of barrage noise jammers are gone," he continued, except for large electronic attack platforms. "You have to use more surgical countermeasures. From the Army's perspective, you want to have a protection bubble and also want to be surgical, while remaining aware of other signal sets around you, which adds a level of complexity."

The last challenge is networking EW systems that can cooperatively deliver defensive measures – disrupting numerous threats in a distributed fashion. "Let's say you have a convoy," says Lisuzzo, "and each system on every platform sees the same thing. To make things more efficient, you can network each one so if the lead vehicle identifies a threat it can indicate it will take charge of it and so on."

Digital technology plays a key role in allowing these types of advanced systems to be implemented within shrinking power budgets and smaller sizes of future platforms. "Digital technology lets us reduce size and helps with power management," Lisuzzo explained, "because we no longer have the unlimited power on a vehicle and we cannot have a trailered gigawatt generator."

MOVING FORWARD

This article highlights just a few of the critical technologies that will become the building blocks of future EW systems, such as the Navy's Next-Generation Jammer (NGJ) and Joint and Allied Threat Awareness System (JATAS), as well as the Army's Integrated EW System (IEWS) and Common IR Countermeasures (CIRCM) System. With the DOD's push toward acquisition reform, the new challenge facing the labs (and industry) is to continue developing EW technologies that deliver improved performance while at the same time helping to lower EW system acquisition costs, as well as life-cycle costs. That's a tall order, and it will require steady funding from the services and DARPA. But it is achievable. And, more importantly, it far less expensive than the price of mission failure.

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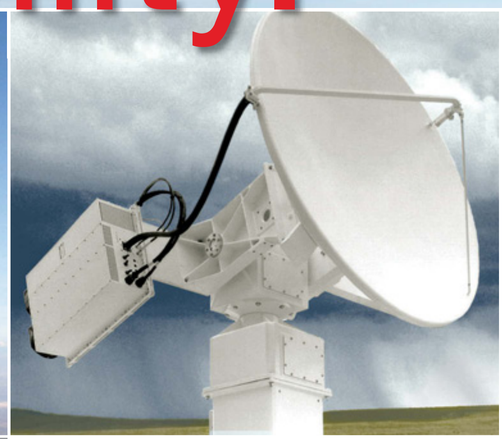

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RF Power Sources for IED/Communications Jammers

By Ollie Holt

The *JED* September technology survey examines power amplifiers that can be used for communications and/or IED jamming applications. Communications and IED jammers normally operate up to only around 6 GHz, but some new communication systems are moving up in frequency, so this survey provides information on power amplifiers up into the millimeter-wave frequencies. This survey includes both Traveling Wave Tube (TWT) and Solid State power amplifiers.

All of the suppliers included in the survey provided information on power amplifiers that can be used in communications and/or IED jammer applications. Some of the devices can also be used for other EW applications such as radar jamming. The applications column on the survey results lists the applications for which the suppliers designed the power amplifier. The frequency column defines the operational frequency range over which the power amplifier was designed to operate at the performance level specified in the other columns.

pHEMT	Pseudomorphic High Electron Mobility Transistor
GaN	Gallium Nitride
LDMOS	Laterally Diffused Metal Oxide Semiconductor
MOSFET	Metal Oxide Field Effect Transistor
SSPA	Solid State Power Amplifier
GaN HEMT	Gallium Nitride High Electron Mobility Transistor

The "technology" column defines the power amplifiers as either solid state or TWT amplifier technologies. The suppliers list multiple types of solid state technologies, which are defined in the table below. The major differences in these solid state devices are in the materials used (gallium nitride, gallium arsenide, etc.) and the physics that occurs within the transistor to cause the signal to be amplified. The transistor technology used in the power amplifier is selected by the supplier in the design phase because certain solid-state transistor designs perform better at different frequencies than other transistor technologies.

The "power output/gain" column is defined as either gain in dB and/or power out in Watts (W). Gain is the measure of the ability of the amplifier to increase the amplitude of the input signal with respect to the output signal. In some cases the supplier provided both a power out (W) and a gain (dB). Others just provided either gain or power out. The power out is the maximum output power achievable from the amplifier before going into saturation. Saturation is the point where a given increase in input power will not provide any increase in output power. When this point is reached, not only will you get no increase in output but you will start to get an increase in the output level of the harmonics and spurious signals. Psat, as some suppliers define it, is the maximum output power/gain from the amplifier.

The "harmonics and spurious" column is the measure of the power of the harmonics and/or spurious signals with respect to the output power of the signal being amplified. The harmonic or spurious signal power is measured as dBc or dB relative to the carrier, in this case the signal being amplified. It is a measure of how much higher the desired signal is with respect to power level of the harmonics or spurious signals created within the device. For most applications the larger this value is, the better the performance.

The "efficiency" column defines the amplifier's ability to turn the input power (DC) the power amplifier uses into power output (RF). Typically, some of the input power is wasted as heat (dissipated power). The goal of amplifier design is to keep the dissipated power as low as possible, making the efficiency as high as possible, but as you see in the results, typical efficiencies of 10% to 50% are common. Efficiency is typically calculated as output power divided by DC power times 100%. Some suppliers provided the efficiency defined as the Power Added Efficiency (PAE). PAE is defined as the output power (RF) minus the input power (RF) divided by the input power (DC). In high-gain systems the results are about the same as efficiency – output power (RF) divided by input power (DC) – but in low-gain systems the efficiency can be very different. Also, take note that in the survey the input power (DC) is average power input. For a pulsed system, the PAE is calculated using the input power (DC) when the pulse is created, not the average input power (DC).

The next column addresses amplifier reliability. Reliability is an estimate of the expected operational life or average time before a failure occurs of the power amplifier before it needs to be replaced. This is usually calculated based on expected operational temperature. If the user exceeds the operational temperature, which is listed in the power amplifiers specification, the reliability will degrade as a function of operational time over the specified temperature. Typically the operational temperature is specified around 25 degrees C. Some transistor technologies perform better in hotter conditions than others.

The "power input" column defines the DC input power used by the power amplifier to create the output signal. Some suppliers provided the input power (DC) while some provided power dissipated (Pdis). To obtain the input power (DC) from the Pdis, just add the output power to the Pdis value and that will give the approximate input power (DC) required by the power amplifier. Another method would be to divide the power out by the efficiency.

The final columns provide the size and weight specification for the power amplifier, information on the environment in which the power amplifier was designed to operate (ground, air, etc.) and additional comments from the suppliers.

JED's next survey, covering EW Simulators for Test and Flight Line Applications, will appear in the December issue. E-mail JEDeditor@naylor.com to request a survey questionnaire.

MODEL	APPLICATION	OPERATING FREQ	TECHNOLOGY	POWER OUT	HARMONIC/SPURIOUS
AML Microwave Power Products; Santa Clara, CA USA; +1-408-727-6666; www.microwavepower.com					
L0505-48	IED/comms jammer	5.3-5.9 GHz	GaN FET	Psat 48 dBm (60 W)	Harmonics > 30 dBc,Spurious >60 dBc
Aethercomm, Inc.; Carlsbad, CA USA; +1-760-208-6002; www.aethercomm.com					
SSPA 0.020-0.520-125	IED/comms jammer	20-520 MHz	GaN	P3 dB: 125 W (typical)	2nd Harmonic @ P3dB: ~ -19 dBc to -40 dBc; 3rd Harmonic @ P3dB: ~ -13 dBc to -30 dBc; Spurious < -60 dBc
SSPA 0.020-1.000-100	IED/comms jammer	20- 1000 MHz	GaN	P3 dB: 100 W (typical)	2nd Harmonic @ P3 dB: ~ -19 dBc to -50 dBc; 3rd Harmonic @ P3dB: ~ -13 dBc to -47 dBc; Spurious < -60 dBc
SSPA 0.020-6.000-50	IED/comms jammer	20-6000 MHz	GaN	P3 dB: 30 W-50 W	2nd Harmonic @ P3dB: ~ -15 dBc to -50 dBc; 3rd Harmonic @ P3dB: ~ -23 dBc to -60 dBc; Spurious < -60 dBc
SSPA 0.5-2.5-50	IED/comms jammer	500-2500 MHz	GaN	P3 dB: 40 W-50 W (typical)	2nd Harmonic @ P3dB: ~ -14 dBc to -46 dBc; 3rd Harmonic @ P3dB: ~ -24 dBc to --47 dBc; Spurious < -60 dBc
SSPA 2.5-6.0-50	IED/comms jammer	2500- 6000 MHz	GaN	P3 dB: 30 W-50 W (typical)	2nd Harmonic @ P3dB: ~ -17 dBc to -74 dBc; Spurious < -60 dBc
BC Systems, Inc.; Setauket, NY USA; +1-631-751-9370; www.bcpowersys.com					
RF3004	IED/comms jammer	1600-2800 MHz	GaN	15 W	*
RF4004	IED/comms jammer	500-2500 MHz	GaN	80 W	*
RF40012	IED/comms jammer	1000-3000 MHz	GaN	80 W	>20 dBc
RF40013	IED/comms jammer	2500-6000 MHz	GaN	35 W	>20 dBc
RF40015	IED/comms jammer	20-305 MHz	GaN	100 W	*
Comtech PST; Melville, NY USA; +1-631-777-8900; www.comtechpst.com					
BME2719-150	EW jamming	20-1000 MHz	GaN	150 W	15/60 dBc
BME88258-250	EW jamming	800-2500 MHz	GaN	250 W	15/60 dBc
BME25869-35	EW jamming	2500-6000 MHz	GaN	35 W	15/60 dBc
BHE87258-300	EW jamming	80-2500 MHz	GaN	200/180/300 W	15/60 dBc
BHED2758-1500	EW jamming	20-500 MHz	LDMOS	1500 W	15/60 dBc
CTT Inc.; Sunnyvale, CA USA; 408-541-0596; www.cttinc.com continued on next page					
AGX/015-4747	comms jammer	200-1500 MHz	GaN	+47 dBm, Psat	*
AGO/027-4747	comms jammer	1500-2700 MHz	GaN	+47 dBm, Psat	*

JAMMERS

EFFICIENCY	RELIABILITY	POWER (W)	SIZE (HxWxL inches/cm)	WEIGHT (lb/kg)	PLATFORM	FEATURES
17.50%	*	300 W	7.2 x 4.66 x 0.55 in.	0.6 lbs	grd-mob, grd- fix, shp, sub	Fast TTL switching of internal high speed pulser circuit available (typical rise/fall time 30ns).
PAE: 50+% (typical)	> 100k hrs	Pdis: 80 W (typical)	3.4 x 6.4 x 1.0 in.	1.5 lbs	air, grd-fix, grd-mob, shp	Typical gain of 58 dB and gain flatness of +/- 2.0 dB. Typical noise figure of 10 dB. Operates from +28Vdc input and a base plate of -40C to + 85C.
PAE: 40%-60% (typical)	> 100k hrs	Pdis: 98 W (typical)	3.4 x 6.4 x 1.0 in.	1.5 lbs	air, grd-fix, grd-mob, shp	Typical gain of 58 dB and gain flatness of +/- 2.0 dB. Typical noise figure of 10 dB.
PAE: 15%-30%	> 100k hrs	Pdis: 62 W (typical)	3.4 x 6.4 x 1.0 in.	1.5 lbs	air, grd-fix, grd-mob, shp	Typical gain of 46 dB and gain flatness of +/- 1.5 dB. Typical noise figure of 8 dB.
PAE: 30%-40% (typical)	> 100k hrs	Pdis: 67 W (typical)	3.4 x 6.4 x 1.0 in.	2.0 lbs	air, grd-fix, grd-mob, shp	Typical gain of 53 dB and gain flatness of +/- 2.5 dB. Typical noise figure of 10 dB.
PAE: 25%-35% (typical)	> 100k hrs	Pdis: 110 W (typical)	2.5 x 6.4 x 1.0 in.	1.5 lbs	air, grd-fix, grd-mob, shp	Typical gain of 48 dB and gain flatness of +/- 2.5 dB. Typical noise figure of 10 dB.
30%	*	*	0.6 x 2 x 3 in.	<0.5 lb	grd-mob, grd- fix	Class AB, unconditionally stable over all load VSWR and phase conditions.
25%	*	*	1.8 x 6 x 8 in.	3 lbs	grd-mob, grd- fix	Operates at full output power into a 2.5:1 load VSWR, ultra fast blanking speed of less than 5 microseconds.
30%	*	*	1.5 x 6.5 x 6.5 in.	2.5 lbs	grd-mob, grd- fix	Over current and over temperature protection, qualified to MIL-STD-810: 3 Axis Vibration "Wheeled & Tracked Vehicles."
20%	*	*	1.5 x 3.5 6.5 in.	1.5 lbs	grd-mob, grd- fix	Operating temperature: -40°C to +85°C, non-operating temperature: -45°C to +95°C.
30%	*	*	1.6 x 4.5 x 5.5 in.	2 lbs	grd-mob, grd- fix	Optional internal coupler.
30%	15k hrs	*	6.75 x 10 x 1.4 in.	6 lbs	air, grd-mob, grd-fix	Forward and reflected monitor,digital controls, quadrature combining, RF sample ports, -40°C to +85°C Operation.
30%	15k hrs	*	9 x 15 x 1.4 in.	10.5 lbs	air, grd-mob, grd-fix	See above.
20%	20k hrs	*	7.5 x 3 x 1.4 in.	3 lbs	air, grd-mob, grd-fix	18 to 36 VDC input, high-power solid-state T/R switch, quadrature qombining, forward and reflected Monitor.
25%	12k hrs	*	8.5 x 19 x 24 in.	110 lbs	air	3 indepdendent amplifiers, simultaneous operation, 24 to 32 VDC input, automatic level control, AM/FM/CW/multi tone, digital controls, quadrature combining, -40°C to +85°C operation.
20%	12k hrs	*	22.75 x 19 x 26 in.	320 lbs	grd-mob	Sub-harmonic filters, solid-state switch, solid-state T/R, digital controls, Ethernet interface , 0°C to +50°C ambient, AC input power.
≈23%	10k hrs	250 W, Typ. (External Cooling Required)	*	<5 lbs	air, grd-fix, grd-mob	Available in rack-mount (3RU) package with cooling fans and heat sinks built-in to maintain safe junction temps. +40 and +43 dBm power output versions available for MPM driver applications.
≈23%	10k hrs	250 W, Typ. (External Cooling Required)	*	<5 lbs	air, grd-fix, grd-mob	See above.

MODEL	APPLICATION	OPERATING FREQ	TECHNOLOGY	POWER OUT	HARMONIC/SPURIOUS
CTT Inc.; Sunnyvale, CA USA; 408-541-0596; www.cttinc.com continued from previous page					
AGM/020-4747	IED jammer	500-2000 MHz	GaN	+47 dBm, Psat	*
ABM/027-4747	IED jammer	800-2700 MHz	GaN	+47 dBm, Psat	*
AGM/060-4747	IED jammer	2.5–6.0 GHz	GaN	+47 dBm, Psat	*
Empower RF Systems, Inc.; Inglewood, CA USA; +1-310-412-8100; www.empowerRF.com					
1094-BBM2E3KKO	broadband mobile jamming	20-520 MHz	LDMOS	100 W	IP3 = +56 dBm/Spur = -70 dBc
1179-BBM3K5OKO	broadband mobile jamming	500-2700 MHz	GaN	100 W	IP3 = +55 dBm/Spur = -70 dBc
1178-BBM5A8CGM	broadband mobile jamming	2000-6000 MHz	GaN	35 W	IP3 = +50 dBm/Spur = -60 dBc
2126-BBS2E3KUT	broadband mobile jamming	20-500 MHz	MOSFET	1000 W	IP3 = +64 dBm/Spur = -70 dBc
2066-BBS3K4AUT	high power CW and pulse applications	500-1000 MHz	LDMOS	1000 W	IP3 = +69 dBm/Spur = -70 dBc
Keragis Corporation; Poway, CA USA; 858-486-1716; www.keragis.com					
KPA0206-50W	Various	2-6 GHz	SSPA	50 W (Sat)	<-20 dBc/-70 dBc
KMIC Technology, Inc.; San Jose, CA USA; +1-408-240-3613; www.kmictech.com					
KMA025060Bxx	IED jamming	2.5-6.0 GHz	GaN	35 W @ +90C	-15 dBc
KMA010025Bxx	IED jamming	1.0-2.5 GHz	GaN	50 W @ +90C	-15 dBc
KMA005010Bxx	IED jamming	0.5-1.0 GHz	GaN	80 W @+90C	-15 dBc
KMA002005Bxx	IED jamming	20-500 MHz	LDMOS	80 W @+90C	-15 dBc
Microwave Amplifiers Ltd; Nailsea, UK; +44 1275 853196; www.maltd.com					
AM8	IED/comms jammer	20 MHz-520 MHz	Solid State	50 dBm	0.214
AM5-2.5-6-46-46	IED/comms jammer	2.5-6 GHz	Solid State	46 dBm	0.214
AM6-0.5-2.5-47-47	IED/comms jammer	0.5-2.5 GHz	Solid State	47 dBm	0.188
AM6-0.5-2.5-48-48	IED/comms jammer	0.5-2.5 GHz	Solid State	48 dBm	0.188
AM9-0.5-2.5-50-50	IED/comms jammer	0.5-2.5 GHz	Solid State	50 dBm	0.188
MITEQ Inc.; Hauppauge, NY USA; +1-631-439-9469; www.miteq.com					
MT4100-450-2/8	ECM/ instrumentation	2-8 GHz	TWT	370 W (55.7 dBm) / 60 dB	-60 dBc Spurs/-4 dBc Harm
PLATH GmbH; Hamburg, Germany; +49 40 237 34-0; www.plath.de					
PAU 5201	comms jamming	1.5 - 30 MHz	Solid State	2000 W (CW)	Fi2/Fi3 -20/-15 dBc
PAU 2201	comms jamming	20 - 100 MHz	Solid State	2000 W (CW)	Fi2/Fi3 -20/-15 dBc
PAU 2102	comms jamming	100 - 500 MHz	Solid State	1000 W (CW)	Fi2/Fi3 -20/-15 dBc
PAU 2103	comms jamming	500 - 1000 MHz	Solid State	1000 W (CW)	Fi2/Fi3 -20/-15 dBc
PAU 2053	comms jamming	500 - 1000 MHz	Solid State	500 W (CW)	Fi2/Fi3 -20/-15 dBc
RFMD; Greensboro, NC USA; +1-336-664-1233; www.rfmd.com					
RF3826	*	30 MHz to 2500 MHz	GaN HEMT	39 dBm	*

JAMMERS

EFFICIENCY	RELIABILITY	POWER (W)	SIZE (HxWxL inches/cm)	WEIGHT (lb/kg)	PLATFORM	FEATURES
≈23%	10k hrs	250 W, Typ. (External Cooling Required)	*	<5 lbs	air, grd-fix, grd-mob	See above.
≈23%	10k hrs	250 W, Typ. (External Cooling Required)	*	<5 lbs	air, grd-fix, grd-mob	See above.
≈23%	10k hrs	250 W, Typ. (External Cooling Required)	1 x 4 x 6 in.	<5 lbs	air, grd-fix, grd-mob	See above.
42%	*	238 W	6.4 x 3.4 x 1.1 in.	1 lb	*	Built-in protection, control and monitoring circuits.
36%	*	280 W	7.9 x 4.2 x 1.1 in.	2 lbs	*	Built-in protection, control and monitoring circuits.
21%	*	168 W	6.9 x 3.6 x 1.1 in.	2 lbs	*	Built-in protection, control and monitoring circuits.
20%	*	5000 W	17.5 x 14 x 22 in.	135 lbs	*	Modular design, built-in control, monitoring and protection functions, ruggedized design.
20%	*	5000 W	17.5 x 14 x 22 in.	150 lbs	*	Modular design, built-in control, monitoring and protection functions, ruggedized design.
12-15.4%	500k hrs	246-302 W	2.1 H x 2.9 in. D	2.2 lbs	all	CW
15%	150k hrs	250 W	6.0 x 2.5 x 1.36 in.	1.3 lbs	grd-fix, grd-mob	Temp monitor, over temp shutdown, programmable output power.
20%	150k hrs	250 W	6.0 x 2.5 x 1.36 in.	1.3 lbs	grd-fix, grd-mob	Temp monitor, over temp shutdown, programmable output power.
30%	150k hrs	250 W	6.0 x 2.5 x 1.36 in.	1.3 lbs	grd-fix, grd-mob	Temp monitor, over temp shutdown, programmable output power.
25%	150k hrs	280 W	6.0 x 2.5 x 1.36 in.	1.3 lbs	grd-fix, grd-mob	Temp monitor, over temp shutdown, programmable output power.
33%	100k hrs	200 W	1.4 x 4 x 8.5 in.	*	grd-fix, grd-mob	Class AB
33%	100k hrs	85 W	1.4 x 4 x 8.5 in.	*	grd-fix, grd-mob	Class AB
33%	100k hrs	120 W	1.4 x 4 x 8.5 in.	*	grd-fix, grd-mob	Class AB
33%	100k hrs	120 W	1.4 x 4 x 8.5 in.	*	grd-fix, grd-mob	Class AB
33%	100k hrs	*	1.2 x 5.2 x 9.5 in.	*	grd-fix, grd-mob	Class AB
17%	35k hrs	3000 W	8.75 x 19 x 24 in.	90 lbs	*	Atten, meters, Ethernet…etc.
25%	*	8000 W	(10+5) HU, 19 in.	80 kg	grd-mob, grd-fix	Security switch-off, Status display, CAN interface.
25%	*	8000 W	(10+5) HU, 19 in.	90 kg	grd-mob, grd-fix	See above.
20%	*	5000 W	14 HU, 19 in.	65 kg	grd-mob, grd-fix	See above.
15%	*	6000 W	16 HU, 19 in.	120 kg	grd-mob, grd-fix	See above.
15%	*	3400 W	10 HU, 19 in.	70 kg	grd-mob, grd-fix	See above.
40%	*	9 W	5.99 x 5.03 x 1.092 mm	*	*	*

Survey Key – RF Power Sources for IED/Comms Jammers

MODEL

Product name or model number

APPLICATION

Communications Jammer, IED Jammer or Both
- IED = improvised explosive device
- EW = electronic warfare
- ECM = electronic countermeasures

OPERATING FREQUENCY

In kHz, MHz or GHz

TECHNOLOGY

Solid State, Tube, etc.
- HEMT = high electron mobility transistor
- pHEMT = pseudomorphic high electron mobility transistor
- FET = field-effect transistor
- GaN = Gallium Nitride
- LDMOS = laterally diffused metal oxide semiconductor
- MOSFET = metal-oxide-semiconductor field-effect transistor
- SSPA = solid state power amplifier
- TWT = travelling wave tube

POWER OUT
- Psat = saturation point

HARMONIC AND SPURIOUS LEVELS

dBc

RELIABILITY

In thousands of hours
- MTBF = mean time between failures

POWER

Dissipated in Watts

SIZE

H x W x L in inches/cm

WEIGHT

Weight in lb/kg

PLATFORM

Listing all that apply
- air = Airborne
- grd-mob = Ground, Mobile
- grd-fix = Ground, Fixed
- shp = Shipboard
- spc = Space

FEATURES

Additional features
- TTL = transistor-transistor logic
- VSWR = voltage standing wave ratio
- T/R = transmit/receive
- RF = radio frequency
- MPM = microwave power module
- CW = continuous wave

OTHER ABBREVIATIONS USED
- opt = option/optional
- dep = dependent
- config = configuration
- wband = wideband
- nband = narrowband
- < = less than
- > = greater than
- min = minimum
- max = maximum
- deg = degree
- freq = frequency

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

OTHER COMPANIES

This reference list includes websites for additional companies in the field that were unable to provide survey information due to security constraints or publication deadlines, or that declined to participate.

Company Name	Website
Advanced Control Components	www.advanced-control.com
Amplifier Solutions Corp.	www.amplifiersolutions.com
AR Worldwide	www.ar-worldwide.com
CAP Wireless	www.capwireless.com
Ciao Wireless	www.ciaowireless.com
Cobham Sensor Systems	www.cobham.com
DAICO Industries	www.daico.com
Endwave Corporation	www.endwave.com
Herley Power Amplifier Systems	www.herley.com
IFI	www.ifi.com
MILMEGA	www.milmega.co.uk
Nitronex	www.nitronex.com
Ophir RF	www.ophirrf.com
RF Core	www.rfcore.com
Rodelco Electronics	www.rodelcocorp.com
Spectrum Microwave	www.spectrummicrowave.com
Stealth Microwave	www.stealthmicrowave.com
TriQuint Semiconductor	www.tqs.com

December 2010 Product Survey: EW Simulators for Test and Flightline Applications

This survey will cover EW simulators for test and flightline applications. Please e-mail JEDeditor@naylor.com to request a survey questionnaire.


Our Big Ideas
Are Measured In Microns

EW Against Modern Radars – Part 10

Leading-Edge Tracking and Dicke Fix Techniques

By Dave Adamy

RANGE GATE PULL OFF

You will recall from the January 2010 "EW 101" column that range gate pull-off (RGPO) deceptive jamming generates a false return pulse that is increasingly delayed (with each subsequent pulse) to convince the radar that the target is turning away from the radar – thus causing the radar to lose range track. RGPO does this by loading up the radar's late gate with the larger energy of the jamming pulse. An electronic protect (EP) technique used to defeat RGPO is leading-edge tracking.

As shown in **Figure 1,** the radar tracks the target's range from the energy in the leading edge of the skin return. Assuming that there is some throughput latency in the RGPO jammer, the leading edge of the jamming pulse starts later than the leading edge of the true skin return. Dr. Schleher, in his book, *EW in the Information Age,* places the value of about 50 nsec on the maximum jamming process latency that would allow the RGPO jammer to capture the range tracking. Assuming more jammer latency than this, the radar processing will not see the jamming pulse and thus continues to track the true target range from the true skin-return pulse.

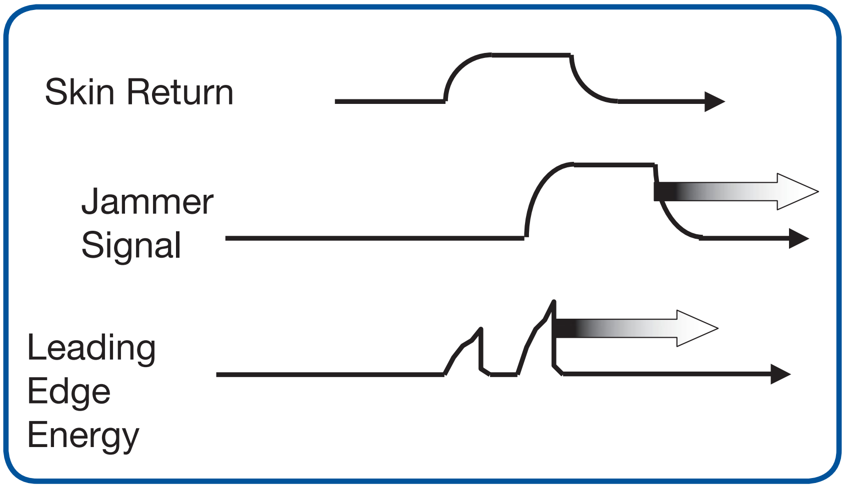


Figure 1: A leading-edge tracker will ignore a range gate pull-off jamming signal. Latency in the jammer causes the leading edge of the jamming pulse to fall outside of the leading edge late gate, so the jammer cannot capture the radar's tracking circuit.

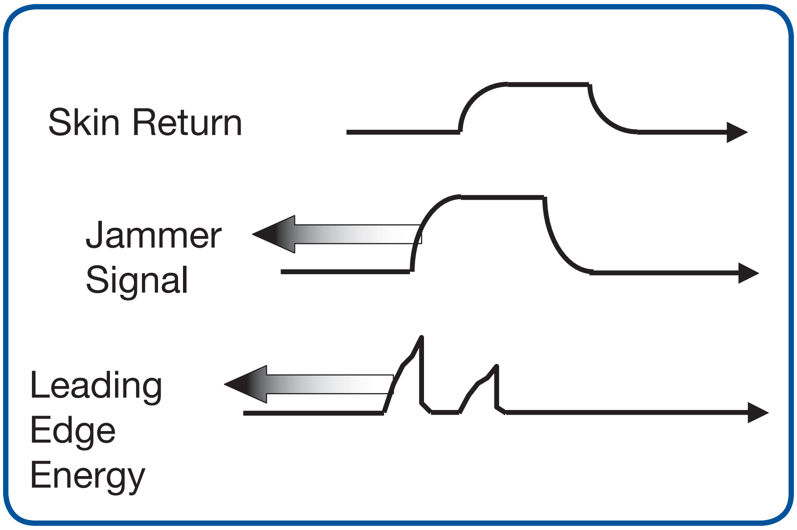


Figure 2: Range gate pull-in jamming generates a pulse that moves ahead of the actual skin-return pulse, thereby capturing the leading-edge tracking circuit.

The jamming technique used to overcome leading edge tracking is range gate pull-in (RGPI), also called inbound range gate pull-off. As shown in **Figure 2,** the jammer generates a false pulse that moves ahead in time, anticipating each pulse by an increasing amount. The false pulses move back through the true skin return pulse – capturing the radar's range tracking (even if the radar is tracking leading edges) and thus convinces the radar that the target is turning toward the radar. This, of course, causes the radar to lose range track. In order to perform RGPI, the jammer must have a pulse repetition interval (PRI) tracker, which allows it to know when the next pulse will occur. The radar EP effective against the RGPI technique is the use of jittered pulses. With jittered pulses, the pulse-to-pulse spacing is a random function, so the jammer cannot anticipate the timing of the next pulse and therefore cannot generate a false pulse that anticipates the pulse in a smoothly increasing way.

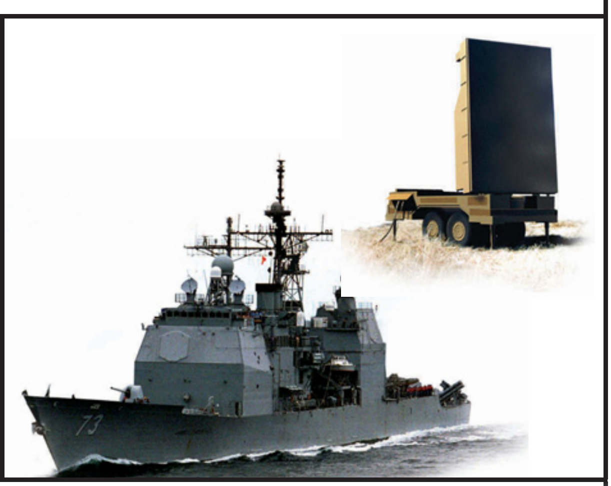
TAILORED SYSTEMS SOLUTIONS...

DEFENSE ELECTRONICS

For need ranging from high power to high density. *Flexible* and *semi-rigid* products to withstand the severe conditions of shipboard, airborne or ground-based operations. A low-density PTFE dielectric *reduces attenuation* by up to 30% over conventional materials.

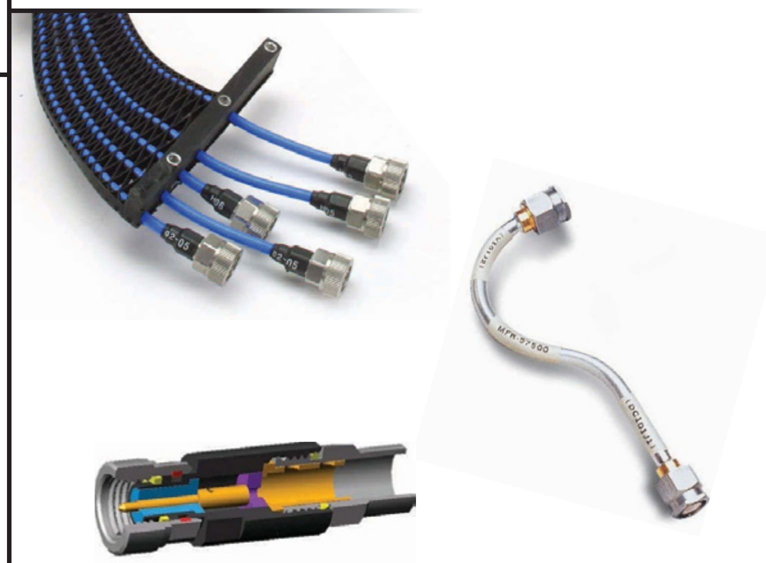
RADAR

Radar systems, including phased array. Products and processes optimize *phase tracking* over flexure and temperature. *Miniature* products with *blindmate* connector interfaces such as GPO™ and GPPO™ allow increased packing density.



For **defense systems** that require:

- High levels of mechanical and electrical performance under extreme environmental conditions
- Product configured to meet program needs
- Strong support during system development
- Reliable performance over time



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AGC JAMMING

In the February 2010 "EW 101" column, we discussed automatic gain control (AGC) jamming in which a strong, narrow jamming pulse is generated at about the scanning rate of the target radar. The narrow jamming pulse captures the radar's AGC, causing the radar to turn down its gain to the point that it cannot see the amplitude variations in the skin return from the radar antenna scan. (See **Figure 3.**) Thus, the radar cannot perform its angle-tracking function. Because the jamming pulse has a low duty cycle, this technique allows effective jamming with minimal jammer energy. The EP against this AGC jamming technique is the "Dicke fix" as shown in **Figure 4.**

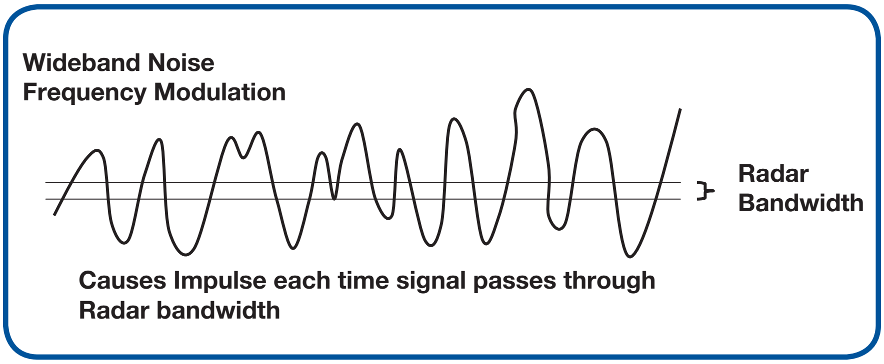

Figure 5: Wideband FM Noise modulation causes ideal noise jamming in a radar's receiver by creating an impulse each time it passes through the radar bandwidth. The Dicke fix reduces the effectiveness of this jamming.

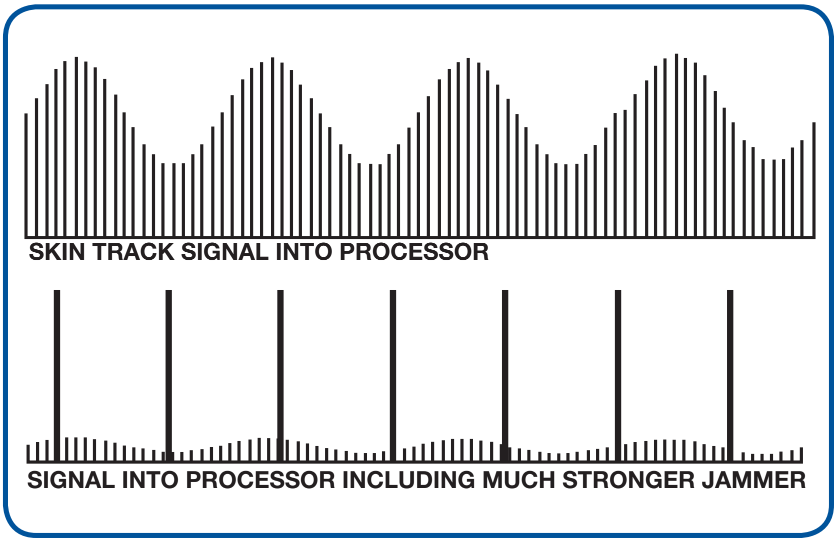

Figure 3: By transmitting strong, narrow pulses at about the radar antenna scanning rate, the AGC jammer captures the radar's AGC, reducing the amplitude variations from antenna scan to an unusable level.

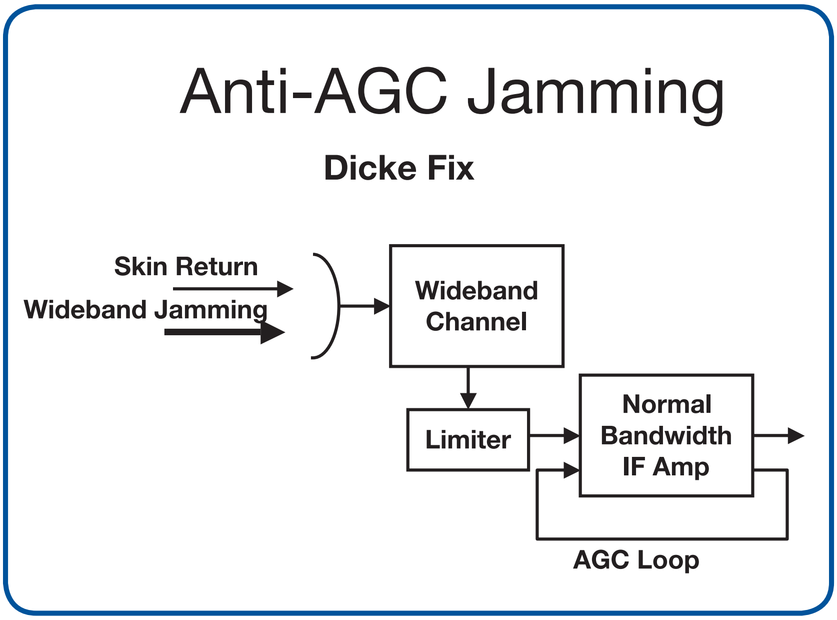

Figure 4: The Dicke Fix feature in a radar limits the output of a wideband channel to reduce wideband signals before input to a narrow channel to protect the AGC function from strong wideband jamming.

The Dicke fix involves a wideband channel with a limiter followed by a narrow channel with bandwidth matched to the radar's pulse. Because the narrow jamming pulse has wide bandwidth, it is clipped in the wideband channel. The radar's necessary AGC function is performed in the narrow channel and can thus not be captured by the previously limited narrow pulses.

NOISE JAMMING QUALITY

The effectiveness of noise jamming is strongly impacted by the quality of the noise. Ideally, jamming noise should be white Gaussian. Thus, the distortion from clipping in a saturated jammer amplifier can reduce the jamming-to-singal (J/S) ratio in the target radar receiver by many dB. One very efficient way to generate high-quality jamming noise is shown in **Figure 5.** A CW signal is frequency modulated by a Gaussian signal across a frequency band much wider than the radar receiver's bandwidth. Each time the jamming signal passes through the radar receiver's band, an impulse is generated. This series of randomly timed impulses causes high-quality white Gaussian noise in the receiver.

Impulses, by their nature, are very wideband. Thus, the limiting in the wideband channel of the Dicke fix reduces the J/S in the narrowband channel. This is an effective EP against this noise-jamming technique.

WHAT'S NEXT

Next month, we will continue our discussion of radar EP with an examination of the features of Pulse Doppler radar. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

association news

DIXIE CROW CHAPTER INDUCTS MEMBERS INTO AOC TECHNOLOGY HALL OF FAME

The Dixie Crow Chapter is very proud to induct six (6) of its finest into the AOC Technology Hall of Fame this year from Robins AFB.

Enrique León – Mr. León has 28 years of EW experience ranging from EW simulation systems to producing, fielding, and sustaining multiple EW systems such as the ALQ-184, ALE-50, and AAR-47. Mr. León was a force in the design and development of the ALE-50 working closely with the Naval Research Lab during the program's inception. Over his 10 years as lead engineer for the ALQ-184 EA pod, he led the development, production, fielding, sustainment, and modification of 893 pods and 60 Intermediate level testers at 38 user locations. His study of MWS capabilities for airlift aircraft led to the installation of the AAR-47 missile warning system on the C-5, C-17 and C-130 vastly improving aircrew survivability.

Suzanne Mason – Ms. Mason has approximately 30 years of EW experience. She has been at the forefront of the development, fielding and sustainment of the ALQ-131 Electronic Attack (EA) pod. Her efforts led to the first government implementation and fielding of changes to the operational flight software for the ALQ-131. For approximately the last 12 years she has been the force behind EW systems integration on AFSOC platforms. Without her tireless efforts the highly successful integration of the federated EW systems on the MH-53 with off-board intel and mission planning systems would not have occurred.

H. Douglas Nation – Doug Nation began his EW career in 1980 as a test engineer at Eglin AFB, FL. His initial efforts focused on the ALQ-119 Lens Array system and the Belgian RAPPORT III internal ECM system in their F-16 aircraft. Mr. Nation served for several years as the EW Test Division's technical advisor with responsibility for DT&E of developmental bomber and fighter defensive and offensive EW systems. Mr. Nation is currently the chief engineer for the 542 Combat Sustainment Group for EW at Robins AFB, GA. As a long time member, he has served the AOC in various capacities, including as President of the Eglin Chapter of the AOC and currently as a member of the Board of Directors of the Dixie Crow Chapter.

Jackie Ringley – Mr. Jackie Ringley has more than 39 years of experience as an EW engineer and has been a Dixie Crow member since 1975. His EW career started in 1970 as design and systems engineer for Navy EA-6B AWG-21 fire control system, QRC effort fielded in 9 months; WR lead engineer from 1975-1980 for ALQ-119, ALQ-119 Compass Tie, USM-464, QRC 80-01, ALQ-184. From 2001-2009 he has served as lead engineer for four ALQ-161 ACAT III programs completing design test and production contract award on schedule as well as ALQ-161 HW & SW sustainment efforts.

Larry Sheets – Mr. Sheets has more than 32 years of EW experience and has been a leader in radar warning receiver (RWR) technology from the early days of the ALR-46 and the inception of the ALR-69. Over the last 20 years, he had been a major contributor to the AFSOC mission through his superior leadership in the integration of RWRs, such as the ALR-69/APR-46, missile warning systems (MWS), the AAR-44/AAR-47, chaff/flare dispensers such as the ALE-40/ALE-47, off-board Intel and mission planning tools.

Steve Strawn – Mr. Strawn has more than 32 years of EW experience and has been the driving force behind RWR technology development and implementation since the timeframe of the ALR-46. His knowledge and skill led to the sustainment and fielding of the ALR-69 and later resulted in the Class IV modification of the ALR-69, a wide-ranging capability improvement for the user. Over approximately the last ten years, Mr. Strawn has led the design, development, testing, and fielding of the state-of-the-art ALR-69A, a digital receiver technology RWR poised to make major improvements to aircrew situational awareness.

COCHISE CHAPTER PRESENTS OUTSTANDING ACHIEVEMENT AWARD

The Cochise Chapter presented an outstanding achievement award to Col Chris Rasmussen, Commander, Electronic Proving Ground. Above, Dick Mortensen of the Cochise Chapter presents the award to Col Rasmussen.

AOC ELECTION RESULTS

The following candidates are the winners of the 2010 AOC Elections. The President-Elect will become president in October 2011. All others begin their offices in October 2010.

President-Elect
Laurie Buckhout

AOC At-Large Directors (in alphabetical order):
Robert Elder
David Hime
Anthony Lisuzzo

AOC International Region I Director
Robert Andrews.

AOC International Region II Director
Gerard Whitford

AOC 2010
47TH ANNUAL INTERNATIONAL
SYMPOSIUM & CONVENTION
ATLANTA, GA

Schedule of Events (as of August 23)

Subject to Change. All sessions will be held at the Hilton Atlanta unless otherwise noted

Tuesday, September 28 - Friday, October 1

9:00 a.m. - 5:00 p.m.	Fundamental Principles of Electronic Warfare *(4 day course)*
9:00 a.m. - 5:00 p.m.	Electro-Optics & Infrared (EO/IR) Fundamentals for EW Engineers and Managers Course *(4 day course)*

Saturday, October 2

9:00 a.m. - 5:00 p.m.	Introduction to Unmanned Aerial Vehicles (UAVs) and Unmanned Aerial Systems (UASs), Their Missions and Systems *(2 day course)*
9:00 a.m. - 5:00 p.m.	Introduction to Microwave Systems Course *(2 day course)*
9:00 a.m. - 5:00 p.m.	Refresher on Electronic Warfare Course *(2 day course)*

Sunday, October 3

9:00 a.m. - 5:00 p.m.	Information as Power Course *(1 day course)*
9:00 a.m. - 5:00 p.m.	Introduction to Unmanned Aerial Vehicles (UAVs) and Unmanned Aerial Systems (UASs), Their Missions and Systems *(2 day course)*
9:00 a.m. - 5:00 p.m.	Introduction to Microwave Systems Course *(2 day course)*
9:00 a.m. - 5:00 p.m.	Refresher on Electronic Warfare Course *(2 day course)*
1:00 p.m. - 5:00 p.m.	AOC Central Open (includes Registration, AOC Membership Booth, and Internet Café)
2:00 p.m. - 5:00 p.m.	Cyber Warfare Course *(1/2 day course)*
5:00 p.m. - 7:00 p.m.	Tour the Georgia Aquarium
6:30 p.m. - 9:30 p.m.	Welcome Reception at the Georgia Aquarium ***Sponsored by Elettronica***

Monday, October 4

7:00 a.m. - 7:00 p.m.	AOC Central Open
7:30 a.m. - 9:30 a.m.	Continental Breakfast
9:00 a.m. - 10:30 a.m.	Opening Session – Awards Ceremony and Keynote Speaker/Session 1
10:45 a.m. - 11:30 a.m.	Session 2 – Making it Happen
11:30 a.m. - 12:15 p.m.	Session 3 – The One Constant in EW
1:00 p.m. - 1:45 p.m.	Session 4 – Military Requirements
2:00 p.m. - 4:00 p.m.	Session 5 – New Technology Planning and Insertion
4:00 p.m. - 7:30 p.m.	Exhibit Halls Open
6:00 p.m. - 7:30 p.m.	Reception in Exhibit Halls
7:30 p.m. - 11:00 p.m.	ITT Roost

AOC 2010
47TH ANNUAL INTERNATIONAL
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Schedule of Events (as of August 23)

Tuesday, October 5

7:00 a.m. - 5:30 p.m.	AOC Central Open
7:30 a.m. - 9:30 a.m.	Continental Breakfast
8:00 a.m. - 9:50 a.m.	***Concurrent Sessions*** Session 6 – International and National Agencies' Requirements Session 7 – New Military Service Programs Session 8 – Evolving Policy on Spectrum Warfare and Management
10:00 a.m. - 10:45 a.m.	General Session and Keynote Speaker/Session 9
11:00 a.m. - 1:00 p.m.	***Concurrent Sessions*** Session 10 – Emerging International Technologies Session 11 – Resiliency as a Means of Achieving Mission Assurance
1:00 p.m. - 2:30 p.m.	Networking Lunch in Exhibit Halls
1:00 p.m. - 6:00 p.m.	Exhibit Halls Open
1:30 p.m. - 4:30 p.m.	Meeting of the Chapter Presidents
2:00 p.m. - 6:00 p.m.	ELINT/EW Databases Course *(1/2 day)*
4:30 p.m. - 6:00 p.m.	Reception in Exhibit Halls

Wednesday, October 6

7:00 a.m. - 4:00 p.m.	AOC Central Open
7:30 a.m. - 9:30 a.m.	Continental Breakfast
8:00 a.m. - 9:50 a.m.	***Concurrent Sessions*** Session 12 – International Activities and Technologies Session 13 – Experimentation: Finding the Needle Amidst the Incredibly Complex Haystacks
10:00 a.m. - 10:45 a.m.	General Session and Keynote Speaker/Session 14
11:00 a.m. - 1:00 p.m.	***Concurrent Sessions*** Session 15 – EW International Opportunities and Challenges Session 16 – Policy and Planning for Law Enforcement and Homeland Security Session 17 – The Real World
1:00 p.m. - 3:00 p.m.	AOC Annual Awards Luncheon, Keynote/Session 18 *(Open to all Full Symposium attendees)*
3:00 p.m. - 5:00 p.m.	AOC Annual Awards Dessert Reception in Exhibit Halls
3:00 p.m. - 5:00 p.m.	Exhibit Halls Open

Thursday, October 7

8:00 a.m. - 5:00 p.m.	Classified Session - Dobbins AFB
9:00 a.m. - 5:00 p.m.	EW and the Brazilian Blue and the Green Amazon Course *(1.5 day course)*
9:00 a.m. - 5:00 p.m.	Directed Infrared Countermeasures (DIRCM) Principles Course *(2 day course)*

Friday, October 8

9:00 a.m. - 1:00 p.m.	EW and the Brazilian Blue and the Green Amazon Course *(1.5 day course)*
9:00 a.m. - 5:00 p.m.	Directed Infrared Countermeasures (DIRCM) Principles Course *(2 day course)*


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AOC 2010 Symposium Agenda

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(as of August 23)

Subject to Change. All sessions will be held at the Hilton Atlanta unless otherwise noted

Electronic Warfare in a Changing Environment

Convention Chairperson: **Mr. Nino Amoroso**

Monday, October 4

9:00 a.m. - 10:30 a.m.	**Opening Session – Awards Ceremony and Keynote Speaker** **Keynote/Session 1 - The Absence of Strategy** *Maj. Gen. Thomas K. Andersen, Director of Requirements, ACC*
10:45 a.m. - 11:30 p.m.	**Session 2 - Making it Happen** *Mr. Harry C. Disbrow Jr., Senior Executive Service, Associate Deputy Chief Staff for Operations, Plans and Requirements, USAF*
11:30 a.m. - 12:15 p.m.	**Session 3 - The One Constant in EW** *Mr. Blaise Durante, Deputy Assistant Secretary for Acquisition Integration, Office of the Assistant Secretary of the Air Force for Acquisition*
1:00 p.m. - 1:45 p.m.	**Session 4 - Military Requirements** *Brig Gen Dwyer L. Dennis, Director, Intelligence and Requirements Directorate, Headquarters Air Force Materiel Command, WPAFB*
2:00 p.m. - 4:00 p.m.	***Concurrent Sessions*** **Session 5 - New Technology Planning and Insertion** *Session Chair: Dr. Lon Pringle, GTRI* ***Maximizing EW Capability Through the Use of Autonomous and Optimized Next Generation Planning, Scheduling and Control of ES and EA Assets*** *Dr. Randal Janka, Zeta Associates (in collaboration with CERDEC, I2WD, Ft. Monmouth, NJ)* ***Interference Detection and Geo-location For Satellite Communication Links*** *Mr. Bill Sward, RT Logic* ***Enhancing Deployment Flexibility of RF Sensors by Common Hardware Platforms*** *Dr. Andreas Schwolen-Baches, Director Plath Signal Products Development Department* ***Military Open Source Software (Mil-OSS)*** *Mr. Joshua Davis, GTRI* **Session 6 - Evolving Policy on Spectrum Warfare and Management** *Session Chair: Ms. Linda Palmer, Defense Acquisition Inc* ***Integrating Navigation Warfare (NAVWAR) into Campaign Level Models*** *Mr. Joe Aldrich, JNWC* ***Gaining a Seat at the Table: Why We Need A Theory of War for the Electromagnetic Spectrum*** *Lt. Col William "Dollar" Young, Jr, USAF*

Tuesday, October 5

8:00 a.m. - 9:50 a.m.	***Concurrent Sessions*** **Session 7 - International and National Agencies' Requirements** *Session Chair: Mr. Pierre Ghazal, ESC* **Session 8 - US Military EW Capability Development for the Future** *Session Chair: Dr. Jack Fleischman, MIT/Lincoln Lab* ***Electronic Attack Effectiveness Analysis: Standardizing Methodologies and Data Reception Processes*** *Mr. Peter P. Wood, USSTRATCOM/J884* ***Policy Issues and Implementation in Spectrum for Satellite-Based Navigation*** *Col. Jon Anderson, GPS Joint Program Office*

Raytheon Electronic Warfare Programs
Mr. Peter E. Aichinger, Raytheon Corporation
Air Net-Centric Spectrum Warfare
Mr. David A. Hime, AFRL Sensors Directorate

10:00 a.m. - 10:45 a.m. **General Session - Keynote Speaker/Session 9**
Dr. Davy Belk, Director, Information Directorate, AFRL/RI

11:00 a.m. - 1:00 p.m. ***Concurrent Sessions***
Session 10 - Emerging International Technologies
Mr. Walter Wolf, BAE Systems
ECLIPSE, a New Breakthrough in SPJ Technology
Dr. Filippo Neri, President, Virtualabs srl, Italy
Finding and Fixing the Radio Network
Mr. Randy Neal, Rohde & Schwarz, Federal Systems
Parameter Estimation of UWB Signals with Sub-Nyquist Sampling
Mr. Feng Yang, National Information Control Laboratory, China
IR (Infra-Red) – a Force Multiplier for Fixed and Rotary Wing Aircraft
Mr. Tsvi Rosen, Elisra Electronic Systems, Ltd.
New Generation Helicopter Electronic Warfare Systems
Mr. Hayrullah Yildiz, Aselsan A.S. (TENTATIVE)
Alternate Briefing: ***Evolution of Multi-Octave Helix Traveling Wave Tubes***
Mr. Anthony J. Challis, e2v technologies Ltd.
Session 11 - Resiliency as a Means of Achieving Mission Assurance
Mr. Gary Gagnon, The MITRE Corporation

Wednesday, October 6

8:00 a.m. - 9:50 a.m. ***Concurrent Sessions***
Session 12 - International Activities and Technologies
Session Chair: Mr. Andrea De Martino, Elettronica SpA
Advanced ES and EA Systems
Ms. Daniela Pistoia, Vice President of Research and Advanced Systems Design, Elettronica SpA, Italy
Realizing Military Open System Architectures
Mr. Steve Roberts, VP, Capability & CTO (EW), Selex Galileo Ltd.
European EW Goes Multifunctional - Next Generation EW on Gripen
Mr. Petter Bedoire, EW Product Manager, SAAB EDS- Jarfalla- Sweden
Full Digital Integrated and Networked EW Systems
Mr. Olivier Kennel, Marketing & Product Policy deputy Director, THALES Systèmes Aéroportés, France
Session 13 - Experimentation: Finding the Needle Amidst the Incredibly Complex Haystacks
Session Chair: Mr. Russ Blaine, Wyle
How EW Neglect Boosts Casualties
Lt Col Johannes Naumann, (Ret.) Dipl-Ing
Comparing Effectiveness of Different Counter Measure Techniques through Simulation
Mr. Matthys Johannes Uys du Plooy, SCIR, DPSS
EW Testing – Trust or Doubt
Mr. Benjamin Wepfer, RUAG Schweiz AG

10:00 a.m. - 10:45 a.m. **General Session - Keynote Speaker/Session 14 - Italian Air Force – Evolution of Electronic Warfare in Air Power Operation**
Brigadier General Giovanni Fantuzzi, Chief Aerospace Planning Division, ITAF AIR STAFF

11:00 a.m. - 1:00 p.m. ***Concurrent Sessions***
Session 15 - EW International Opportunities and Challenges
Session Chair: Mr. Jim Fallon, Cobham
Session 16 - Policy and Planning for Law Enforcement and Homeland Security
Session Chair: Mr. Jeffrey Sands, The MITRE Corporation
Session 17 – The Real World
Session Chair: Mr. Mick Riley, Test Equipment Solutions

1:00 p.m. - 3:00 p.m. **AOC Annual Awards Luncheon** *(open to all full symposium attendees)*
Keynote Speaker/Session 18
Lt Gen Ted Bowlds, Commander, Air Force Electronic Systems Center

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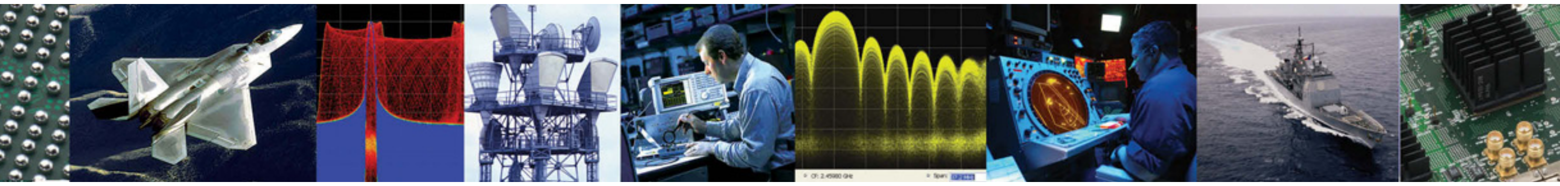

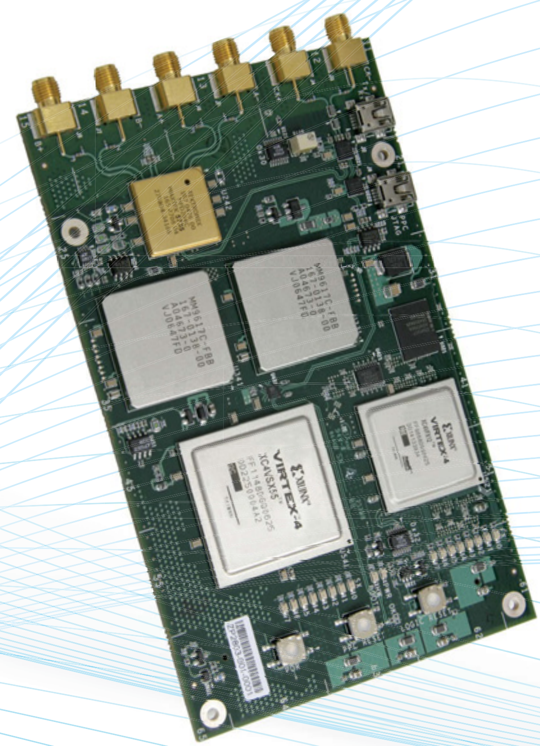

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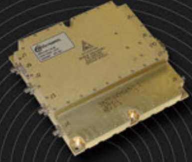

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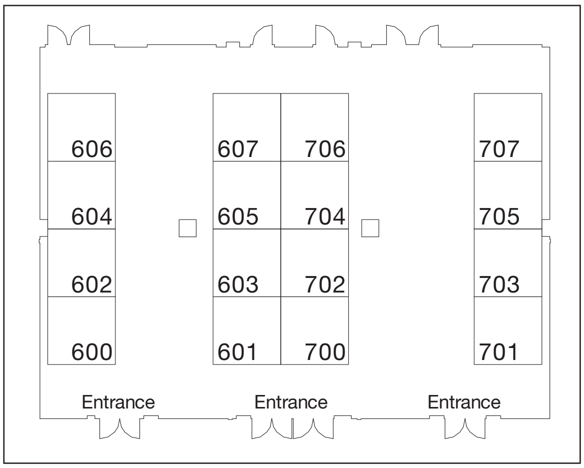

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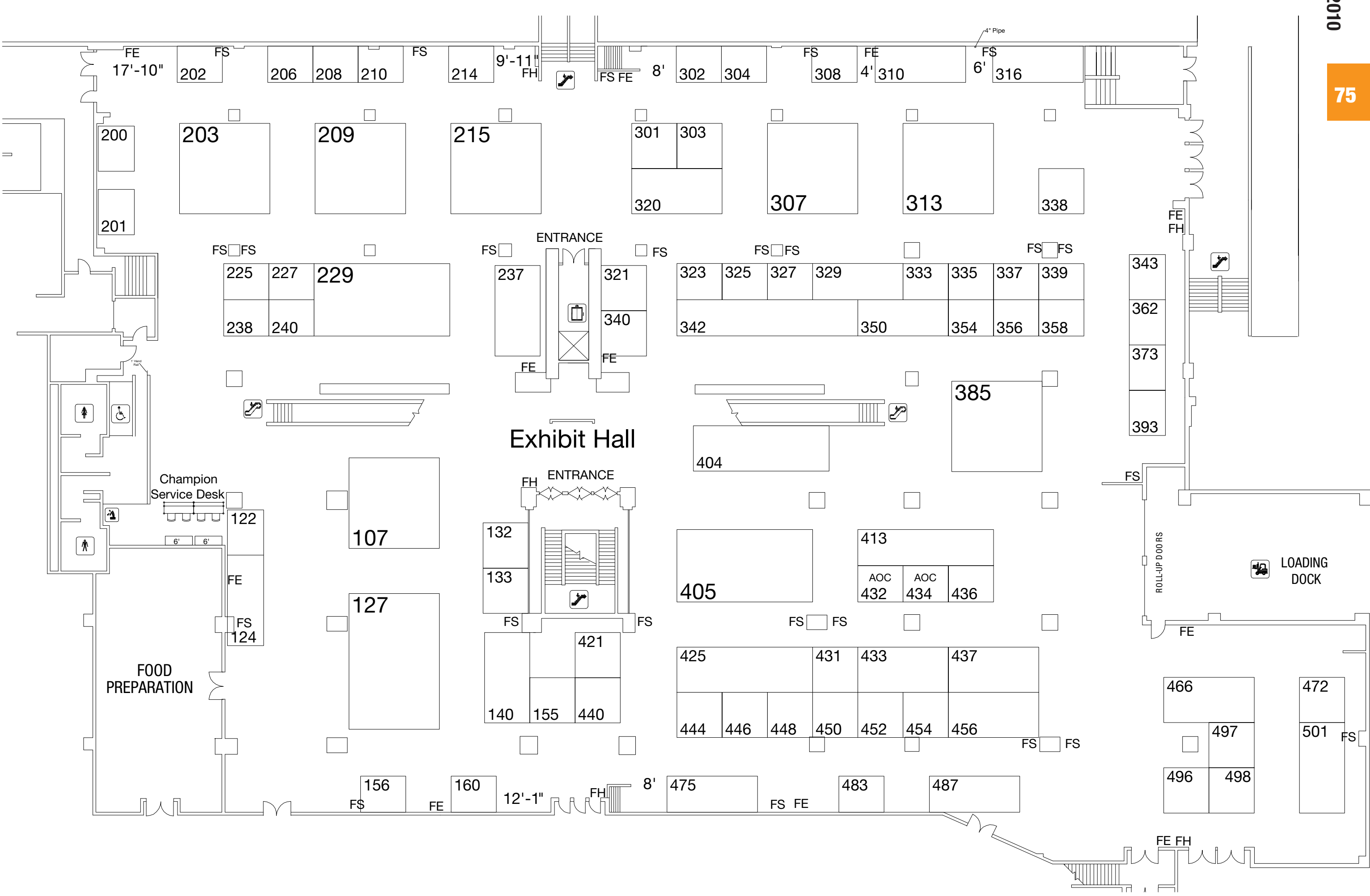

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