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The AOC Electronic Warfare Publication
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REACHING OUTSIDE EW

This month's issue of *JED* marks the beginning of a new series of articles named Senior Leadership Outreach. This series will examine the role of EW in air warfare, naval warfare, land warfare, etc., with the aim of explaining how EW is essential to operations in each of the warfighting domains – air, land, sea, space and cyberspace. The target audience of these articles isn't the typical EW professional, although I hope you will find them useful. The primary target we are aiming to reach is anyone and everyone, from a soldier to a four-star, who needs to better understand how EW works and why it is important to modern warfare.

The EW community is making tremendous contributions to operations in Iraq and Afghanistan, and senior leaders are taking a significant interest in the EW discipline at the moment. At the same time, EW itself is evolving from a support role to a primary role in current and future operations. Senior defense leaders are recognizing that their forces cannot fight in any domain without free access to the electromagnetic domain. While these are positive trends, the EW community needs to take advantage of them while the opportunity exists.

If the EW community is going evolve and take on this larger role, we need to clearly articulate to the broader defense community what EW is and why it is essential. In the past, we have not done a stellar job of communicating EW concepts. For one thing, our EW lexicon – ES, EA and EP – is not very intuitive. It does a poor job of explaining EW concepts to the broader defense community, which ultimately means EW is poorly understood. The EW community often complains about the lack of consistent support and funding from leaders and we bemoan all those people who don't "get it" when it comes to EW. Well, maybe we're the ones who don't "get it," and we need to find a better way to communicate EW to the rest of the defense community.

This month's *JED* kicks off the Senior Leadership Outreach series with an article by Wg Cdr John Clifford, RAF (Ret.), who writes about "Maneuver in the Electromagnetic Domain – You've Got to Be in It to Win It!" The article takes a broad look at the EM Domain and explains it in terms of maneuver, something that any commander can understand. It also addresses some of the challenges the EW community has imposed on itself in terms of language and lexicon. I think you will enjoy it. I also hope it generates some thought (and criticism). As always, *JED* invites your letters.

– John Knowles

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www.ausa.org

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Arlington, VA
www.navysna.org

Collaborative Electronic Warfare Conference
January 26-28
Point Mugu, CA
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FEBRUARY

Singapore Airshow
February 2-7
Singapore
www.singaporeairshow.com

EW India 2010
February 9-11
Bangalore, India
www.ew-india.com

Air Warfare Symposium
February 18-19
Orlando, FL:
www.afa.org

Cyber and Spectrum Operations Integration Conference
February 23-25
Chantilly, VA
www.crows.org

AUSA Winter Symposium
February 24-26
Fort Lauderdale, FL
www.ausa.org

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March 23-28
Santiago, Chile
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APRIL

Australian EW and IO Convention
April 12-13
Adelaide, SA, Australia
www.oldcrows.org.au

AAAA Annual Convention
April 14-17
Fort Worth, TX
www.quad-a.org

MAY

Navy League Sea-Air-Space Expo
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Washington, DC
www.seaairspace.org

3rd Annual EW Gaps and Capabilities Conference
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WHERE HAS ALL THE SPECTRUM GONE?

Last month your Association engaged with the US Congress over continued efforts to reallocate and sell portions of the electromagnetic spectrum (EMS) for commercial use. Our actions were in response to HR 3125, the Radio Spectrum Inventory, a bill which we believe will significantly and disproportionately affect the joint warfighters who rely on the EMS to train and fight in demanding environments such as Iraq and Afghanistan.

It is becoming increasingly obvious that the EMS is a warfighting domain fundamental to the range of military operations (ROMO). Its availability is essential to existing and emerging technologies in electronic warfare (EW), network-centric capabilities, communications systems, satellite resources and multi-spectral sensors. Current HR 3125 language threatens to undermine the growing military requirement to conduct operations within and across the EMS and raises four primary concerns that our association has regarding the bill:

1. Spectrum Utilization. The Department of Defense (DOD) utilizes the spectrum much differently than the commercial wireless industry. "Utilization" is a snapshot of spectrum activity; however, the bill does not clearly account for passive usage – when receivers and sensors are listening to the EM environment, but not necessarily transmitting signals. Passive spectrum usage is critical to our military's electronic intelligence (ELINT) and other signals intelligence (SIGINT) capabilities.

2. Annual Inventory/Reallocation. The annual inventory and reallocation process would hurt both DOD and defense industry's capacity to invest and develop advanced spectrum-utilizing technologies necessary for combat in the 21st century. Defense planning and program management often has a long-term outlook to ensure proper coordination and deconfliction. An annual process creates uncertainty that would dissuade investment in long-range research and development and increase acquisition costs for our nation's military. "Underutilized" today does not mean unnecessary tomorrow. DOD is experiencing the rapid growth of military spectrum requirements, which is leading to advances in spectrum-utilization technologies and spectrum management.

3. National Security. While the legislation seeks to protect against harming national security, the inventory requires the release of data on spectrum utilization that would harm warfighters. We believe the legislation must provide DOD with greater authority to withhold data from inclusion in the inventory. Furthermore, within the framework of national security, the US military focuses primarily on mission effectiveness. Spectrum encroachment today is detrimental to the military's ability to train and conduct operations. Our warfighters must be able to "train like they fight" in complex, congested and contested spectrum environments.

continued on page 22

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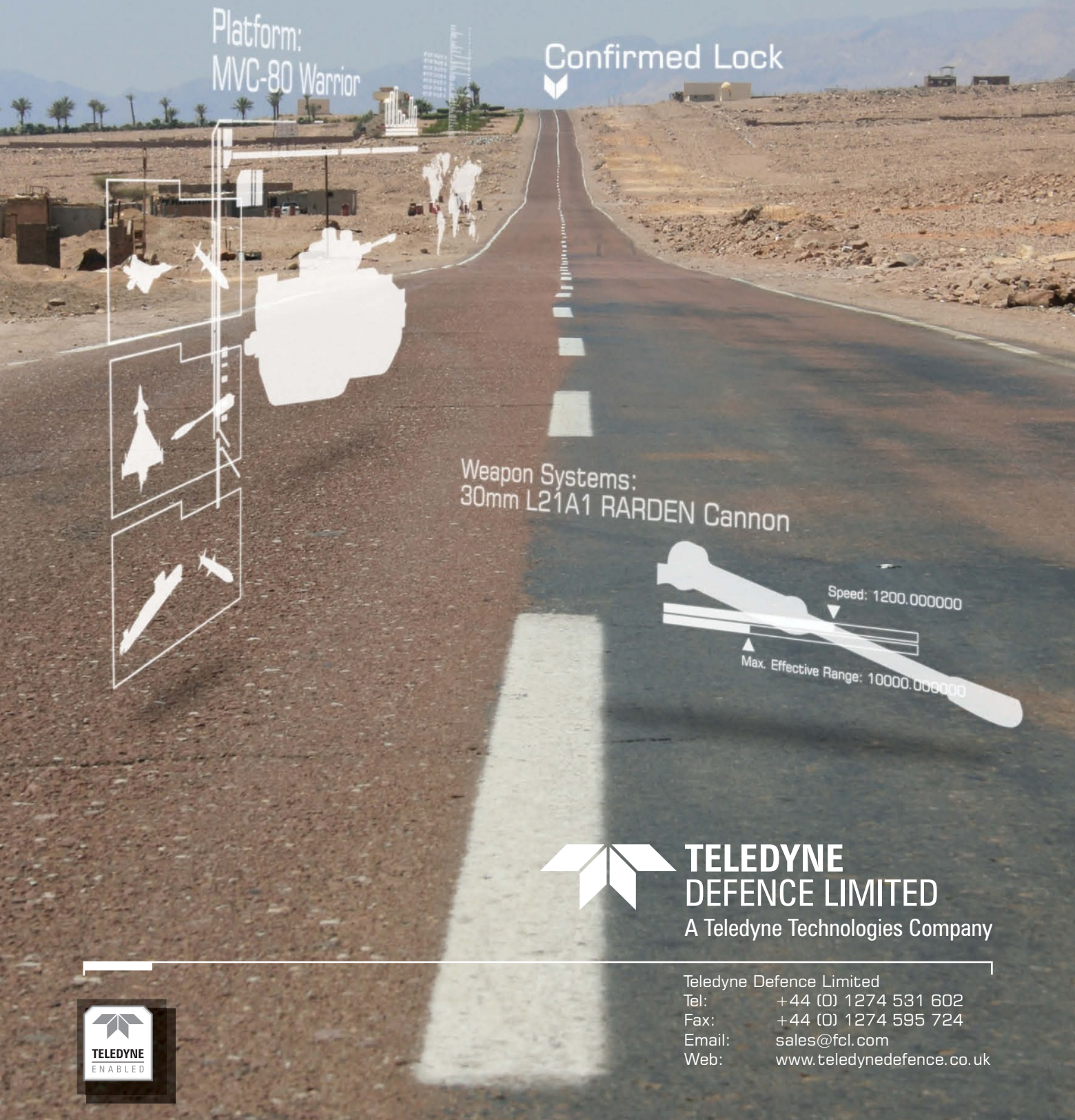

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NAVY GROWLER COMPLETES THE HOME STRETCH

Ashton Carter, the Under Secretary of Defense for Acquisition, Technology and Logistics, approved full-rate production of the US Navy's new EA-18G Growler airborne electronic attack (AEA) aircraft on November 23. The Boeing EA-18G, a derivative of the service's two-seat, twin-engine F/A-18F Super Hornet strike fighter, is replacing the Navy's carrier-based four-seat EA-6B Prowler support jamming aircraft. Electronic attack squadron VAQ-132 was the first operational unit to transition to the EA-18G. It achieved an initial operational capability with the Growler in September – only three years after the aircraft's first flight – after successfully completing a three-month independent Operational Evaluation in May.

The Navy plans to buy 88 Growlers to replace all of its EA-6Bs by 2013, enough to outfit each of its 10 carrier squadrons with five operational EA-18Gs and nine two-person aircrews. Boeing had delivered 16 of 34 low-rate initial production aircraft as of early December. Northrop Grumman supplies an enhanced version of the Prowler's latest ICAP III jamming suite (which saw limited fielding) for the Growler. The heart of the ICAP III upgrade for the EA-18G is Northrop Grumman's ALQ-218 wideband receiver, which can direct surgical jamming on specific frequencies and also can geo-locate enemy radars. The Growler also inherits the EA-6B's existing ALQ-99 external jamming pods. The home base for the Navy's EA-6B and EA-18G squadrons is the Naval Air Station Whidbey Island, WA.

The new Growler retains the inherent strike fighter capabilities of the F/A-18F Super Hornet and is faster and more maneuverable than the Prowler. CDR Jim Stoneman of the Super Hornet/Growler program office (PMA 265) at Naval Air Systems Command, NAS Patuxent River, MD, told the Electronic Warfare Infra-

structure Conference in Atlanta, GA, on December 2 that the Growler has nine weapon stations. Its typical external load-out is one high-band jamming pod, one High-Speed Anti-Radiation Missile (HARM), one Advanced Medium-Range Air-to-Air Missile (AMRAAM) and one auxiliary fuel tank under each of its wings, along with a single low-band jamming pod under the fuselage. "That gives you a total [gross take-off weight] of about 60,000 pounds, which is still 6,000 pounds below the maximum weight for the Growler."

A key addition to ICAP III that came in 2006 was the Link 16 Multi-function Information Distribution System (MIDS) tactical data link radio. MIDS terminals automatically exchange situational awareness information with each other in real time and show the locations of enemy air defenses, friendly and enemy aircraft, ships and ground forces on a cockpit display. "The increased situational awareness with Link 16 [combined with the ALQ-218] is really going to change where and how we use our AEA platforms," Stoneman said. "I'm excited to see what's going to happen when the air wings get a hold of the Growler. Where are they going to employ it? Who's it going to talk to? What are the tactics that are going to be developed? This is a chance, I think, for the members of the Navy's AEA community to grow and become EW battle managers." – *G. Goodman*

NEXT-GENERATION JAMMER ADVANCING TO NEXT PHASE

BAE Systems, ITT/Boeing, Northrop Grumman and Raytheon submitted bids by October 15 for the Technology Maturation phase of the US Navy's Next-Generation Jammer (NGJ) development program. The Navy plans to award up to four 10- to 14-month contracts valued at $15-30 million each by March 31. The NGJ program's aim is to provide a replacement beginning in 2018 for the aging ALQ-99 external jamming pods used by the Navy's EA-6B Prowler and new EA-18G Growler airborne electronic attack (AEA) aircraft. A variant of the NGJ also is expected to be carried on the Joint Strike Fighter currently in development and potentially on unmanned aerial vehicles.

The four competitor teams previously each completed six-month NGJ trade

study contracts awarded last January. The Navy provided the companies with performance objectives and they investigated the range of alternative NGJ technology solutions at the system level. During the Technology Maturation phase, the selected contractors will refine their system concepts and components. Each will develop a preliminary design of a system-level concept demonstrator that integrates and matures five critical technology elements – power generation, exciters, beam formers, radio-frequency power amplifiers and electronically steered antenna transmit arrays.

Following Milestone A approval by DOD officials, the program will then enter an 18- to 24-month Technology Development phase in FY11 with at least two contractors. Each will build a prototype of its system-level concept demonstrator, which will undergo flight testing aboard a surrogate test bed aircraft. Following a Milestone B decision in early FY13, the Navy will select a single contractor to conduct an engineering and manufacturing development phase over four years. The Navy's EA-6B/AEA Program Office (PMA-234) at Naval Air Systems Command (NAS Patuxent River, MD) manages the NGJ program. – *G. Goodman*

NEW ARMY SIGINT VEHICLE DEBUTS

The US Army's first new Prophet Enhanced wheeled vehicle-mounted tactical signals-intelligence (SIGINT) system rolled off General Dynamics C4 Systems' production line in Scottsdale, AZ, in early December. The Army had awarded General Dynamics a six-year indefinite delivery-indefinite quantity contract last February with a potential value of $866 million.

Prophet is the service's principal ground-based tactical communications-intelligence (COMINT) sensor. It detects, identifies and locates enemy communications emitters on the battlefield, performing stationary and on-the-move direction-finding. Prophet provides force protection and intelligence support to brigade combat teams, armored cavalry regiments and battlefield surveillance brigades.

The Army previously procured 126 up-armored Humvee-mounted Prophet Spiral 1 systems from L-3 Linkabit (San Diego, CA) beginning in 2001. The new Prophet Enhanced (PE) system offers an open architecture that can be readily upgraded by incorporating new software applications – instead of adding new hardware to the vehicle – to keep pace with changing threat signals of interest.

The Army has ordered PE systems housed in both an up-armored Humvee and in the service's new blast-resistant Panther 6x6 wheeled Medium Mine-Protected Vehicle (MMPV), built by BAE Systems (York, PA). The service plans to buy at least 50 PE systems. It may upgrade its 120+ Prophet Spiral 1 systems to the PE configuration or could replace them with PE variants. L-3 Linkabit and Northrop Grumman Information Technology (Chantilly, VA) are General Dynamics' principal subcontractors.

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Each brigade combat team will have two Prophet Spiral 1 or PE systems and one Prophet Control vehicle, each manned by three soldiers. The data from the Prophet sensor systems are passed to Prophet Control for processing and then forwarded to brigade intelligence elements. A major capability added in the PE configuration is satellite beyond-line-of-sight communications on the move, which will be provided by the Army's new WIN-T (Warfighter Information Network-Tactical) communications system. – *G. Goodman*

ONR SEEKING INDUSTRY PROPOSALS

The Office of Naval Research (ONR) in Arlington, VA, is soliciting industry proposals for its Electronic Warfare Discovery and Invention program, which is expected to yield a number of $100,000-$750,000 contracts totaling $3 million per year in FY11, FY12 and FY13. ONR released a Broad Agency Announcement (BAA 10-007) that seeks innovative proposals to develop and demonstrate technologies for next-generation EW components and systems in the areas of improved threat warning systems, decoys and countermeasures, electronic warfare support (ES), electronic attack (EA) and electronic protection (EP). White papers are due by February 2, 2010. Only those companies submitting white papers are eligible to submit full proposals, which are due by May 11, 2010.

ONR's areas of interest include:

- Distributed ES Concepts – a spatially dispersed set of ES systems, including small, unmanned or unattended ES systems, to provide broader area coverage and improve Navy and Marine Corps battlespace awareness by continuously monitoring all critical portions of the electromagnetic spectrum; quickly and accurately classifying emitters and emitter functions; precisely and rapidly locating platforms, people, things and events; and conducting accurate long-term monitoring and tracking of hostile forces.
- ES Adaptive Signal Processing – improving the capability of Navy and Marine Corps ES systems to detect and process signals in a complex EM environment characterized by an increasing density and diversity of signals that span broad frequency bands.
- Detect and Defeat Passive Sensing Systems – capabilities to detect and counter passive detection technologies which do not rely on RF or EO/IR emissions from the controlling platform, such as Passive Coherent Location (PCL) systems, Anti-Radiation Homing (ARH) sensors, Infrared Search and Track (IRST) systems, adversary ES systems and acoustic detection sensors.

The BAA is available at www.onr.navy.mil/en/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements.aspx. The technical points of contact at ONR are Dr. Peter Craig, e-mail peter.craig@navy.mil or David Tremper at david.tremper@navy.mil; the business contacts are Silvia Molinillo at silvia.molinillo@navy.mil or Vera Carroll at vera.caroll@navy.mil. – *G. Goodman*

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LtGen Daniel P. Leaf (Ret AF)
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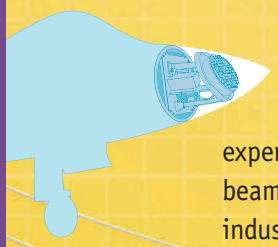

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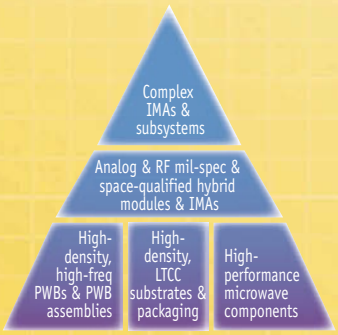

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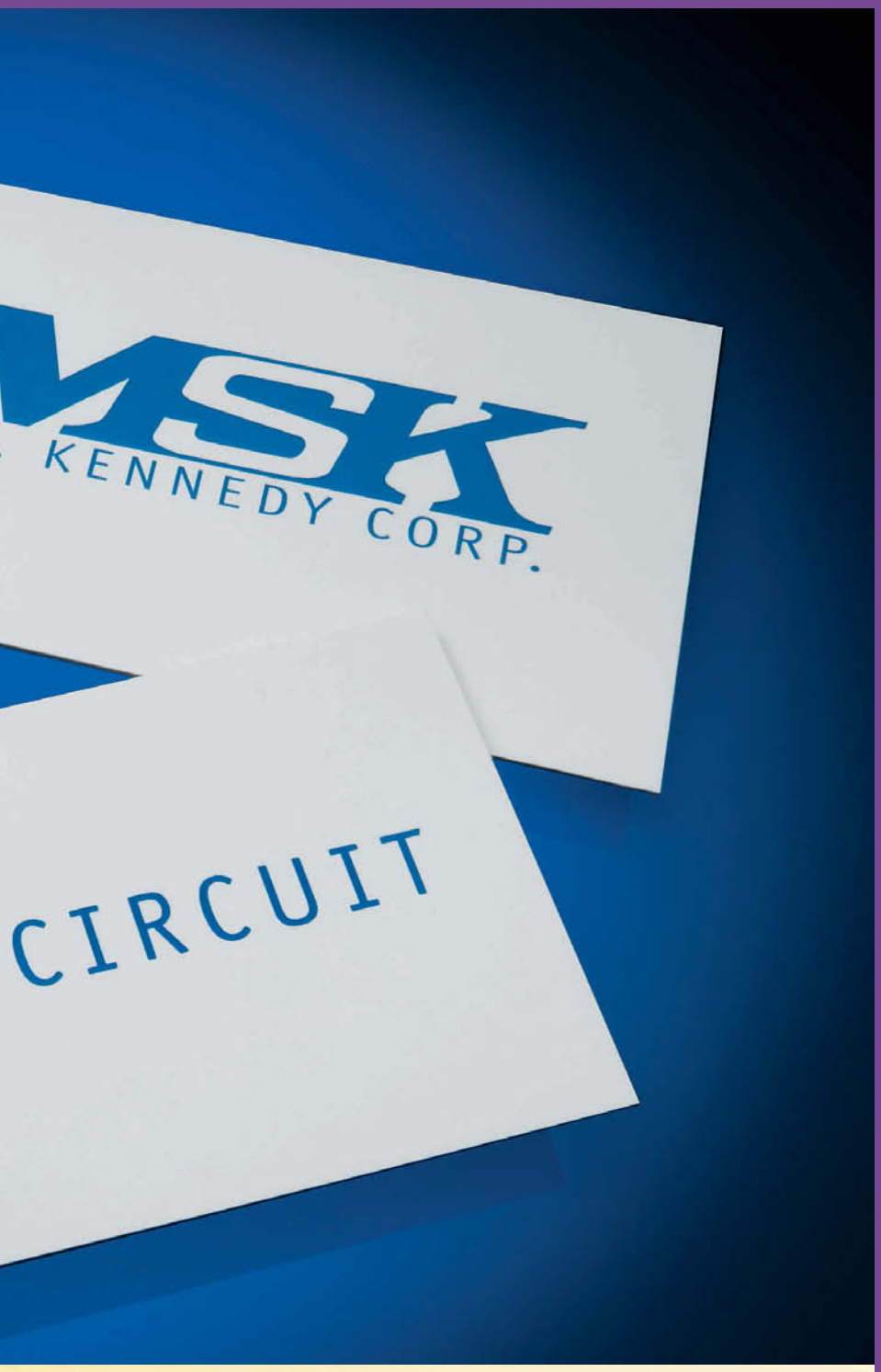

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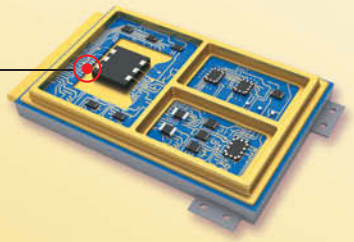

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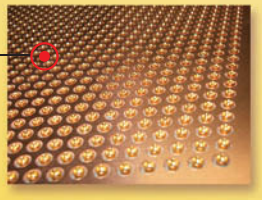

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is being awarded a $12 million contract for procurement of component parts for supporting repair of Department of Navy Large Aircraft Infrared Countermeasures (IRCM) systems, AAQ-24(V)25, which supports H-46 and H-53 helicopters. Work will be performed in Rolling Meadows and is expected to be completed by December 2011. Northrop Grumman CES was also awarded a $7.5 million delivery order from Naval Air Systems Command (NAVAIR) against a previous basic ordering agreement to perform upgrades to the V-22 Large Aircraft IRCM system, including modifications to its direct IRCM (DIRCM) system. Work on this project is expected to be completed in September 2012.

✪ ✪ ✪

Sierra Nevada Corp. (Sparks, NV) is being awarded a $7.4 million modification to a previously awarded contract with Naval Sea Systems Command (NAVSEA) to exercise an option for spares and consumables for 1,300 dismounted joint counter radio-controlled improvised explosive device electronic warfare (JCREW) systems. The contract is for the procurement and support of JCREW systems to be used by each of the military services of the US Central Command (CENTCOM). Work will be done in Sparks and Rancho Cordova, CA and is expected to be completed by December 2010.

Message from the President continued from page 12

4. Public Disclosure. The legislation creates a Web-based portal to make the inventory publicly available. If defense spectrum activity data becomes publicly available it will be too easy for adversaries and peer competitors to learn about how the US military is utilizing the spectrum and ultimately exploit weaknesses. Protecting sensitive information about spectrum utilization is challenging today and H.R. 3125, as written, will only make it more difficult – potentially putting the lives of our warfighters at risk.

The AOC understands the potential economic value of spectrum inventory and reallocation. We also recognize the important contributions of the commercial wireless industry to the advanced military capabilities our warfighters are presently using in combat. However, it is vital to mission effectiveness and for the safety of our warfighters that our military controls the electromagnetic spectrum in operations from the first day of conflict until the last. The EMS is a dynamic and ever-changing environment, and the US is no longer a generation ahead of its peer competitors.

As a nation, we must ensure that DOD can manage military utilization of the spectrum and provide long-term strategic planning and program development. So get in touch with your congressman and let him know you are concerned about the Spectrum!

– Chris "Bulldog" Glaze

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washington report

CONGRESS CONSIDERS SPECTRUM REALLOCATION

In recent months, the US Congress has begun considering measures that would require an inventory of each spectrum band, paving the way for the government to sell off bands deemed to be "underutilized," ostensibly to the commercial wireless industry.

The Radio Spectrum Inventory Acts – HR 3125, introduced last summer by US Rep. Henry Waxman (D-CA), and S 649, introduced last spring by Sen. John Kerry (D-MA) – would each require an inventory of the spectrum bands, though the Senate version specifies an inventory that would occur every two years and encompass the bands from 300 MHz to 3.5 GHz, while the House bill does not include the biennial notation and includes bands from 225 MHz to 10 GHz.

Both bills require that the inventory report include: "the licenses or government user assigned in the band; the total spectrum allocation, by band, of each licensee or government user (in percentage terms and in sum); the number of intentional radiators and end-user intentional radiators that have been deployed in the band with each license or government user; and if such information is available – the type of intentional radiators operating in the band; the type of unlicensed intentional radiators authorized to operate in the band; contour maps that illustrate signal coverage and strength; and the approximate geo-location of base stations or fixed transmitters."

Both versions of the bill also require creation of a centralized Web portal that would be used by each government agency to make its inventory available to the public. And they each require the information in these portals to be updated in "near real-time fashion" whenever there is a change in allocation or licensing.

The major issues from the US military side center on exactly how "underutilized" spectrum is defined – especially given that the military uses bands that receive signals and do not actively transmit. There is also the issue of how placement of the entire US inventory spectrum on-line would allow anyone to see exactly what bands are being used.

Another key issue is authority. The Senate bill gives determination of national security interest to the National Telecommunications and Information Administration (NTIA), which is part of the Department of Commerce and not the Department of Defense. The House bill gives authority to the NTIA, but also to the FCC.

Speaking at the AOC's EW Infrastructure Conference Dec. 2 in Atlanta, Ken Miller, AOC director of industry and government affairs, noted that "the DOD has to provide the Department of Commerce clear and convincing evidence that information on what they're doing in the spectrum is harmful to the national security if it's released to the public. And then, of course, Department of Commerce has the final say."

Also speaking at the AOC conference, Jason "Boots" Winn from the Joint Electronic Warfare Center's Electromagnetic Red Team, discussed the impact on testing. "We need to be able to test the entire spectrum of this particular threat with our weapons systems in a reasonable environment. You can't do it in a simulator," he said. "I deal with this as we try to find opportunities to test. There are very few places where you can do these tests where you get minimal GPS jamming, minimal comms jamming because it impacts the FAA, it impacts banking systems, it impacts everybody.

"We have no idea what our stuff is going to do in a true environment. We need 200-300 miles of range. And we need to be able to operate our systems [across] the whole spectrum and [understand] how we're going to manage it. Otherwise we're going to show up to the war unprepared."

The Senate bill has already passed out of committee and last month, the House Subcommittee on Communications, Technology and the Internet held hearings on HR 3125 with five witnesses from wireless, telecommunications and broadcast arenas, and one from the defense industry. Testifying before the subcommittee, Ray O. Johnson, Senior Vice President and Chief Technology Officer at Lockheed Martin, noted that the company supported the act with modifications, specifically dealing with how the bill looks at spectrum utilization. "It is also critical to recognize and reflect that a highly effective spectrum-dependent system may not transmit at all, or only infrequently," Johnson told the committee.

Johnson also discussed the need to preserve the classified license to protect sensitive spectrum usage information from being disclosed and the need to recognize our international cooperative agreements supporting allied interoperability. And Johnson also questioned the annual review component in the House bill, noting that it might have a dampening effect on industry development.

"This review may create an impression of volatility and instability in spectrum allocations, thus impacting long-term research and development, acquisition and deployment of new systems and solutions," he said. – *E. Richardson*

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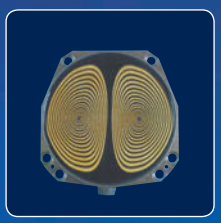

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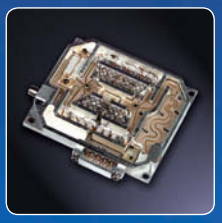

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world report

EADS' INDIAN JOINT VENTURE STALLS

A proposed joint venture between EADS and Larsen & Toubro, which would have cooperated to provide EW systems, radars and avionics to India, has reportedly stalled because of Indian government concerns that it would exceed the country's foreign investment limits.

Larsen & Toubro, India's biggest private defense contractor, is part of an overall engineering powerhouse dealing in everything from software to energy. The link up with EADS was designed to take advantage of the Indian government's increased military procurement funds – up to US$30 billion over five years – as the country replaces its aging equipment.

Issues with the agreement emerged in late summer when India's Foreign Investment Promotion Board (FIPB) dug into the financials and determined that while overall foreign investment from EADS would be below the country's cap of 26 percent, additional equity being funneled through the joint venture could possibly allow EADS up to 49 percent equity. Though several industry lobby groups are pushing to increase foreign ownership limits up to 49 percent, for now the FIPB has rejected the current EADS and L&T joint venture.

However, this is not the first joint venture to experience difficulty with the Indian foreign investment rules. EADS may be able to adjust the agreement to secure approval. Case in point: BAE Systems' joint venture with Indian automaker Mahindra & Mahindra, designed to produce armored vehicles for the country, experienced a similar issue in October. A revised proposal adjusting BAE's ownership stake down to the 26 percent cap was approved by the FIPB last month. And there will be incentive for foreign companies to make these adjustments as a way to get at least a foot in the door of the lucrative Indian defense market. – *E. Richardson*

AUSTRALIA TAKES WEDGETAIL, REAFFIRMS JSF

Boeing has delivered the first two of the new Wedgetail 737 Airborne Early Warning and Control (AEW&C) aircraft to the Australian Department of Defense.

The Wedgetail, based on the new Boeing 737 commercial airframe, provides upgraded radar and sensor AEW&C capabilities. The deliveries allow the Royal Australian Air Force to begin training on the aircraft, even though Air Vice Marshal Chris Deeble, Australia's AEW&C Program Manager, noted in the DOD release that: "Development, test and evaluation are still ongoing with many hurdles still to be overcome, particularly with respect to radar, electronic support measures and integrated system performance and stability."

Last month, *The Australian* reported that Boeing will end up paying the Australian government nearly AUS$100 million for delays in the program, which is about four years behind schedule.

The company is contracted to deliver three additional Wedgetails to the RAAF by the end of 2010, one of which is scheduled to include an upgrade to the final configuration of the Elta-manufactured ESM system. The remaining two aircraft should receive the upgraded ESM by early 2011. The country is set to buy six total Wedgetails at a cost of more than US$3.7 billion.

In late November, the Australian government also approved an AUS$3.2 billion acquisition program for the RAAF's first 14 F-35 Joint Strike Fighters (JSF). The DOD has plans to acquire three operational squadrons totaling at least 72 aircraft and, according to the DOD release, will consider funding approval for the remaining aircraft in 2012, as well as whether to increase to an additional squadron "in conjunction with a future withdrawal decision on the F/A-18F Super Hornets." – *E. Richardson*

In Brief

- The United Arab Emirates have requested the sale of CH-47F helicopters and communication equipment, as well as parts, equipment, training and logistical support via Foreign Military Sale (FMS) from the US. The package, worth approximately $2 billion, includes 16 Chinooks, 20 single channel ground and airborne radio systems (SINGCARS) with electronic counter-countermeasures, as well as 18 APR-39A(V)1 radar signal detecting sets with mission data sets. The proposed sale gives the UAE capability to transport equipment and troops and to support US and allied airlift needs in Afghanistan.
- Turkey has also requested sale of CH-47F helicopters, as well as parts, equipment, training and logistical support via FMS. The package, worth approximately $1.2 billion, includes 14 Chinooks, 28 SINGCARS and 14 APR-39A(V)1 radar signal detecting sets along with support equipment, spare and repair parts, personnel training and training equipment and logistics support. The proposed sale improves Turkey's ability to meet current and future domestic defense needs.
- The Naval Surface Warfare Center (Crane, IN) has announced plans to award a sole source, firm-fixed-price contract to Israel Military Industries (IMI) (Ramat Hasharon, Israel) for countermeasure decoy flares to be used in the Foreign Comparative Testing (FCT) program, which will test the flares against US and other foreign countries' flares.

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EW IN THE ASIA-PACIFIC REGION: ALL EYES ON CHINA?

By John Knowles

Stretching from Pakistan to the Korean Peninsula and southward to Australia and New Zealand, the Asia-Pacific region represents one of the leading international electronic warfare markets. With some of the world's most developed economies, and a Chinese military undergoing rapid modernization, many of the countries in this region are showing more interest in improving their EW capabilities.

The region's governments approach their EW needs in a variety of ways. In addition to the many countries that depend on foreign suppliers, there are those building their own EW systems. As EW users, the region's militaries are becoming ever more sophisticated in their requirements, support and training.

The US is the region's leading EW supplier, thanks in part to the large number of US-made weapons systems operating in the region – from F-15s, F-16s, F-18s and C-130s to surplus US Navy frigates and destroyers. Most of these platforms are equipped with EW systems from ITT, Northrop Grumman, Raytheon and BAE Systems. The region also includes a number of former British colonies that have maintained strong military ties with the UK government, enabling companies such as Selex and Thales to supply a range of EW equipment to various nations.

Over the past decade, however, many countries in the region have broadened their EW supplier base, with companies such as Elsira, EADS and Saab chalking up significant sales. China's rapidly developing economy is funding a military program that is increasingly capable of projecting power far outside its borders. This factor, more than anything else, will drive the region's EW market over the long term. Here's a look at some of the notable EW programs and opportunities in the region's various countries.

INDIA: MAKING NEW FRIENDS

India is establishing itself as an economic and political leader within the region, and part of that strategy depends on a strong military. Over the past several decades, India has built a significant and largely government-owned defense industry to realize its goal of self-reliance. It also has frequently turned to Russia to supply (either through export or licensed manufacturing) some of its most complex weapons systems. Occasionally, it has tapped UK, French and Israeli companies as well. This formula has enabled India to achieve a military capability that has stood up well inconflicts with Pakistan. Looking into the future, however, India acknowledges that it must replace its aging Soviet-era weapons systems with a new generation of aircraft, ships and ground vehicles that feature more advanced technology, particularly EW, radars and communications systems.

Rather than scrap the traditional weapons acquisition strategy, however, the leadership in New Delhi decided to simply add another layer by rewriting its defense policy to allow more foreign participation and technology partnerships in its defense industry. Israeli companies were among the first to take advantage of this new policy, supplying a wide range of aircraft self-protection systems, UAV SIGINT/ESM sensors and ground-based communications jammers. European and US companies have approached the Indian market more slowly, but with a lot of fanfare, announcing multiple teaming agreements with government labs, state-owned companies and private sector companies over the past few years.

One of the first major programs to emerge under India's new policy is the high-profile Medium Multi-Role Combat Aircraft (MRCA) program, which could see the Indian Air Force buy up to 126 fighter aircraft to replace its aging MiG-21 fleet. Multi-phase flight evaluations began in 2009 and will extend through the summer, with six bidders – Eurofighter (Typhoon), Dassault (Rafale), Saab AB (JAS 39 Gripen IN), RAC MiG (MiG 35), Lockheed Martin (F-16IN) and Boeing (F/A18IN) – pursuing the $10 billion program. While India is seeking the latest airborne EW capabilities, it appears to be content with mostly "off the shelf" solutions available for these aircraft. Raytheon is offering a variant of its ACES suite for Lockheed's F-16 bid, and its ALR-67(V)3 RWR is part of Boeing's F/A-18IN bid, which features an EW suite based on the US Navy's F/A-18E/F aircraft. The F/A-18IN also includes ITT's ALQ-214 RF Countermeasures (RFCM) subsystem. Both aircraft also feature the ALE-47 dispenser from Symetrics. The MiG-35 bid includes Elettronica's ELT-568(V)2 jammer. Saab Avitronics is reportedly offering some of the new EW capabilities developed for the Gripen NG. The Rafale features the Spectra EW suite from Thales and MBDA. The Typhoon bid includes the Praetorian EW suite from Selex, Elettronica, Indra and EADS with the possible addition of Selex's Seer digital RWR.

The MRCA program may be grabbing most of the attention, but India is pursuing several other EW programs. It is buying Saab's Compact Integrated De-

fensive Aids Suite (CIDAS) for its Dhruv light helicopters as well as the company's Land Electronic Defense System (LEDS) 150 for its T-90M tanks. Northrop Grumman has supplied its AAQ-24 Nemesis DIRCM systems for three head-of-state aircraft. And Elisra has worked on a number of EW projects, including development of self-protection systems for the Su-30 MKI and the Tejas light combat aircraft.

PAKISTAN: RE-ESTABLISHING RELATIONSHIPS

The Global War on Terror (GWOT) has not only changed Pakistan's defense strategy, but it has also provided it with an opportunity in recent years to access more advanced weapons systems than it previously could acquire from western nations. One of Pakistan's most significant programs has been the acquisition of new fighter aircraft. Last month, Lockheed Martin delivered the first of 18 F-16 Block 52 aircraft (12 F-16Cs and 6 F-16Ds) equipped with the ALQ-211(V)4 Advanced Integrated Defensive Electronic Warfare Suite (AIDEWS) from ITT Electronic Systems. In the Block 52 aircraft, these are being delivered in an internal (V)4 configuration. In 2008, Pakistan requested the sale of 21 additional AIDEWS systems in a podded configuration known as the (V)9. Although a contract has not been signed to date, these pods are slated for use on the Pakistan Air Force's older model F-16s. Pakistan has also bought seven P-3C maritime patrol aircraft from Lockheed Martin. These aircraft are being equipped with ITT's ALR-95 ESM systems.

MALAYSIA: MIXING BLUE AND RED

Malaysia began to focus on developing EW capabilities in the early 1970s, and it has continued on that path through today. Like India, Malaysia has bought a mix of Russian and western military equipment, such as F/A-18D, MiG-29N and Su-30MKM fighters, Scorpene submarines and UK-built frigates. In some cases, it has opted to integrate western EW onto its Russian equipment. When it bought Su-30MKM fighters from Russia a few years ago, for instance, it chose to integrate a Saab Avitronics missile warner (the MWS-300) onto the aircraft.

Over the next decade, Malaysia is expected to buy a second batch of locally-built Kedah-Class Next Generation Patrol Vessels (the first batch has been fitted with Thales Sceptre X ESM systems and Lockheed Martin Sippican's ALEX decoy launchers), and it is soon expected to issue an RFP to replace its 18 MiG-29N fighters, which are slated for retirement this year. Industry sources believe this program will attract many of the bidders who are pursuing India's MRCA program.

Malaysia has done a successful job of focusing on in-country EW sustainment and EW training. The country's armed forces have bought EW aggressor services from Cobham's FR Aviation, via its local Falcon Special Air Services subsidiary, and operational EW training services from Malaysian companies such as Megamars.

SINGAPORE: DEFENDING THE CITY-STATE

Singapore's small size and strategic location at the southern tip of the Malay Peninsula have required it to develop one of the most advanced military capabilities in the region. It has embraced EW as a force multiplier and, more recently, as an integral part of a network-centric fighting force.

The Republic of Singapore Navy operates several ship classes, each featuring a different EW suite. Over the past few years, six French-built Formidable-Class frigates have entered service (the last two were commissioned in early 2009). These have been fitted with Rafael's C-PEARL-M ESM systems and Sagem's New Generation Dagaie System (NGDS) decoy launchers. Six Victory-Class corvettes were bought in the 1990s. These are equipped with Elisra's NS-9003/5 ESM system and Rafael's RAN1011 Jammer. It also features Rafael chaff launchers. Last year, the Navy announced a life extension program for these ships, which means they are likely to undergo EW upgrades over the next few years as well. In the 1990s, the Navy also bought 12 Fearless-Class patrol vessels, six of which are equipped for anti-submarine warfare missions. These are equipped with Elisra's NS-9010C ESM system, as well as Marine Shield decoy launchers.

The Republic of Singapore Air Force (RSAF) also has developed strong ties with Israeli EW suppliers. When it bought the first 12 (of 24) F-15SG aircraft from Boeing in 2005, the RSAF caused a bit of a stir in Washington by selecting an Elisra EW system (based on the company's SPS-2110) rather than US equipment. While it should not have been a surprise to many in the US (the US Air Force has never funded a substantial EW upgrade for the F-15), it did lead Boeing to eventually take the initiative and begin development of a new EW system for the aircraft. In 2008, the company selected BAE Systems EIS as the supplier of the Digital EW Suite (DEWS), which it is offering to current and future F-15 customers. DEWS leverages technology from the Barracuda system developed for the F-35.

The Republic of Singapore Air Force also flies more than 60 F-16C/D Block 52 aircraft, which it has bought in small batches since 1998. These are fitted with a standard EW suite (ALR-56M and ALE-47) and they are candidates for an eventual EW upgrade, with Elisra, Raytheon and ITT among the potential suppliers. In the long term, the Air Force is considering a new fighter, with the F-35 being among the leading possibilities. But delays in the F-35 program increase the chances of an F-16 EW upgrade in the interim.

AUSTRALIA: LESSONS LEARNED

EW is an essential component of the Australian Defence Force (ADF), which features some of the most sophisticated EW capabilities in the region. Australia's participation in the GWOT has driven the acquisition of new IR countermeasures systems for its helicopters and transports. However, these upgrades have not derailed any of the ADF's other EW modernization efforts.

The ADF's largest EW program, Project Echidna, has been something of a disappointment. Started in the late 1990s, Echidna was an ambitious program to develop a common, modular EW suite that could be installed on most of the ADF's helicopters and fixed-wing aircraft. After drawing significant interest from US, European and Israeli suppliers, the program began to unravel after just a couple of years due to budget pressures and was subsequently "scoped down" to include fewer suite components and fewer aircraft types.

One of Echidna's main thrusts was development of the ALR-2002 RWR by BAE Systems. While BAE encountered some challenges during development of the RWR (the government was careful to point out that that BAE Systems' performance during the contract "met all expectations"), the main problem Echidna faced was essentially a matter of the cost and schedule to integrate the RWR onto various aircraft. In September 2009, the Australian government announced that it was discontinuing development of the ALR-2002 and would proceed with other portions of the Echidna program on a limited basis – primarily the EW upgrades for 12 UH-60 Blackhawk helicopters.

As Project Echidna encountered problems, the Royal Australian Air Force (RAAF) opted for alternatives. It selected Raytheon's ALR-67(V)3 RWR for its Hornet Upgrade Program. Its C-130H aircraft have been fitted with Elisra's SPS-1000 RWR, which has also been installed on the Royal Australian Navy's Seahawk and Super Seasprite helicopters.

Another issue facing the RAAF is modernization of its strike aircraft fleet. It had planned to retire its aging F-111C fleet and buy the F-35 in the 2015-2020 timeframe. With delays in the F-35 program, however, the Australian government decided in 2007 to purchase 24 F/A-18F Super Hornets as an interim capability. From an EW perspective, this will provide some degree of commonality with the RAAF's older Hornets, as they both will operate the ALR-67(V)3 RWR. The Super Hornets, which will also feature the ALQ-214 RFCM subsystem and ALE-50 towed decoys (eventually, they are slated to carry the ALE-55 fiber-optic towed decoys), are slated to become operational later this year. The RAAF contract includes the option to upgrade 12 of the Super Hornets with elements of the EA-18G suite, namely the ALQ-218 ESM system. Dubbed "Growler Lite," this would not include the ALQ-99 jamming pods (according to the current plan), but it would provide the Super Hornets with advanced emitter detection, identification and geolocation capabilities. Because of the RAAF Super Hornet production schedule, the RAAF can exercise the "Growler Lite" option through 2012.

The Royal Australian Navy's (RAN's) main project at the moment is the construction of three new Hobart-Class Air Warfare Destroyers. In May, four companies – Thales, Indra, Elisra and ITT – were invited to submit bids for the EW suite. As *Australian Defence Magazine* pointed out at the time, the list of bidders raised some eyebrows mainly because BAE Systems Australia and Rafael – two companies that have previously supplied ESM systems to the RAN – were dropped from the bidding process. The AWD contract could become more significant if the RAN opts to buy a fourth destroyer and/or specify the EW suite for its two Canberra-Class amphibious assault ships.

CHINA'S EASTERN NEIGHBORS

Of all the countries in the region, Taiwan, Japan and South Korea are perhaps the most wary of China's defense modernization. All three have developed robust defense capabilities, relying on a mix of domestic manufacturing and imported weapons systems.

Taiwan has built some of its EW systems in the past, but its most advanced systems come from the US and France. This includes Raytheon ALQ-184 jamming pods for its F-16s and SLQ-32 shipboard EW systems for its frigates. In the 1990s, France supplied Mirage 2000-5 fighters and La Fayette-Class frigates (both fitted with Thales EW systems). Much of this EW equipment is due to be upgraded or replaced in the coming decade. In the near-term, Taiwan must decide how to replace its aging F-5 fighters. Taiwan has been seeking more than 60 new F-16 Block 52 fighters from the US. However, after nearly three years of waiting for approval, Taiwan is revisiting its upgrade options (including radar and EW) for a portion of its 144 F-16A/B Block 20 aircraft. It is also considering installation of a new internal EW suite on its Indigenous Defense Fighter (IDF) fleet.

Japan has traditionally relied on domestic EW suppliers, such as Mitsubishi Electric Company (MELCO), to provide a large portion of its EW capability. However, it also operates some US systems, such as the ALQ-131 jamming pod, on its F-4 aircraft. The Japanese Air Self Defense Force is likely to buy the F-35 when it becomes available. In addition, it is weighing the possibility of upgrading its F-15J fleet with new capabilities, such as AESA radars and the Digital EW System, which have been offered by Boeing as part of the "Silent Eagle" package.

South Korea is gradually taking more responsibility for its national defense, anticipating that the US cannot maintain its current troop levels in that country over the long term. It has developed a local defense industry that supplies tanks (K2 Black Panther), ships (KD-3 destroyers) and is developing a light fighter aircraft (FA-50). Many of the country's front-line weapons systems are equipped with EW systems bought from US suppliers such as ITT (shipboard EW suites, ESM systems for P-3 aircraft, and airborne radar jammers) and Northrop Grumman and BAE Systems (together supplying the F-15K's EW suite). Over the past few years, it has started to work with a broader EW supplier base that includes EADS (AAR-60), Elisra (RWRs for C-130H aircraft and EW suites for the FA-50 light combat aircraft in development) and HAVELSAN (pilot EW training system). With few of its advanced EW systems manufactured in country, South Korea's EW industry has mostly focused on supporting and sustaining its EW systems and training its personnel. This buying pattern is likely to continue in the coming years, as the country continues to focus on building weapons systems rather than radars or EW. With a large inventory of aircraft and ships, South Korea will represent an attractive upgrade market for EW suppliers.

CHINA RISING

As mentioned earlier, the evolution of China's military power is being watched closely by its neighbors. Like the Soviet Union during the Cold War, China is expected to become a major military equipment supplier to many of its allies in the region. At the same time, the US and Russia are likely to release more advanced weapons systems into the region, such as air defense systems and fifth-generation fighters, in order to retain their status in the Asia-Pacific market. In the long term, this is likely to result in the sale of more threat systems and the procurement of more EW equipment to defeat those threats. The biggest question facing the region is not if this trend will occur but how quickly it will evolve.

Maneuver in the Electromagnetic Domain

You've got to be in it to win it!

By Wg Cdr John Clifford, OBE, RAF Ret.

At the beginning of Operation Enduring Freedom-Afghanistan (OEF-A) (Oct 7, 2001) and Operation Iraqi Freedom (OIF) (Mar 20, 2003), it was a given that coalition forces were operating in an environment that was well understood. The operational environments, urban or rural, might be challenging, harsh even, but lay well within the operational capabilities of coalition forces. Once the high intensity war-fighting phases were over, little if any conventional military action by the defeated adversaries was expected or in fact experienced. With decades of western military thinking, long established doctrine and cutting-edge military capability, what could possibly go wrong? Well, just suppose that the US, UK and other coalition partners had misunderstood the operational environment? Sure, we knew about the land domain, the air domain, the space domain and the maritime domain and they all played and continue to play vital roles. We even understood the information environment, at least in terms of getting information to coalition forces, although perhaps not in terms of influencing others. What was missed in truth was the importance of another war-fighting maneuver space, the electromagnetic domain (EMD).

TIPPING POINT

What wasn't expected was the asymmetric and terrorist equivalent of "shock and awe." When, that is, Iraqi insurgents, Al-Qaeda and then the Taliban, began to exploit the electromagnetic domain in a way never before done on such a scale, to kill coalition forces with Remote Controlled Improvised Explosive Devices (RCIEDs). Many hundreds, if not more, coalition warfighters were killed, maimed or traumatized by these activities. By 2007 the Washington Post reported that around two-thirds of US casualties were due to IEDs. A tipping point was reached with the realization that the coalition had been wrong footed, that a massive effort was needed to tackle the problem, and that whatever had gone wrong couldn't ever be allowed to go wrong again. *JED* readers will be only too aware of the huge effort that went into defeating this unexpected use of the EM environment by adversaries. This article is not just about honoring all coalition warfighters in these conflicts; neither is it just about recognizing the astonishing achievements of the many thousands of workers, scientists, engineers, policy makers and procurement staff who contributed to their substantive defeat. It is about ensuring that never again will we be caught out through failure to recognize the operational maneuver space that is the EMD.

GETTING A GRIP

To hammer the point home that this was different, many of you will have heard first-hand the experiences of the outstanding individuals in the battle against IEDs. One key point raised by many of the vastly experienced EW folk from the USN, USAF and USMC who deploye to support the US Army, is that despite all their training, all the schools attended, all the courses passed and all the previous missions, nothing had prepared them for the RCIED offensive in Iraq. Despite all the EW capability initially fielded at the time, almost nothing was available – except on a small scale to just one or two coalition members – to defeat those RCIEDs.

The heroic job of deploying vast numbers of CREW (Counter-RCIED EW) and similar equipment has also been told before in JED and elsewhere. What is perhaps less well known are the very considerable problems caused by the CREW deployment, essential though it was. These problems, mostly in the land domain, ranged from triggering electronic devices on parked aircraft (such as chaff and flare dispensers), interfering with coalition systems including other Counter-IED systems, disrupting electronic surveillance and intelligence collection and making the spectrum managers' job an unmitigated nightmare. The worst effects by far were on communications, both friendly military and those of the population at large. To some extent the problems still happen today and issues remain with bringing new sophisticated ISR system and modern air platforms into operational theaters. It is worth remembering that an Army that cannot communicate is an Army that cannot maneuver effectively or safely, and land commanders were initially faced with the choice of communicating or being protected by their IED jammers – not a happy choice. Moreover, if land/air communications are disrupted, air support, strikes, logistics, ISR, situational awareness, casualty evacuation, become much more difficult. It is not perhaps surprising that land force commanders – army, marines, SOF leaders – are now in the vanguard of those who understand that something new has occurred and that we better get a grip and understand what it means for future operational success and survival.

CONCEPT! WHAT CONCEPT?

These problems and their solutions now form the basis of much thinking about how to ensure we are properly prepared for the next conflict. Requirements-based approaches are increasingly irrelevant given the pace and scope of future warfighting. Using this approach, we risk only ever being prepared for the last battle. The decade-plus long Airborne Electronic Attack Analysis of Alternatives (AEA AoA) is testament enough; it has yet to deliver ANY capability. In the US Army, the lack of any clear idea of what EW should be doing led over many years to it becoming a niche activity, largely behind the "green door," subservient to NSA, run by MI, and of no practical use in the fight against IEDs.

Even today, as briefed at the recent AOC Convention, collection activity appears not to be contributing directly or significantly to the firefight in some important instances. If the requirements-based approach fails, urgent operational requirements and Quick Reaction Capabilities then become essential to fill critical capability gaps. But they are costly, raise issues across lines of development, bring huge sustainment issues with them and can gather a momentum all of their own, further skewing future requirements.

Witness CREW. Many nations have turned to a concepts-based approach to at least try to think sufficiently ahead to give direction to capability and force development. These higher level analytical concepts take account of the likely threats, political guidance, science and technology, alliances and coalitions, geo-physical and environmental factors, etc. They are aimed 20 or more years in the future and are fairly high level. They can include out-of-the box and blue-sky thinking, but they ultimately must be rooted in reality. They are essentially an expression of an idea of how we expect to fight. From these higher level ideas more detailed work can follow to influence developments happening now. So, what far reaching ideas are there about EW? Where is it going? How can we ensure the mistakes of the past that cost so many so dearly are avoided? This is where the concept of the EMD comes in.

THE EM DOMAIN

The EM Domain is, by direct comparison with the other domains, the part of the operating or operational environment where EM operations are conducted and EM effects realized. Like what? Like navigation, communications, data links, situational awareness and shared situational awareness, protection of forces, platforms and areas, offensive action, intelligence gathering, etc. Warfighters are linked into winning forces through the EM Domain. In network-centric or network-enabled warfare, it is through the EM Domain that warfighters are connected to the network. So, too, are all the other battle field systems and devices that employ electromagnetic energy – sensors, communications, targeting devices,

blue-force tracking systems, and maybe someday EM weapons. All the other domains are connected together in real-life operations through the EM domain. This is but one reason why the EMD must be considered on a par with the other operating domains. It must have its own lines of development (DOTMILPF in the US and NATO, TEPIDOIL in the UK (1)), its own resources, proponents and leadership. The EMD is the totality of all that is going on in the electromagnetic environment that is in anyway connected to operations and operational maneuver.

During development it might be worth biting the linguistic bullet and actually using EM instead of "E" (for electronic); electromagnetic warfare, etc. One problem is that a lot of two and three letter acronyms with have considerable usage already!

To reiterate the point, it is the EMD that ultimately encompasses the warfighters operating in any other domain. For example, take info/cyber. On the battlefield, if cyber is to have a role there, it will most likely employ the EMD to connect to an adversary's systems. That is no different from the EMD connecting soldiers, aircraft and ships to each other – and to the adversary.

THREATS

If the opportunities presented from recognizing the EMD are potentially huge, then so is the risk of not recognizing it. In future, opponents will have more fully grasped the opportunities arising from it. Not only from the vast arsenal of EM-dependent military hardware already out there, developing rapidly and proliferating widely. Not only from relatively low-tech weapons used now, but also from the sophisticated commercial-off-the-shelf technology that now abounds. An Internet search will show that not only are sophisticated jammers of all types becoming readily available, but that the knowledge and components to build them is also out there. Of course, we must not forget the "traditional" threats familiar to readers such as the many IR-, UV-, RF- and laser-guided threats. However, it is worth reflecting that there also has been a huge and costly effort to protect coalition air platforms in Iraq and Afghanistan from some of the more rudimentary of these threats, like SA-7 IR-guided surface-to-air missiles (SAMs). For this reason we must not neglect the EMD, or more precisely the effects that can be achieved through it to hurt us.

MANEUVER

All is not doom and gloom though. Exploiting the EMD opens many more opportunities. New forms of warfare become possible – some of these have graced the pages of JED and been presented at AOC Conferences. They rely on sufficient maneuver in the EMD to enable networked effects to persist in the face of enemy activity. So what is maneuver in the EM Domain? It is exactly the same as maneuver in any other domain, which is perhaps why it appeals to commanders and senior leaders and their battle staff. That is, those who understand and practice maneuver already. It has the same purpose, the same processes and the same components. Maneuver comprises offensive and defensive operations, and shaping, exploitation and management of the domain. The doctrine for specific domains such as air or maritime spells out what this means. As the EMD is newly recognized, its lines of development have not been addressed in any detail. However, astute readers will realize that the doctrine that supports the EMD, whether it pertains to communications, navigation, imagery and sensors, spectrum management and yes, Electronic Warfare, will have a different complexion to that which exists today. In fact, as EW is the sharp end of offensive and defensive operations, EW doctrine must change the most.

LANGUAGE

It is interesting that commanders and indeed lay-people seem to "get" the EMD and so, too, do some who manage the EMD, such as spectrum managers. In truth, what the EMD most brings is fresh language – the language of warfighters, not the highly specialized language of the life-long EW proponent. Maneuver concepts introduce subtlety into warfighting ideas. Rather than simply (but probably impossibly) seeking to "control" or "dominate" the EMS as US doctrine has it today, we can maneuver – shape, exploit, manage, attack or defend – in the EMD. Language is very important. Detailed understanding of the "stuff" of a domain is vital, whether it be type of soil or terrain, characteristics of the atmosphere or sea or EM energy and radiation. But – and it's a big but – the language must not stop there. An appreciation of the local operational conditions, the environment or environmental weather even is fundamental and as such is always near the front of any commander's appreciation, estimate or direction. These then continue to focus on maneuver and the effects required. Language can also be a trap and a well intentioned definition in one specific arena made long ago may be less than helpful today and lack subtlety.

You might like to consider whether Electronic Attack (2) is as useful a definition today as when conceived by the USAF

many years ago. Is protecting troops from RCIEDs really a form of attack or is it really a defensive measure? To the unbiased, it is defensive and only a form of attack if the definition of attack has been changed so as not to be the same understanding of attack used by any other warfighter. And there is the nub of the problem. In today's joined up battlespace, we had better all understand the meaning of words and use them properly; even more so in future conflicts. Does it matter? It absolutely does, as we need more subtlety to cope with increasing complexity. For example, using a jammer to provide a reactive defensive shield around a vehicle is one thing, while using an aerial platform to proactively seek to prematurely detonate IEDs is another. One is defensive and the other offensive. Clumsy or arcane language only ever helps those who seek to preserve "their" territory and then only for a while, while the world moves on without them.

ALLIES

In the UK MoD in 2006, when EW policy was being re-written by the joint operations staff, an informal meeting took place with the operations directors – an Army general and a Marine general, both highly experienced warfighters. While considering whether UK concepts and doctrine for EW were right, given the on-going conflicts, it was mooted that perhaps the best way to think about EW was in the context of the larger piste, in terms of all of EM operations and effects and perhaps we should think of the EM environment as any other operational environment. The Chief of the General Staff; the Chiefs of the Maritime, Land and Air forces and their respective Commanders in Chief; the Chief of Defence Intelligence and the Chief of Joint Operations all signed up. The requirement for a Future EM Operational Concept was included in UK EW Policy. It seems that once again very senior operationally experienced Commanders simply "get" the point. They understand intuitively the need to recognize the EM domain as a warfighting domain, alongside the others.

NATO – FIRST STEPS

UK EW policy remit was to test the water on the EM domain concept in NATO. The entire Military Committee of NATO subsequently agreed, quickly and unanimously, and MCM-0142 was issued in 2007 as the "MC Concept for the Transformation of NATO EW"; it focuses on introducing the EM environment (EM Domain in the US) into NATO thinking and on the adoption of effects-based language appropriate to commanders at all levels, concerning maneuver, which they naturally understand if they are effective commanders, and which is orthogonal to the equipment or spectrum language favored and needed by specialists (at all levels). As an example, ECM, EPM and ESM are all used in Electronic Defense (or better Electromagnetic Defense), to protect against RCIEDs and RF-guided SAMs or air-to-air missiles. EA delivers effects that might include destruction, damage, deception, or any other term applicable to Fires. So the specialists use their knowledge to deliver what the commanders need, as the language now exists that both understand. As the complexity of the battlespace increases and the range of effects diversifies, subtle but simple language becomes increasingly important.

A NOTE FROM HISTORY

Land warfare and sea warfare have been around throughout the historic ages. Once such warfare reached an industrial scale with standing forces and supporting industry, they were righty seen as operational environments or domains in their own right, recognized by leading thinkers and military writers. Aeroplanes were around for a couple of decades, supplementing the land and maritime domains. Once air power reached an industrial scale in terms of its presence in the battlespace and the intensity of the effects it enabled, it was recognized as another operational domain in its own right. This recognition was no easy thing, and had to be imposed with much kicking and screaming, with resistance most often from those who should have known better.

World War 2 saw the first recognition that a joint approach to warfare provided the best results, combining operations and maneuver, although arguably only in recent times have we truly practiced what was preached. From its dawn in the 1950's, Space, too, is now a recognized operational domain. Highly specialized in its implementation, in its application it is key to operations in the other warfighting domains. What then of the EM Domain? What indeed? It is time to recognize that the EM Domain is a warfighting domain just the same as all the established ones. Maybe then there will be no more tipping points resulting from ignorance, lack of intelligence or lack of investment across all lines of development.

THE FUTURE

Accepting the reality and role of the EMD is the first step into the future of warfare. Much remains to be done as a viable concept is only the first step. One day, perhaps soon, we will need much more from EM capability along with an EM Battle Staff and trained and experience leaders at all levels who understand the EMD. Much work will be needed, but of all the leading nations the US is most capable of articulating a shared vision of the EMD and acting on it decisively. Now is the time to start so that the US and its allies can be assured of operations as safe and effective as possible in the entire future operational environment.

ENDNOTES

1. Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities – US. Training, Equipment, Personnel, Information, Doctrine and Concepts, Organization, Infrastructure and Logistics all underpinned by interoperability – UK.
2. Electronic Attack: The use of electromagnetic or directed energy to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability.

Wg Cdr John Clifford OBE has held many positions in EW throughout his career. From 2006 to 2008, he led the EW effort in the Directorate of Joint Capability as EW1 in the Ministry of Defence, where he developed and coordinated joint EW policy, concepts, doctrine and operations. He was honored by HM The Queen for his work. He retired from the RAF in 2008 and is now an international EW consultant and president of JMC Defence Ltd.

Photos courtesy BAE Systems, US Navy and German Luftwaffe.

TECHNOLOGY SURVEY

SURFACE NAVAL EXPENDABLES AND LAUNCHERS

By Ollie Holt

This month's survey focuses on Surface Naval Expendables and Launchers. *JED* has provided past surveys and articles on airborne expendables (flares, RF decoys and chaff) and airborne dispensers. This survey addresses the surface naval variants of RF and IR decoys and their launchers.

Surface Naval forces have a larger problem than ground or airborne platforms because they sit on a flat, wide-open area with only two degrees of freedom of movement and on a cold surface relative to the temperature of the ship. This makes surface ships more vulnerable to active RF, homing RF and IR missiles. The threat is the modern Anti Ship Missile (ASM or AShM). These missiles are fast, deadly and accurate. Typical times from launch to impact range from 120 to 150 seconds for the typical ASM and 25 to 30 seconds for the faster missiles. These missiles can be launched from the air, surface and subsurface. They can be guided by radar, IR or Electro Optical homing devices. They are usually sea skimming, but can also be high diving.

Decoys first contribute to ship self-defense with detection avoidance. In an RF scenario, for example, chaff is usually used to offer the adversary's radar realistic but false targets in number. Chaff rounds are launched, usually by missiles, to get them a good distance away (1 to 5 km or even further) from the ship. The missile then can dispense multiple chaff bundles, each one creating a chaff cloud that offers the radar with a more attractive target than the ship. As long as the ship can create a state of confusion for the adversary's sensors, it can deny or delay the missile launch and provide much-needed time to either move out of range or mount its own missile attack.

If the ship detects an incoming ASM, it can employ anti-missile missiles to try to destroy the incoming ASM or it can use decoys to distract the missile during its search phase. If the incoming missile is a homing missile, it will try to lock-on to either an IR or RF emission from the target. The ship can use chaff, flares or RF decoys to create a distraction that is more enticing than the ship. One of these RF decoys, the Nulka, is rather interesting because it simulates the ship's RF emissions as it slowly moves away from the ship and attracts the incoming RF homing missile – drawing it away from the ship, which at that point will have stopped all RF emissions.

The final stage uses IR and chaff to deny the missile range to the target and tries to get the missile to drop into the water before it reaches the ship. Also in the final stages, high-rate-of-fire guns are used to shoot the missile down before reaching the ship.

This survey contains a mixture of decoy technologies including RF chaff, RF reflectors, active RF devices along with IR, EO and laser decoys. Some are just for endgame situations, while others are in support of confusion and distraction techniques to deny launch or target acquisition after launch. The survey also includes some shipboard launchers that can be configured for different types of decoy rounds.

This survey was performed following the same process as previous surveys with a set of questions sent to suppliers of surface naval expendables and launcher technologies. These companies were asked to provide information for up to five of their products for inclusion in this survey. Only information supplied by the survey respondents was used in this compilation.

JED's *next survey, covering TWTs and MPMs, will appear in March 2010. E-mail editor@crows.org to request a survey questionnaire.*

TECHNOLOGY SURVEY: NAVAL DECOYS

MODEL	NATO STOCK	EXP TYPE	PURPOSE	EJECT
Airborne Systems Ltd; Bridgend, Wales, UK; +44 (0)1656 727 000; www.airborne-sys.com				
IDS300	*	passive RF reflector	seduction and distraction	pneumatic
BAE Systems Australia; Edinburgh Parks, SA, Australia; +61 3 9918 4000; www.baesystems.com/Businesses/BAESystemsAustralia				
Nulka Active Missile Decoy	*	active RF	seduction and distraction	solid fuel rocket motor
Chemring Countermeasures Ltd.; Salisbury, Wiltshire, UK; +44 (0) 1722 411611; www.chemringcm.com				
Cartridge Countermeasure Chaff 130mm seduction Mk36 Type 1; Part Number 58641	5865-99-834-7767	chaff	seduction	mortar
Cartridge Countermeasure IR 130mm TALOS (Autofire); Part Number 58624	1377-99-563-4880	IR	seduction	mortar
Cartridge Countermeasure IR 130mm VR Mk1; Part Number 58622	5865-99-350-2201	IR	seduction	mortar
Cartridge Countermeasure Chaff 130mm VR Mk1; Part Number 58623	5865-99-153-1955	chaff	seduction	mortar
Cartridge Countermeasure Chaff 130mm Dist CCM216 Mk1 Type1; Part Number 58611	1377-99-244-8451	chaff	distraction and seduction	rocket
Cartridge Countermeasure Chaff 130mm Dist CCM216 Mk 3; Part Number 58608	5865-99-958-2869	chaff	distraction and seduction	rocket
Cartridge Countermeasure IR/ Chaff 130mm CHIMERA Mk3; Part Number 58629	5865-99-936-7712	chaff and IR	seduction	mortar
Kilgore Flares Company, LLC; Toone, Tennessee, USA; +1-731-658-5231; www.kilgoreflares.com				
TALOS Autofire	1377-99-563-4880	IR	seduction	pyro
TALOS	*	IR	seduction	pyro
LACROIX Defense & Security; Mazeres, France; +33 561 677 900; www.etienne-lacroix.com				
SEALEM 15-01/15-02	*	RF reflector	seduction, distraction, dilution or confusion	pyro
SEALIR 15-01	*	IR multispectral decoy	seduction or distraction	pyro
SEALEM 08-01/02	*	RF reflector	seduction	pyro
SEALIR 08-01	*	IR multispectral decoy	seduction	pyro
SEAMOSC 08-03	*	masking effect	masking effect laser/UV/EO	pyro
SEAMOSC 08-01	*	masking effect	masking effect, laser/UV/EO	pyro
Rafael Advanced Defense Systems LTD.; Haifa, Israel; +972-4-8794372; rafael.co.il				
C-GEM		active RF	seduction	rocket

SIZE: HxWxL (in./mm.)	WEIGHT (lb./kg)	FEATURES
varies	varies	Each decoy has a bespoke launcher. The decoys RCS performance is tailored to be greater than the ship's RCS. Gives a ship-like return with time – The RCS varies on the sea surface similar in pattern to a ship. Is resistant to chaff discriminators of modern ECCM missile seekers. Is insensitive to the polarization of the missile radar (horizontal or vertical). Radar reflector performance is consistent, regardless of the threat direction, bearing or azimuth. Provides capability against broad frequency, agile, coherent and LPI threats.
2080mm length x 160mm diameter	50 kg; 70 kg encanistered	Thrust vector control for rapid launch and precise decoy positioning throughout flight. A single decoy is capable of defeating multiple anti-ship missiles simultaneously. Fitted to over 130 ships of the United States, Canadian and Royal Australian Navies.
1220mm length x 130mm diameter	23 kg	Fixed range and height, high performance center-burst chaff with fast bloom rate to create large RCS.
1208mm length x 130mm diameter	22 kg	Automatic payload firing sequencer giving "walk off" capability using 5 sub-munitions. High-intensity, fast rise time and long duration IR response.
TBD x 130mm diameter	25 kg	Under development. This round will offer enhanced protection against IR seeker missile threats. Controlled prior to launch via an umbilical data link, it deploys a series of six sub-munitions at variable ranges to create the optimum pattern of IR decoy clouds.
TBD x 130mm diameter	25 kg	Under development. This round provides enhanced protection to ships against anti-ship missiles guided by RF sensitive seekers. Controlled prior to launch via an umbilical data link, it deploys a series of six RF decoy clouds at variable ranges to provide an appropriate solution to decoy the missile.
1260mm length x 130mm diameter	27 kg	An advanced RF distraction decoy round with selectable variable range out to greater than 2km and a variable chaff deployment height. It has a single center-burst chaff payload with the burst height independent of the ship's roll. It has full tactical flexibility, it does not need a level deck for launch. It can provide seduction defense of ships in company as well as supporting active onboard systems in an RGPO dump role.
TBD x 130mm diameter	27 kg	An advanced RF distraction/seduction decoy round with variable controlled range and chaff deployment height via an umbilical data link, and commensurate control of response time. The payload can be deployed at shorter ranges, giving the potential to use the rounds in the seduction mode. It has a single high-performance chaff payload.
1278mm length x 130mm diameter	20 kg	Chimera is designed to counter both new and older missiles featuring centroid and imaging seekers and is suitable for conventional ships up to light frigates and larger stealthy ships. It is compatible with all 130mm Seagnat and SRBOC launchers and sub munitions can be fired at incremental times as low as 150m.
1206mm length x 130mm diameter	22 kg	Automatic payload firing sequencer (fire and forget). Compatible with all 130mm SRBOC launchers. Effective against all seeker types.
1206mm length x 130mm diameter	22 kg	Compatible with all 130mm SRBOC launchers.
1800mm length, 150 mm diameter	35 kg	Existing RF chaff technologies have been replaced by the use of structural elements whose signature and profile are very close to that of the ship. Designed with safe inductive firing interface. 08-02 provides high level RCS.
1800mm length, 150 mm diameter	35 kg	Designed with safe inductive firing interface. Uses a spectral pyrotechnic composition, which reduces temporal & spatial fluctuations and simulates the spectral signature of the ship.
1300mm length, 62mm diameter	4 kg	Existing RF chaff technologies have been replaced by the use of structural elements whose signature and profile are close to that of the ship. Designed with safe inductive firing interface. 15-02 provides high level RCS.
422mm length, 80mm diameter	3.5 kg	Designed with safe inductive firing interface. Uses a spectral pyrotechnic composition, which reduces temporal & spatial fluctuations and simulates the spectral signature of the ship.
1300mm length, 80mm diameter	12 kg	Deploys a large screen once the threat is detected in order to generate laser/UV/EO masking effects: laser absorbing effects and laser beam attenuation.
180mm ht. x 220mm width x 520mm length	25 kg	Designed with safe inductive firing interface. Deploys a large screen once the threat is detected in order to generate laser/UV/EO masking effect. Suitcases designed to be fitted with SYLENA anti-laser module.
40 in. length x 4.5 in. diameter	15 kg	Wide frequency range, high ERP, solid-state active array, electronic beam steering.

TECHNOLOGY SURVEY: NAVAL DECOYS

MODEL	NATO STOCK	EXP TYPE	PURPOSE	EJECT
Rheinmetall Waffe Munition GmbH; Schneizlreuth; Germany; +49 8651 703-0; www.rheinmetall-wm.com				
MASS Omni-Trap ammunition (81mm)	1315-12-370-3748	multispectral (EO, LASER, IR, RF)	screening, confusion, distraction or seduction	combined rocket and mortar
BULLFIGHTER – 130mm combined IR/RF decoy	1320-12-348-DS 36	combined IR/RF (dual mode)	screening, confusion, distraction or seduction	mortar
Wallop Defence Systems; Middle Wallop and Portsmouth – Hampshire; UK; +44 (0) 1264 781456 and +44 (0)2392 375915; www.wallopdefence.com				
SuperStockade	*	chaff	confusion, distraction or seduction	pyro
SuperPallisade	*	chaff	confusion, distraction or seduction	pyro
Stockade	*	chaff	confusion, distraction or seduction	pyro
Pallisade	*	chaff	confusion, distraction or seduction	pyro

TECHNOLOGY SURVEY: NAVAL LAUNCHERS

MODEL	EXP TYPE	QUANTITY	PROGRAMMABLE	TRAINABLE	INTERFACE
LACROIX Defense & Security; Mazeres, France; +33 561 677 900; www.etienne-lacroix.com					
SYLENA	RF reflector, IR multispectral decoys, optional SEAMOSC modules	12 SEALEM 08-01 / 2 SEALIR 08-01 per launcher. Two to four launchers per ship	selection and implementation of relevant tactics according to the applicable target designation and proposed tactics. Management of decoy renewal	fixed	MIL-STD 1399; standard interface with CMS and/or EWS: LAN ethernet RJ45; could be interfaced with serial link: RS 422
Lockheed Martin Sippican; Marion, MA, USA; +1-774 553 6226; www.sippican.com					
ALEX (Automatic Launch of Expendables) System	All NATO SEAGNAT family of SRBOC 130mm decoys	each Mk 137 SRBOC launcher has six 130-mm launch tubes. Depending upon ship size, ALEX may use two, four, or six launchers per shipset	in most cases, this is a function of the decoy, not the Decoy Launch System (DLS)	fixed	RS-232 or ethernet
Rheinmetall Waffe Munition GmbH; Schneizlreuth; Germany; +49 8651 703-0; www.rheinmetall-wm.com					
ROSY_N (Naval Rapid Obscuring System)	40mm short range IR decoys, 40mm long range RF decoys	in total, 16 rounds per launcher	engagement calculated by dynamic algorithm, therefore unlimited number of stored programs	fixed	RS 422, ethernet or any other standard interface
MASS (Multi Ammunition Softkill System)	81mm OMNI-TRAP with multi-spectral effectiveness (electro-optical, laser, Infrared (SWIR, MWIR, LWIR), radar (I-,I/J-Band), optional mmW)	32 per launcher in total (8 magazines with 4 rounds each)	fully automatic, with 5-DOF* decoy deployment, engagement calculated by dynamic algorithm - therefore unlimited number of stored programs	automatically trainable	RS 422, ethernet or any other standard interface
Terma A/S; Lystrup, Denmark; +45 8743 6000; www.terma.com					
MK-137	IR, chaff, active RF, illuminating, acoustic	6	yes	no	*
DL-6T	IR, chaff, active RF, illuminating, acoustic	6	yes	no	*
DL-12T	IR, chaff, active RF, illuminating, acoustic	12	yes	no	*
Wallop Defence Systems; Middle Wallop and Portsmouth – Hampshire; UK; +44 (0) 1264 781456 and +44 (0)2392 375915; www.wallopdefence.com					
SADLS (SuperBarricade Advanced Decoy Launcher System)	IR, chaff and illuminating	two launcher system is 24; four launcher system is 4	yes, 20 programs available, 8 selectable at one time	system is fixed to give 360° coverage	RS232, RS422, RS485, ethernet (others as required)
0512 (57mm) Launcher System	IR, chaff, illuminating and maroon	two single-barrel launchers	no	manual training to give 180° coverage for each side	no Interface – standalone system

SIZE: HxWxL (in./mm.)	WEIGHT (lb./kg)	FEATURES
360mm x 81mm, caliber 81mm	3 kg	Multi-spectral effectiveness (Electro-Optical, LASER (Nd:YAG, CO2), Infrared (SWIR, MWIR, LWIR), RADAR (I-,I/J-Band), optional mmW). Electronic delay element (programmable fuze). Omni polarization. high RCS density. Very rapid blooming (less than 5 sec). For complete missile defense (blue water warfare, littoral warfare and against terrorist attacks)
1208mm length, caliber 130mm	21 kg	Combined dual mode – IR and RF with IIR capability, omni polarization, high RCS density, very rapid blooming (less than 5 sec).
750mm height x 102mm diameter	9.5 kg	*
873mm height x 102mm diameter	11.5 kg	*
376mm height x 57mm diameter	1.25 kg	*
376mm height x 57mm diameter	1.5 kg	*

REQ. POWER	SIZE: HxWxD (in./m.)	WEIGHT (lb./kg)	FEATURES
standby: < 330 W; power peak when firing: < 480 W	48.4 in. x 36.4 in. x 40.15 in.	250 kg (fully loaded)	Tailored for anti-missile warfare in RF, IR and EO/UV domains for small and medium sized ships. SYLENA is designed to be stealthy and lightweight.
the ALEX System requires 115 V, 60 Hz	launcher: 0.7m x 1.24m x 0.4m	launcher: 125 kg	The ALEX system can be fully integrated with ship's command system, ESM, navigation, and wind sensors. Can also function as an independent, standalone system. Provides and implements optimum tactics for every scenario. Handles multiple-threat scenarios. Automatic decoy cartridge reseed. Automatic Misfire Detection and Correction. Built-in Test.
power dissipated < 0.12 kW	less than 0.5m x 0.9m x 0.8m	less than 30 kg (fully loaded), excluding ROSY Control Unit	Complete missile defense for small vessels (< 35 m). Effectiveness: RF, (I)IR, visual. Confusion, distraction, seduction. Immediate readiness after pressing the CAP (Command Authorization Panel) Switch. Automatic, semi-automatic, and manual threat designation. Short reaction time. Multi-mission capability. Small size and low weight. Stealth design. Compatibility with all CMS and all ESM sensors. Cost effective.
standby: 250 W; expending max: 10 kW	launcher: 1.1m height, sweeping radius 1.3m; control unit: 1.6m x 0.8m x 0.6m	launcher: 330 kg, control unit: 230 kg	Complete missile defense: blue water warfare, littoral warfare, against terrorist attacks. Turnkey solution offering multispectral protection. Highly integrated and fully automated. Fully computerized and trainable launcher with pitch-and-roll compensation. Omni-spectral awareness and effectiveness. Easy installation on all ship types due to stealth design, small dimensions, small weight. Easy integration into all combat management systems. Standalone option with integrated sensor suite (MASS_ISS), featuring built-in sensors for detecting radar, laser and electro-optical threats.
<150W Standby; <600W firing	43 in. x 20 in. x 63 in.	200 kg	Six tubes, single direction launcher, launch control computer, launch interface unit, control unit, advanced algortihms, support all 130mm decoys.
<150W Standby; <600W firing	40 in. x 47 in. x 47 in.	640 kg	Six tubes, three directions launcher, launch control computer, launch interface unit, control unit, advanced algortihms, support all 130mm decoys.
<150W Standby; <600W firing	40 in. x 47 in. x 94 in.	1280 kg	12 tubes, four directions launcher, launch control computer, launch interface unit, control unit, advanced algortihms, support all 130mm decoys.
standby: 50 VA; expending: 1 W peak	1.44m x 1.51m x 0.9m	179 kg (unloaded)	System control (below decks equipment) consist of touch screen modules including: Tactical Computer, Control Unit plus a Bridge Display Unit, 2 Remote Fire. Pushes and safety switches/sirens located by launchers. System incorporates a torpedo decoy system that allows set patterns of acoustic decoys to be deployed over a set "track."
standby: 12 VA; expending: 1 W peak	0.45m x 0.2m x 0.5m	10.8 kg	Safety switch located next to each launcher. Firing Pulse Amplifier located next to each launcher. System controlled by a control unit located "below decks." System adjustable in azimuth and elevation.

Survey Key – Naval Chaff/Flare Decoys and Launchers

DECOYS

MODEL
Product name or model number

NATO STOCK
NATO stock number

EXP TYPE
Expendable type
- RF = radio frequency
- IR = infrared
- EO = electro optical

PURPOSE
Purpose (confusion, distraction, seduction, etc.)
- UV = ultra violet

EJECT
Ejection method
- pyro = pyrotechnic

SIZE
HxWxD in inches/mm

WEIGHT
Weight in lb/kg

FEATURES
Additional features
- RCS = reconnecting current sheet
- ECCM = electronic counter counter-measures
- LPI = low probability of intercept
- RGPO = range gate pull off
- SRBOC = Super Rapid Bloom Off-board Chaff
- ERP = effective radiated power
- IIR = imaging infrared

LAUNCHERS

MODEL
Product name or model number

EXP TYPE
Expendable type

QUANTITY
Quantity of expendables

PROGRAMMABLE
Can it launch decoys to reprogrammable dispense programs?

TRAINABLE
Is the system fixed or trainable?

INTERFACE
Interface for control
- EWS = electronic warfare system
- CMS = combat management system
- LAN = local area network

REQ. POWER
Power required in Watts

SIZE
Size HxWxD in inches/meters

WEIGHT
Weight in lb/kg

FEATURES
Additional features
- ESM = electronic support measures

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
Elbit	www.elbitsystems.com
Sagem Défense Sécurité	www.sagem-ds.com
Sechan	www.sechan.com
Selex SAS	www.selexgalileo.com
Selex System Integration	www.selex-si.com

March 2010 Product Survey: TWTs and MPMs

This survey will cover travelling wave tubes (TWTs) and microwave power modules (MPM). Please e-mail editor@crows.org to request a survey.

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EW Against Modern Radars – Part 2

Radar Jamming Techniques

By Dave Adamy

This month, we will review jamming techniques. These techniques can be divided into cover and deceptive jamming. The jamming effectiveness of both types of techniques is stated in terms of jamming-to-signal ratio (J/S) as discussed last month.

Cover Jamming

The object of cover jamming is to reduce the quality of the signal in the radar's receiver enough that the radar cannot acquire or track its target. It can be used in either self-protection or remote-jamming geometry. Cover jamming usually has a noise waveform, but sometimes other waveforms are used to overcome electronic protection (EP) features of the radar. These EP techniques will be covered later in this series.

The equations for J/S and burn-through presented last month assumed that all of the jammer's power was within the bandwidth of the radar receiver. If a jammer uses noise that is wider in frequency than the effective bandwidth of the radar receiver, only the part that is within the radar's receiver bandwidth is effective. Jamming efficiency is the total jammer effective radiated power (ERP) divided by the effective jammer ERP. This is equal to the radar receiver bandwidth divided by the jamming bandwidth. For example, if the radar receiver bandwidth is 1 MHz and the jamming signal bandwidth is 20 MHz, the jamming efficiency is 5 percent.

Barrage Jamming

Barrage jamming is generated by a wideband jammer that broadcasts noise over a whole band of frequencies that is expected to contain one or more threat radars. This technique was frequently used in early jammers, and is still an appropriate approach for many jamming situations. The great advantage of barrage jamming is that it does not require real-time information about radar operating frequencies. Look-through (i.e., interruption of jamming to look for threat radar signals) is not necessary. The problem is that barrage jamming typically has very low jamming efficiency. Most of the jamming power is wasted because the effective J/S is reduced by the efficiency factor, and the burn-through range is correspondingly increased.

Spot Jamming

When the bandwidth of the jamming signal is reduced to a little more than the target radar bandwidth and the jammer is tuned to the radar broadcast frequency – this is called spot jamming. As shown in **Figure 1**, spot jamming wastes little of its jamming power, so the jamming efficiency is increased significantly. Spot width is enough to cover the uncertainty in target signal and set-on frequencies. (We will cover coherent jamming in a later column.) Efficiency is still the radar bandwidth divided by the jamming bandwidth – but the ratio is more favorable. Dr. Schleher, in his book *Electronic Warfare in the Information Age*, defines spot jamming as jamming over a bandwidth less than five times the radar's bandwidth.

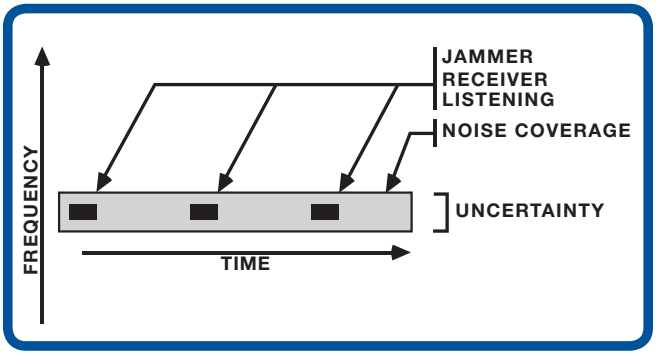

Figure 1: Spot Jamming concentrates noise around the radar's operating frequency.

Swept Spot Jamming

If a narrowband jammer is swept across all of the frequency range that is expected to contain threat signals, as shown in **Figure 2**, it is called a swept spot jammer. The swept spot jam-

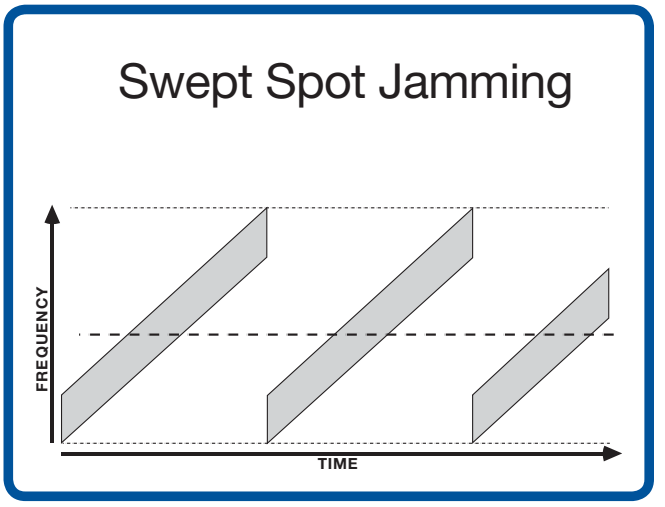

Figure 2: Swept Spot Jamming moves a narrow jamming band across the whole band in which the radar might operate.

mer, like the barrage jammer, does not require look-through and will jam any signal within the sweeping range. While the jammer is within a target radar's bandwidth, it will provide the same jamming efficiency as a set-on spot jammer. However, the jamming duty cycle will be reduced by the ratio of the spot bandwidth to the sweeping range. This can still provide adequate jamming performance against some radars in some situations. The spot bandwidth and sweeping range must be optimized for the situation.

Deceptive Jamming

A deceptive jammer makes a radar think it is receiving a valid skin return from a target, but the information it derives from the received signal causes the radar to lose track on the target in range or angle. Because the deceptive jammer must key to the target signal at the target – to sub-microsecond accuracy – deceptive jamming is generally limited to self protection applications. It is possible to do some deceptive techniques from a remote jammer, but it is very seldom practical. Thus, deceptive techniques will be discussed, here, as self-protection jamming. We will first discuss techniques that deceive the radar in range, then those that deceive it in frequency, and then in angle.

Range Deception Techniques

We will consider three range techniques: range gate pull-off (RGPO), range gate pull-in (RGPI), and cover pulses.

RGPO

An RGPO jammer receives each radar pulse and returns it to the radar with increased power. However after the first pulse, it delays subsequent pulses by an increasing amount. The rate of change of delay from pulse to pulse is exponential or logarithmic. Because the radar determines the distance to a target from the round trip propagation time of its pulses, the target seems to be moving away from the radar.

Figure 3 shows the early and late gates in the radar's processor. These are two time gates which are typically about the width of a pulse when the radar is tracking (longer during acquisition). The radar tracks range by balancing the energy from returned pulses in these two time increments. By delaying a stronger return, the jammer causes the energy in the late gate to dominate over the early gate, causing the radar to lose range track on the target.

The radar's resolution cell is the spatial volume in which the radar cannot resolve multiple targets. The center of this cell in range is the range at which the round trip propagation time places a transmitted signal at the junction of the early and late gates. Thus the radar assumes that the target is at the center of the cell. As shown in **Figure 4** in two dimensions), a RGPO jammer causes the radar to move its resolution cell out

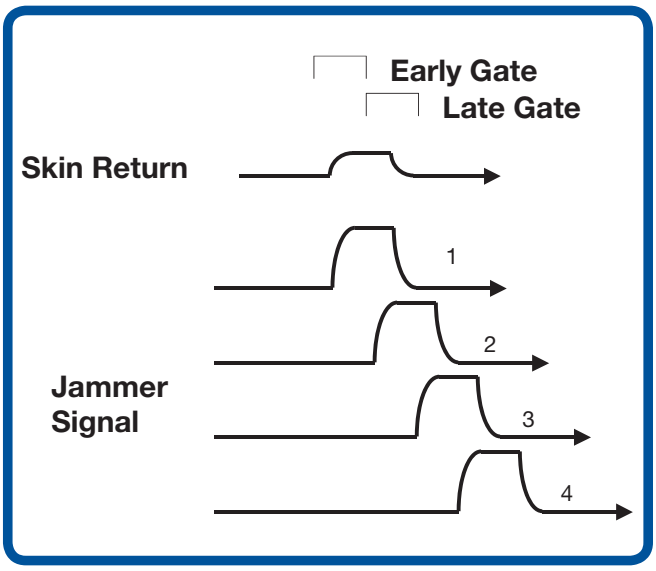

Figure 3: Range gate pull off involves sequential delay of the return pulse, which loads up the radar's late gate.

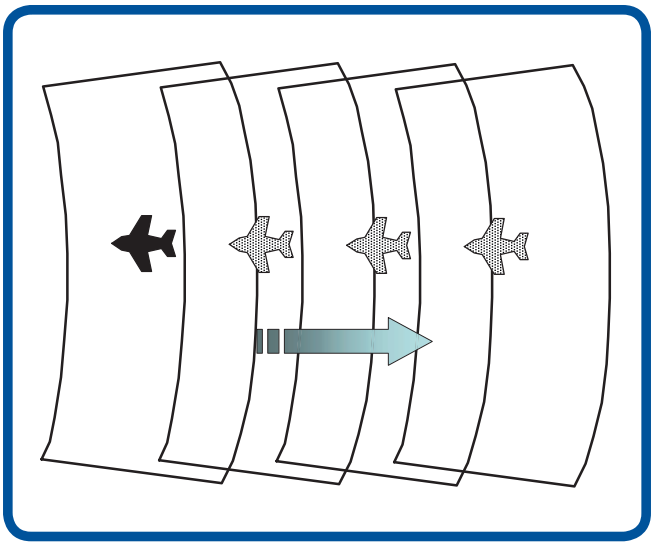

Figure 4: Loading up the late gate causes the radar's resolution cell to move out, making the radar think the target has moved farther away.

in range. Once the true target is out of the resolution cell, the radar has lost range tracking.

When the RGPO reaches its maximum delay, it snaps back to zero delay and repeats the process (many times). The radar will then have to reacquire its target in range, which takes several milliseconds, by which time the range track will have been pulled off again.

RGPI

Range gate pull-in is also sometimes called "Inbound Range Gate Pull Off." It is used against radars which track in range using only the energy in the leading edges of its pulses. Thus

the early and late gates balance the leading-edge energy. Because there is latency in the process of generating a deceptive jamming pulse, a RGPO jammer is unlikely to capture the tracking gates during the leading edge energy burst, so it will not deceive the radar. The RGPI jammer tracks the radar pulse repetition timing and generates a stronger return pulse that anticipates the next pulse by an exponentially or logarithmically increasing amount as shown in **Figure 5**. This loads up the early gate and makes the radar think the target is approaching.

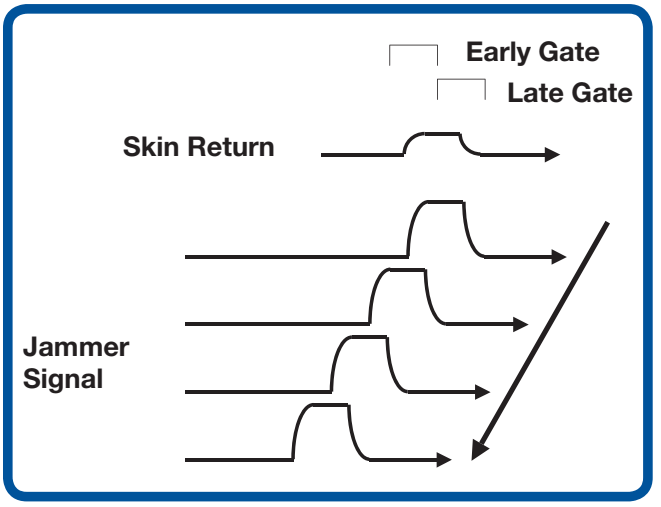

Figure 5: Range gate pull in involves sequentially increased anticipation of the return pulse, which loads up the radar's early gate.

Note that RGPI jammers work fine when the radar has a constant pulse repetition frequency (PRF) or when it has a low level staggered PRF. However, a random PRF cannot be tracked, so RGPI will not work against this type of signal.

Cover pulses

While not deceptive jamming (technically speaking), cover pulses are intimate with the timing of pulses at the target, so they are discussed here. If the jammer has a pulse train tracker, it can output a long pulse centered on the radar's skin return pulse. This denies the radar range information and thus prevents range tracking.

What's Next

Next month, we will continue our discussion of deceptive jamming with frequency and angle deception techniques. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

association news

CALL FOR NOMINATIONS: AOC 2010 ANNUAL ELECTION

Each year the AOC membership helps determine the future direction of the AOC by electing representatives to its Board of Directors. Nominations for the 2010 election are now being accepted effective January 4, 2010.

This year's election slate will include the position of President, who will serve as Vice President in 2011 and as President in 2012. The AOC President appoints the Association's Secretary and Treasurer, presides over the Board of Directors and Executive Committee and appoints committee chairs. The President is also the AOC's primary spokesperson, visiting AOC chapters across the world and meeting with leaders in the Electronic Warfare community. This is a significant but rewarding commitment.

The 2010 election slate will also include three At Large Director positions. At Large Directors serve a three-year term. In addition, Regional Directors will be elected for three-year terms from the International I and International II Regions.

Nomination forms are available on the AOC website at www.crows.org or by contacting Carole Vann at the AOC at vann@crows.org. Nominations must be submitted to Ms. Vann by close of business on April 21, 2010.

For any questions or assistance, please contact:

Carole Vann, AOC Election Coordinator
Office: (703) 549-1600
Fax: (703) 549-3279
E-mail: vann@crows.org

BILLY MITCHELL CHAPTER HOSTS TECH DISCUSSION

On Jan. 15 the Billy Mitchell chapter will host a luncheon talk by Dr. David Akopian, Associate Professor, UTSA, EE Dept., discussing assisted GPS and wireless technology trends.

During recent years, location technologies have emerged as a research area with many possible applications in wireless communications, surveillance, military equipment, etc. For example, US Federal Communication Commission Enhanced 911 (E911) Mandate seeks to provide emergency services personnel with location information that will enable them to dispatch assistance to wireless 911 callers much more quickly.

Assisted GPS (A-GPS, aGPS) is an extension of the conventional Global Positioning System (GPS) which integrates wireless systems with GPS receivers for wider coverage and higher sensitivity in indoor and urban areas where GPS signals are very weak. A-GPS is supported by all cellular network standards as one of the most accurate technologies.

Start-up sensitivity improves by as much as 25dB relative to conventional GPS and reduces start times to less than six seconds. The presentation will introduce A-GPS, associated communication protocols and software GPS receiver implementation aspects.

Details: Jan. 15, 11 a.m. - 1 p.m., Lackland AFB, Gateway Club, Gateway Room. No more than $14, RSVP to Wayne Shaw, AWSREAD@aol.com by Jan. 11.

NEW YORK METROPOLITAN CHAPTER HONORS CAPTAIN PAUL J. OVERSTREET

The NY chapter met Nov. 13 for its annual scholarship dinner in Woodbury, NY to honor Captain Paul J. Overstreet, Commander, Advanced Tactical Aircraft Protection Systems (PMA-272) for his visionary leadership and outstanding contributions to Electronic Warfare in the Global War on Terror. In addition to honoring the Captain, the chapter also provided three college scholarships to deserving local NY students. NY Metro Chapter President, Pat McMahon, presided over the annual event that had more than 250 "crows" attending. (Pictured is Capt. Overstreet speaking at the event.)

SUSQUEHANNA ROOST HOSTS INAUGURAL EVENT

The new Aberdeen Proving Ground Susquehanna Roost will host an inaugural event Saturday, January 16, from 1-5 p.m. at the Chesapeake Inn Restaurant & Marina 605 2nd Street, Chesapeake City, MD. Tickets are $30 per person or $50 per couple. Contact erica.bertoli@us.army.mil for more information.

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MEDIUM (50-399 Employees)	$1,000	15
SMALL (10-49 Employees)	$500	10
CONSULTANT (1-9 Employees)	$300	5

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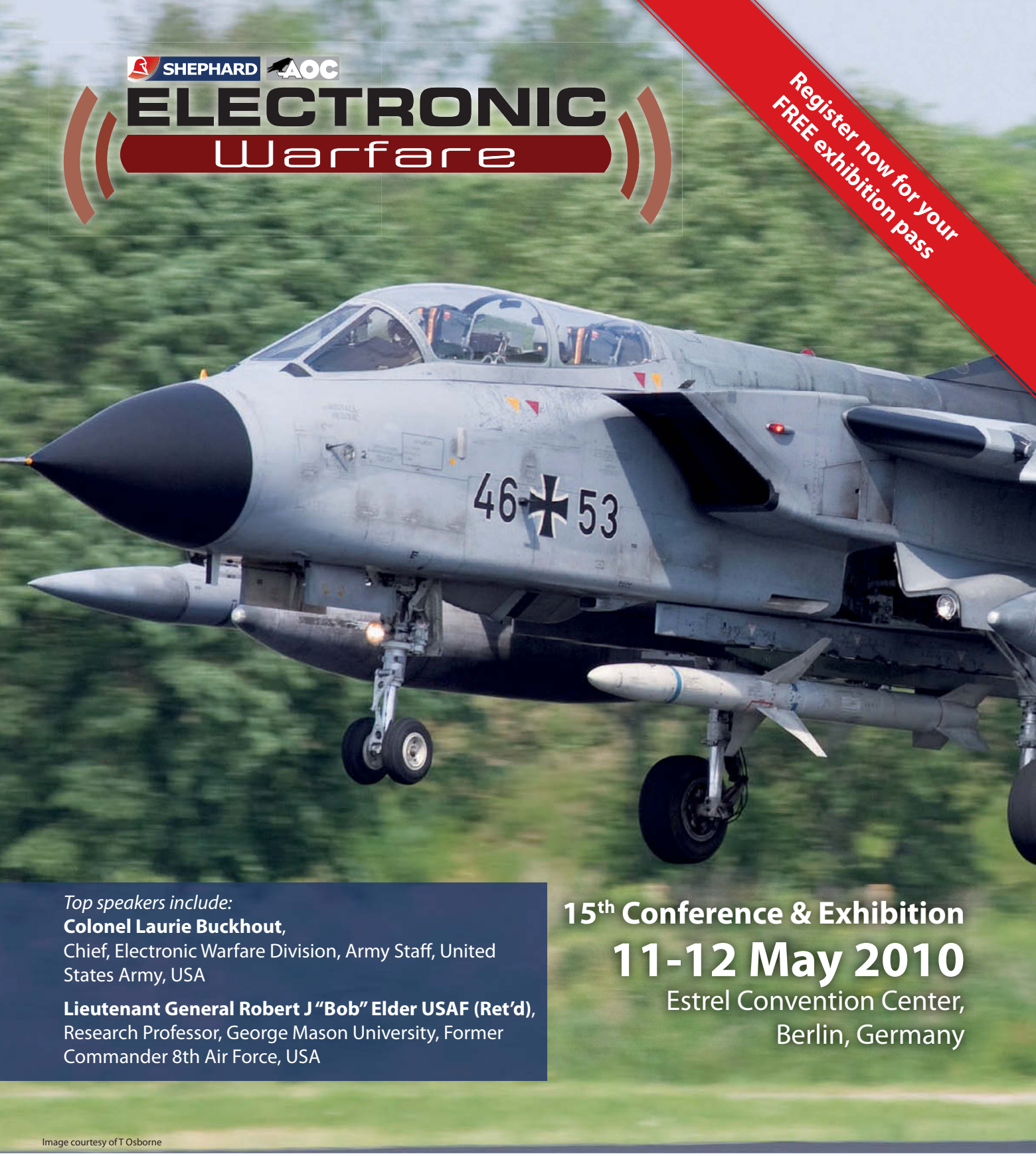

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