JULY 2010
Vol. 33, No. 7

The AOC Electronic Warfare Publication
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JED

The Journal of Electronic Defense

SIGINT for Special Mission Aircraft

Also in this issue:

Fighter Aircraft EW: Shifting from Defense to Attack

Technology Survey: Airborne Radar Jammers

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the view from here

EW ON THE ATTACK

This month's *JED* features an article from Gàbor Zord about the evolution of fighter aircraft EW. From the vantage point of 2010, it is clear that we have come a long way from the 1960s, when EW systems were first integrated into fighter aircraft on a large scale. Back then (with the exception of SAM-hunting Wild Weasel aircraft), EW systems were truly defensive in their function. In the following decades, as aviation engineers gained more experience with EW systems, they also grew more adept at integrating EW with the rest of the fighter's avionics system – giving the fighter new offensive capabilities. Gradually, this trend has helped to reverse the deadly dynamics of the fighter vs. SAM contest.

Today, we are quickly approaching an era where our newest fighters will, in effect, be as potent and as deadly to a SAM system as a Wild Weasel (and perhaps more so). This is not purely an EW achievement, however. The combination of low-observable aircraft designs, supercruise engines, stand-off targeting systems, long-range precision-guided munitions and data links that provide off-board targeting and situational awareness information (to name a few) have played a major role in this fighter survivability transformation, too. In fact, fighter *lethality* is probably a better term to describe what these technologies bring to the fight.

At the same time, some EW capabilities that historically have been difficult to acquire, such as digital RF memories (DRFMs), are becoming much easier to buy. As some "less advanced" air forces are now beginning to realize, DRFMs can help to level the playing field between their legacy fighter aircraft and an adversary's more advanced fighters (especially in scenarios in which the legacy fighters have a distinct numerical advantage). This, in its way, is another form of using EW in an attack mode.

Considering the attributes of modern fighter aircraft and what they are capable of achieving, I sometimes wonder if we are approaching an era in which we drive most RF SAM systems and even some fighters out of the RF spectrum. (Think of the emphasis that Russian aircraft manufacturers are placing on forward-looking infrared [FLIR] sensors instead of radars, for instance.) Even if this proves true, it would be foolish to think that we are somehow nearing the end of the measure-countermeasure game between EW and radars. Radar designers are a resilient bunch and air defense radar operators are innovative tacticians. The balance of the game may shift for a while, but it isn't over. In the meantime, however, I wouldn't recommend a career as a SAM operator. The odds of his survival don't seem very good at the moment.

– John Knowles

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JULY

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www.cranfield.ac.uk

Farnborough International Airshow
July 19-25
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www.farnborough.com

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Dayton, OH
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AUGUST

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Unmanned Systems North America
August 24-27
Denver, CO
www.auvsi.org

C4ISR Joint Symposium & Expo
August 24-26
Baltimore, MD
www.quad-a.org

SEPTEMBER

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

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

Modern Day Marine
September 28-30
Quantico, VA
www.marinemilitaryexpos.com

OCTOBER

AOC 47th Annual Convention & Symposium
October 3-6
Atlanta, GA
www.crows.org

AUSA Annual Meeting & Exposition
October 25-27
Washington, DC
www.ausa.org

Euronaval
October 25-29
Paris, France
www.euronaval.fr

NOVEMBER

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

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

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

DECEMBER

Electronic Warfare Symposium
December 1-2
Swindon, Wiltshire, UK
www.cranfield.ac.uk

FEBRUARY

Aero India 2011
February 9-13
Bangalore, India
www.aeroindia.in

IDEX
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Abu Dhabi, UAE
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www.pe.gatech.edu

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July 20-22
Denver, CO
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ELINT and EW Database Fundamentals
July 26
Wright-Patterson AFB, OH
www.crows.org

AUGUST

Introduction to Electromagnetic Compatibility
August 23
Herndon, VA
www.afcea.org

Developing Prototype RF Hardware
August 31 - September 2
Atlanta, GA
www.pe.gatech.edu

SEPTEMBER

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Atlanta, GA
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Advanced RF EW Principles
September 27-October 1
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Basic Concepts of RF Printed Circuits
September 28-30
Atlanta, GA
www.pe.gatech.edu

OCTOBER

Infrared/Visible Signature Suppression
October 5-8
Atlanta, GA
www.pe.gatech.edu

Principles of Radar Electronic Protection
October 12-15
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www.pe.gatech.edu

Electromagnetic Environmental Effects
October 19
Fairfax, VA
www.afcea.org

Radar Cross Section Reduction
October 25-27
Atlanta, GA
www.pe.gatech.edu

NOVEMBER

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November 8-12
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www.cranfield.ac.uk

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IR Countermeasures
November 30-December 3
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message from the president

A DAY WITHOUT SPECTRUM

There have been decades of debate over what the Prussian military theorist Carl von Clausewitz meant by the term "center of gravity" (COG) in his treatise *On War*. However, I like the definition defended by Dr. Antulio Echevarria II in his 2002 monograph entitled "Clausewitz's Center Of Gravity: Changing Our Warfighting Doctrine – Again!" Dr. Echevarria states that Clausewitz intended the center of gravity to function much as its counterpart in the mechanical sciences does, that is, *as a focal point*. He thus argues that "the Clausewitzian center of gravity is not a strength, nor a weakness, nor even a source of strength. A center of gravity becomes the one element within a combatant's entire structure or system that has the necessary centrifugal force to hold that structure together." This is why Clausewitz wrote that a blow directed against a COG will have the greatest effect. So, within this framework, the concept of a COG was not related to a source of strength or point of weakness, as has been proposed by US military doctrine in the past, but rather represented as an operational fulcrum or "tipping point," which when positively affected would significantly impact the outcome of military operations.

Over the past few months we have discussed the importance of the electromagnetic spectrum (EMS) to 21st century warfare. In the 2010 AOC white paper titled *21st Century Electronic Warfare*, the critical impact of having available, reliable and secure spectrum is highlighted against the backdrop of electronic warfare activities. However, if we broaden our horizon to the envisioned "net-centric" operations of the future, it appears that our net-centric approach to warfare fits neatly into Clausewitz's COG *focal point* theorem.

I have lost count of the number of times I have seen PowerPoint briefings with "operational views" (OV-1s) of systems and systems of systems connected by "lightning bolts" of connectivity, which describe a utopian world of spectrum availability and information transfer. What if this ubiquitous connectivity is viewed as a "tipping point" by our adversaries? What would it take to deny portions of the spectrum most critical to joint/coalition operations? How long would this denial of spectrum be required?

These and other questions need to be addressed by our military services as we move deeper in the spectrum dependency required of net-centric warfare. The AOC, as a part of its greater issues series of papers, will soon begin its own "Day Without Spectrum" investigation. We look forward to bringing you an objective look at this issue and as always we welcome your feedback!

Non Videbunt.

– Chris "Bulldog" Glaze


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quality
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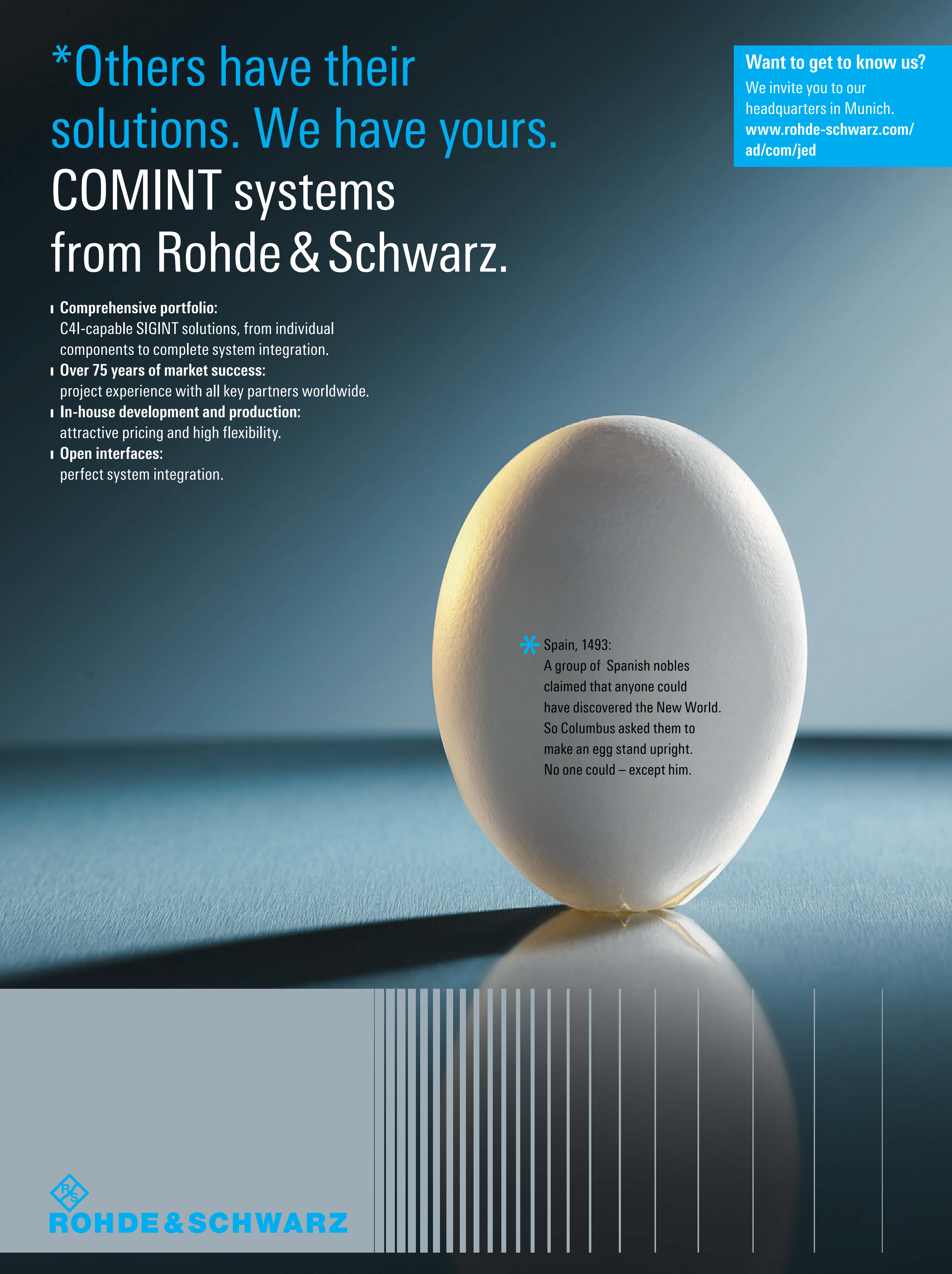
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* Spain, 1493:
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US ARMY COMPLETES NEW ISR TURBOPROP

Industry teams submitted their bids on June 25 for the US Army's Enhanced Medium-Altitude Reconnaissance and Surveillance (EMARSS) aircraft, the latest scaled-down iteration of the service's former Aerial Common Sensor (ACS) program. The Army specified the small, twin-engine King Air 350ER turboprop built by Hawker Beechcraft (Wichita, KS) as the EMARSS platform. The teams are competing for a winner-take-all engineering and manufacturing development (EMD) and low-rate initial production (LRIP) contract to outfit 36 of the aircraft with intelligence, surveillance and reconnaissance (ISR) sensors and communications equipment on an accelerated schedule.

The Army plans to award the EMARSS EMD contract in late September. Teams led by Boeing and by L-3 Communications are known to be chasing the program. The winning team will deliver four EMD prototypes for test and evaluation. The Army's current schedule calls for DOD Milestone C approval for LRIP to occur only a year after the EMARSS contract award, and an early operational capability to be achieved with EMD models made available for overseas duty under a Forward Operational Assessment.

EMARSS will be equipped with two ISR sensor systems – a rotating ball turret with long-range, high-resolution, electro-optical and infrared cameras and a communications-intelligence (COMINT) payload – with the specific systems proposed by each bidder. The aircraft will have a pilot, a co-pilot, a sensor operator and a COMINT specialist, with the latter two manning workstations. The EMARSS requirements call for mission endurance time at 25,000 feet of between five and seven hours.

The Army previously fielded about 20 modified King Air B200 and 300 models in Iraq and Afghanistan under Quick Reaction Capability programs, with the latest called MARSS (see photo above). The Air Force also has been fielding 37 MC-12W King Air 350 and 350ER aircraft modified under the Project Liberty program championed by Defense Secretary Robert Gates. These small low-cost ISR turboprops have proven to be of great utility in directly supporting US ground forces engaged in irregular warfare. – *G. Goodman*

DOD EMS CONTROL ORGANIZATION PROPOSED

Key DOD panels are expected to receive briefings this month about two recent studies that address how the DOD could establish a new joint organization to provide warfighter support across a range of electromagnetic spectrum (EMS) warfare activities.

The two studies were directed in a 2009 Joint Requirements Oversight Council Memorandum (JROCM) after the JROC was briefed on results of an Electronic Warfare (EW) Capabilities Based Assessment that identified critical EW gaps and a follow-on Functional Solutions Analysis that proposed fixes for those gaps. The leading issue identified in those studies, which were conducted by US Strategic Command's (USSTRATCOM's) Joint EW Center, was the need for an organization that focused not just on EW or spectrum management, but instead looked across the full range of joint warfighter needs for establishing EMS Control.

Based on the 2009 JROCM, USSTRATCOM and the US Joint Forces Command were tasked to collaborate on an EMS organizational study. In order to obtain an outside perspective, the JROC also requested a second study to be performed by a non-DOD organization. The Center for Strategic and International Studies (CSIS) was selected to carry out the second analysis. The CSIS study recommended that the DOD's leading short-term option is to establish an EMS Control Center within USSTRATCOM that would be responsible for joint EMS policy and doctrine, requirements, resources, operational support and intra-government and private sector coordination. Within USSTRATCOM, the Joint IO Warfighting

Center's Joint EW Division (formerly the Joint EW Center) could provide some of the core expertise needed to establish an EMS Control Center.

Toward this end, USSTRATCOM's Capability and Resource Directorate (J8) has started the process of briefing the various EMS Control organization options (as well as a recommendation for a USSTRATCOM EMS Control Center) to key panels in the DOD, such as the Force Application Functional Capabilities Board and the Joint Capabilities Board. The briefing process is expected to continue into this month. – *J. Knowles*

US AIR FORCE TO DEVELOP "COGNITIVE JAMMER"

The Air Force Research Lab's Sensors Directorate (Wright-Patterson AFB, OH) is soliciting proposals for development of a new generation of RF jammers that will adapt to agile threats and to the larger RF environment in which it operates. Dubbed the "cognitive jammer," the effort will focus on software algorithm development and fabrication of a prototype system.

The advent of wideband software defined radio/cognitive radio technologies means that a new generation of radars, navigation systems and communications systems will rely on some type of dynamic spectrum access technology that enables these systems to quickly adapt to the RF environment around them (including jamming). This changes the EW vs. threat paradigm, in which EW systems have traditionally been able to rely on pre-determined frequencies and well-exploited threats. Future RF jammers will need to tackle a wide range of agile and adaptive RF threats while at the same time sensing the RF environment to minimize jamming fratricide problems for friendly and civilian RF systems.

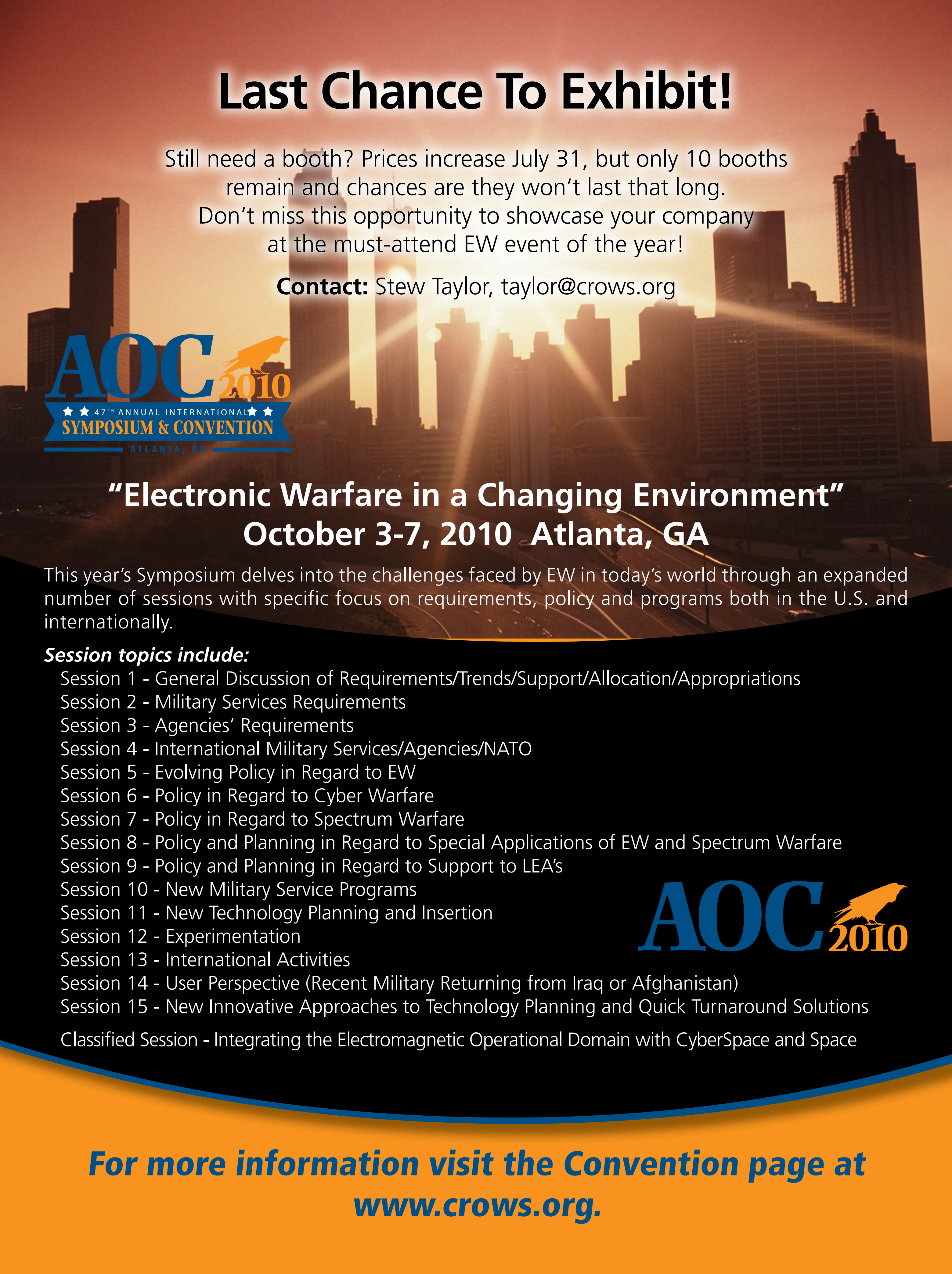
This trend is driving the Sensors Directorate to develop a cognitive jammer that is "adaptive, multifunctional (communications, radar, navigation and etc.) and employ[s] multi-layer attacks depending on the threat, situation and scenario." In the solicitation, the Sensors Directorate has outlined a four-year basic effort and two 12-month option phases valued at $2.45 million. During the program the contractor(s) will deliver data, software and a prototype cognitive jammer system that will be tested "in a robust real-world environment in the presence of realistic threat and blue force signals."

Proposals are due July 6, and contract award(s) is scheduled for September. The technical points of contact are Dr. Vasu Chakravarthy, AFRL/RYRE, (937) 528-8269, vasu.chakravarthy@wpafb.af.mil; and Clifton Bullmaster, AFRL/RYRE, phone (937) 528-8249, clifton.bullmaster@wpafb.af.mil. – *J Knowles*

ASSAULT VEHICLE MAY GET COUNTER-IED MISSION

Lockheed Martin Missiles and Fire Control (Orlando, FL) announced that it has been asked by the US government to assess the feasibility of converting its Future Combat System (FCS) Multifunction Utility/Logistics and Equipment Vehicle (MULE) for use in counter-IED duty.

Briefing reporters during last month's Eurosatory exhibition, Morri Leland,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Session 6 - Policy in Regard to Cyber Warfare
Session 7 - Policy in Regard to Spectrum Warfare
Session 8 - Policy and Planning in Regard to Special Applications of EW and Spectrum Warfare
Session 9 - Policy and Planning in Regard to Support to LEA's
Session 10 - New Military Service Programs
Session 11 - New Technology Planning and Insertion
Session 12 - Experimentation
Session 13 - International Activities
Session 14 - User Perspective (Recent Military Returning from Iraq or Afghanistan)
Session 15 - New Innovative Approaches to Technology Planning and Quick Turnaround Solutions
Classified Session - Integrating the Electromagnetic Operational Domain with CyberSpace and Space
AOC 2010
For more information visit the Convention page at www.crows.org.

Lockheed Martin's director of International Business Development for Tactical Missiles/Combat Maneuver Systems, said the government requested estimates for payload capacity and accelerated timelines for production specifically for counter-IED missions. The MULE, which the US Army has renamed the Armed Robotic Vehicle-Assault (Light) (ARV-A-L), is a 2.5-ton class autonomous platform that was originally designated to have three variants to carry out armed, transport and countermine missions. DOD cutbacks have eliminated the transport and countermine variations, though this recent request may reflect a potential retasking of the ARV-A-L.

In System Development and Demonstration (SDD) phase since 2003, the ARV-A-L is intended to integrate weapons with reconnaissance, surveillance and target acquisition to support dismounted infantry. Though the latest acceleration and payload requests have not identified particular counter-IED system specifications, Leland speculated that a counter-IED variant of the ARV-A-L could include a suite of sensor, mechanical and RF solutions, including the Symphony Radio Controlled Improvised Explosive Device (RCIED) Defeat jammer system. In March, the US Navy gave Lockheed Martin an initial task order valued at $40.8 million as part of a larger $940 million sole source, indefinite delivery, indefinite quantity (ID/IQ) contract for Symphony systems through 2014. More than 1,000 Symphony systems have been produced and delivered since 2006. – *S. Grant*

FAA SEEKS HANDHELD DF UNITS

The Federal Aviation Administration (FAA) is conducting a market survey to solicit statements of interest and capabilities from interested vendors that can provide the agency with required handheld Radio Frequency Interference (RFI) direction finding (DF) kits.

The FAA Spectrum Engineering Services Directorate would use the kits to detect, locate and resolve radio spectrum interference issues that disrupt communication, navigation and surveillance systems.

The agency anticipates buying as many as 86 units, including a wideband receiver with a frequency range from 500 kHz to 3 GHz, as well as specific parameters for sensitivity and selectivity. Interested companies must provide a capability statement demonstrating ability to provide the handheld RFI DF kits that meet the listed requirements. Responses are due by July 21. The point of contact is Nadia Shash, (202) 385-6753, nadia.shash@faa.gov. – *E. Richardson*

US NAVY AWARDS EW RANGE SUPPORT CONTRACTS

The Naval Air Warfare Center Weapons Division (China Lake, CA) has awarded multiple contracts to companies for support of the Combat Environment Simulation (CES) at China Lake and the Airborne Threat Simulation (ATS) Division at Point Mugu, CA.

Tybrin Corporation (Fort Walton Beach, FL) was awarded $241.5 million; L-3 Services (Chantilly, VA) was awarded $210.9 million and Lockheed Martin (Gaithersburg, MD) was awarded $207.8 million. The companies are tasked with the design, development, fabrication, installation, integration and testing of net-centric warfare equipment and/or systems designed to provide a dense, realistic electromagnetic environment – including radio frequency, infrared, electro-optic and laser energy – for weapons system development, real-time, aircrew tactical training, test and evaluation of defense suppression systems, electronic warfare systems, electronic countermeasures equipment and electronic counter-countermeasures equipment. In accordance with the joint mission, developed solutions are to emphasize commonality and interoperability among all DOD ranges, taking on the look and feel of a unified acquisition.

All awarded contracts are cost-plus fixed fee, ID/IQ contracts and include a five-year ordering period. – *E. Richardson*

US NAVY SEEKS ENHANCED IED JAMMERS

The Naval Surface Warfare Center at Indian Head, MD has issued a request for information (RFI) that seeks white papers spelling out potential performance improvements to the DOD's existing Dismounted Counter Radio-Controlled Improvised Explosive Device Electronic Warfare (CREW) 3.1 jammer.

NAVSEA said it wishes to investigate system-level hardware that would provide near-term improved performance over current system capabilities, particularly a reduction in system weight. Secondary areas of interest are a reduction in system size, an increase in system effective range and a reduction in noise generated by system fans. Man-portable IED jammers have demanding size, weight and power requirements and have to be much smaller and lighter than vehicle-mounted systems, while including an antenna and a battery pack.

Sierra Nevada Corp. (Sparks, NV) is the incumbent supplier, having competitively won the initial NAVSEA contract in June 2009 to produce up to 2,500 of the CREW 3.1 dismounted backpack jammers. The CREW Program Office (PMS 408) at NAVSEA is the DOD's executive agent for developing common ground-based CREW systems for the DOD's Joint IED Defeat Organization. Submissions to the RFI are due July 16. The RFI number is N0017410SND27. The point of contact is Omar Roque, e-mail omar.roque@navy.mil.

In a separate counter-IED development effort, the Office of Naval Research (Arlington, VA) last month announced its intention to award a number of small three-month $25,000 purchase orders to companies to study the application of multi-function communications and EW technologies to counter-IED operations – essentially, combining IED jammer and software-programmable radio capabilities in a single system.

In an unusual practice, only those companies that attended an ONR workshop held on May 11-13 will be eligible for the purchase orders. The companies

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CORRECTION

The *JED* article, "European EW" (May, 2010, p. 30) incorrectly identified the countermeasures dispenser on the UK's Chinook HCMk.2/3/3A, Puma, AW Merlin HC Mk.3 (and 3A) and Commando Sea King (Mk.4). The article should have indicated that all of these aircraft carry the ALE-47 dispenser manufactured by Petards Joyce-Loebl in the UK (under license from BAE Systems in Austin, TX, USA). The article also incorrectly identified the manufacturer of the ALE-47 dispensers on the Royal Navy's Merlin HM.1, which is also Petards Joyce-Loebl. *JED* regrets the errors.

IN BRIEF

Homer Walter Prue, former vice president of advanced technology for the countermeasures division at **BAE Systems Electronics & Integrated Solutions** (formerly Sanders Associates), died May 28. Prue's career with Sanders Associates and its successor companies spanned 38 years, during which he held numerous engineering and managerial positions in EW. He contributed to EW systems such as the ALQ-149 and ALQ-126B countermeasures programs, the Integrated Electronic Warfare System (INEWS) and the F-22 and JSF EW programs. After his retirement in 1998, the company established the Homer W. Prue Electronic Warfare Award, presented annually to the individual demonstrating outstanding technical excellence in EW.

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The US Air Force's **647th Aeronautical Systems Squadron** (AESS) at Wright-Patterson AFB, OH has issued a Capability Request for Information (CRFI) to identify potential suppliers of advanced IR decoys and countermeasures flares. The 647th AESS is working with the EO Sensor Technology Division at the Air Force Research Lab's Sensors Directorate to investigate new flare technologies that can counter advanced IR missile seekers that employ counter-countermeasures techniques, such as spectral, spatial and temporal discriminants. Companies with promising IR decoy solutions may receive some level of modeling and simulation support from the EO Sensor Technology Division. Responses to the CRFI are due August 6. The CRFI points of contact are Steve Miller, (937) 255-3409, steven.miller2@wpafb.af.mil and Dan Powlette, (937) 255-2949, daniel.powlette.ctr@wpafb.af.mil.

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Armtec Countermeasures (Coachella, CA) has received a $30 million ID/IQ contract from the US Air Force, for approximately 50,000 MJU-23A/B countermeasures flares, which are used primarily on the service's B-1B bomber. Currently, $16.7 million has been obligated under the contract.

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The US Navy's Space and Naval Warfare Systems Center (SPAWARSYSCEN) Atlantic (Charleston, SC) plans to award a contract worth up to $27 million to **Concurrent Technologies Corporation** (Johnstown, PA) for engineering and technical support services for development of ALR-95 and ALR-97 Electronic Support Measures (ESM) Operational Libraries (EOLs), Small World Threat Data Libraries (SWTDLs), and In-Country Reprogramming systems.

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The **US Army Mission and Installation Contracting Command (MICC) Center** (Fort Bragg, NC) is seeking information from companies that can provide Electromagnetic Spectrum Operations (EMSO), Cyberspace Operations and Electronic Warfare (EW) subject matter experts. MICC is soliciting information on the availability and capabilities of potential small business firms to provide technical expertise and support services to the US Army Signal Center of Excellence (SIGCoE), Capability Development Integration Directorate (CDID) TRADOC Project Office, Network Operations (TPO NETOPS). The requirement includes analyzing and recommending solutions to the government for the planning, management, employment, training and operations for new, enhanced EMSO capabilities for full spectrum operations. Interested parties should contact Virginia Roberts, at (910) 643-7005 or virginia.a.roberts@us.army.mil.

✪ ✪ ✪

The **US Air Force Materiel Command** (Tinker, AFB, OK) issued a request for information (RFI) June 14 to solicit industry availability for the development and production of an IR countermeasures system for the KC-135 aircraft. The system must be capable of defending against Man-portable Anti-Aircraft Defense (MANPAD) threats, to which the KC-135 can be uniquely vulnerable. The system also must not impact the aircraft's flight dynamics or interfere with its primary mission of refueling other aircraft, should be self contained and should not require extensive modification to the main aircraft structure. Contact Donna R McKibben, contract specialist, at (405) 739-4445 or donna.mckibben@tinker.af.mil.

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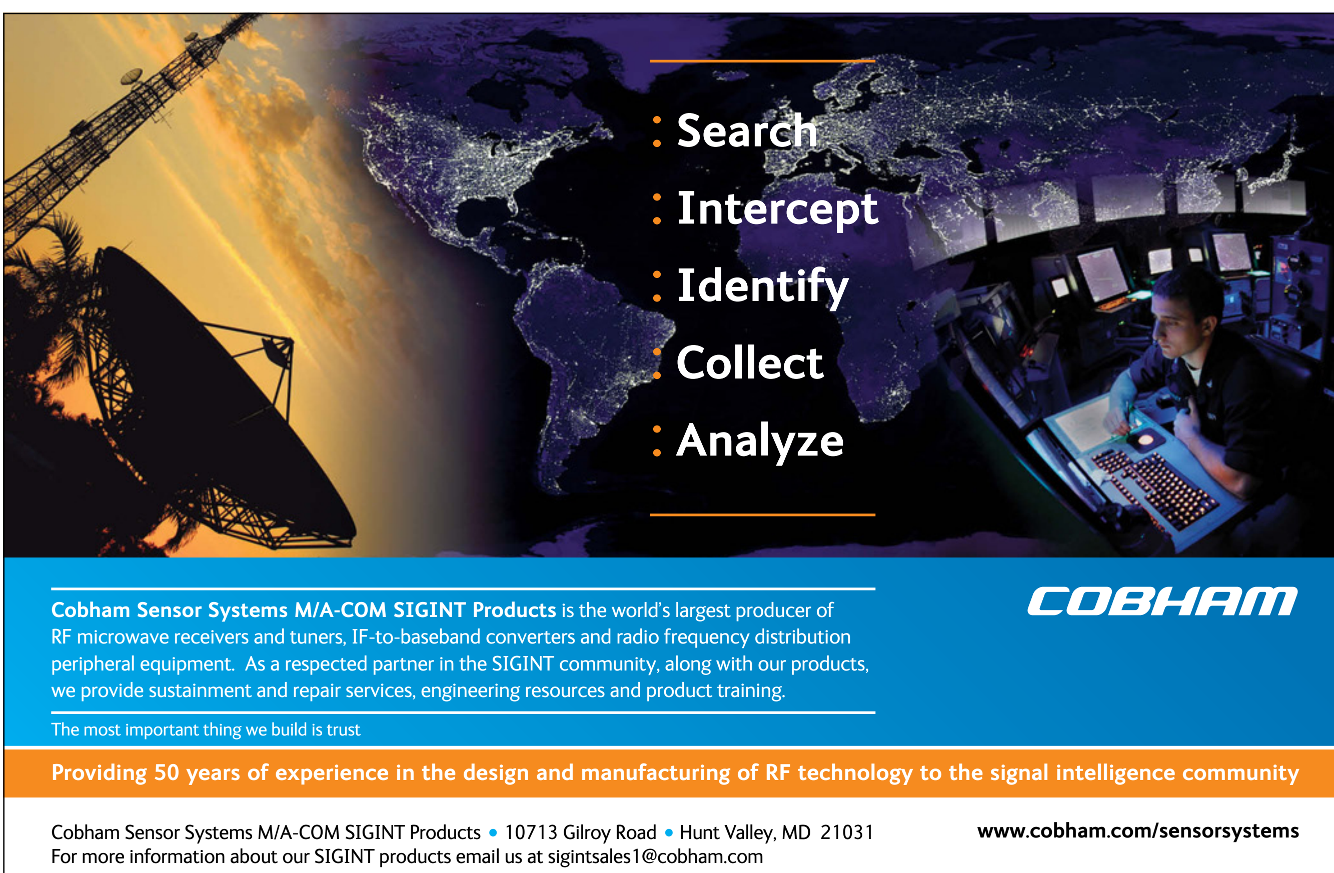
Argon ST Network Systems (Ventura, CA) was awarded a $44 million contract by Naval Air Systems Command (NAVAIR) to produce antenna-based systems for the Airborne Threat Simulation Organization (ATSO). The systems will be installed in sub-scale aerial targets, airborne pods for use on manned aircraft and ground based applications, and will be integrated with transmitter modules to complete required simulator system configurations, applicable to training and testing of weapon systems.

✪ ✪ ✪

AAI Corp. (Hunt Valley, MD) is being awarded a $6 million contract by the Naval Surface Warfare Center (NSWC) for the procurement of Universal Test Sets used in supporting operational-level testing of Joint Counter Radio-Controlled Electronic Warfare (J-CREW) systems. Work will be performed in Charleston, SC, and is expected to be completed by December.



washington report

SENATE TO DEBATE FY2011 DEFENSE AUTHORIZATION BILL

This month, the full US Senate is expected to debate its version of the FY2011 Defense Authorization Bill, which includes a number of provisions for electronic warfare (EW) and signals intelligence (SIGINT) programs. The defense policy bill, S. 3454, was marked up by the Senate Armed Services Committee (SASC) in May and passed by the committee last month.

In the committee report (Senate Report 111-201) that accompanied the authorization bill, the SASC addressed several SIGINT programs. Noting that the Army's Enhanced Medium Altitude Reconnaissance and Surveillance System (EMARSS) "has an ambitious and risky development schedule that has already suffered schedule delays," the SASC felt that the Army's $88.5 million request for procurement funding was unlikely to be used in FY2011. The SASC recommended "a provision that would prohibit the obligation of any funds for the Airborne Common Sensor, EMARSS, until the Assistant Secretary of the Army for Acquisition, Logistics, and Technology certifies to the congressional defense committees that the system has successfully completed its limited user tests and demonstrates the technical performance necessary for successful Milestone C approval."

The SASC recommended cutting $24.2 million of the Army's $30.2 million request for the RC-12 Guardrail Common Sensor Program within the Overseas Contingency Operations (OCO) portion of the budget. "The Army decided to modernize and retain 14 GRCS platforms after the budget was submitted," the SASC noted in its justification for the funding decrease.

The SASC also expressed concern over Navy airborne SIGINT programs, especially in light of the cancelled EP-X program, which was slated to replace the Navy's fleet of EP-3E Aries SIGINT aircraft. The SASC recommended a provision that would prohibit the Navy from retiring its EP-3E or Special Projects Aircraft until it has "readied replacements that are equivalent or better in terms of meeting the requirements of the combatant commanders." It added, "The EP–3E and SPA fleets must be maintained and kept current while the Navy firms up and executes plans to acquire SIGINT on the Broad-Area Maritime Surveillance unmanned aerial system (UAS), and develops and produces the ship-based medium-endurance UAS."

The SASC also recommended a cut of $18.3 from the Air Force's MQ-9 Reaper UAS procurement line. This is the amount needed to begin production of the Airborne SIGINT Payload 2C (ASIP 2C) system for these aircraft. The SASC, citing the Government Accountability Office, said that the ASIP 2C would not be ready for production in FY2011.

The SASC had less to say about EW programs, but it did make funding adjustments in these budget lines. The committee recommended adding $5 million to the Navy's common electronic countermeasures procurement line for an AAR-47 computer processor upgrade. The Navy also received an additional $7 million to accelerate a series of upgrades to the Nulka anti-ship missile decoy.

The Army's $18.4 million request for development of EW technologies (PE 063270A) was plussed-up by $3 million to develop laser technologies for "light aircraft missile defense." This was requested by both senators from Michigan and is directed at Omni Sciences Inc. (Ann Arbor, MI), which is developing mid-IR fiber lasers. The Army also received an additional $5 million in its EW development line (PE 0604270A) for further development of hostile fire detection technology for helicopters.

In the Air Force procurement account, the SASC added $7.5 million for modernization of the Joint Threat Emitter (JTE). Several senators provided plus-ups to acquire JTE systems for military training ranges in their states. Another Air Force program that received a boost from the SASC was the Large Aircraft IR Countermeasures (LAIRCM) Program. The SASC plussed-up this procurement line by $11 million to provide LAIRCM systems to the Michigan Air National Guard.

The SASC also focused on directed energy programs. Noting that the Air Force is planning to install and test a solid-state laser on a B-1B bomber, it has asked the DOD for a report on the cost and viability of installing high-energy lasers on other aircraft, as well.

The US House of Representatives passed its version of the defense authorization bill (H.R. 5136) in late May. The Senate hopes to pass its version of the defense policy bill before Congress adjourns for the August recess. Members of the House and Senate will then meet in a conference session to iron out differences and draft a single defense policy bill for consideration by the House and the Senate. Both the House and Senate's appropriations committees are expected to draft their respective versions of a defense spending bill sometime this month. – *J. Knowles*

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FINNISH AIR FORCE CONTRACTS FOR NEW SIGINT AIRCRAFT

The Finnish Air Force's Materiel Command has awarded a US$100 million contract to Lockheed Martin Information Systems and Global Services Defense (IS&GS-Defense) for the delivery of an airborne surveillance system to be installed on board a new Airbus Military C-295M tactical transport aircraft. The new aircraft will replace the Air Force's Fokker F.27-100 aircraft that is currently used in a SIGINT role.

Airbus Military will provide the C-295M platform and Lockheed Martin will integrate and deliver the aircraft's surveillance system, modify the C-295M platform to accommodate it and test the final airborne configuration. Lockheed Martin will also supply the ground stations, communications terminals to support the airborne system, and provide one year of logistics support. Delivery is scheduled for 2013.

Although Lockheed Martin will not comment on the mission system, it is reportedly a roll-on/roll-off palletized SIGINT suite. Subsystems will be supplied by Rockwell Collins, Applied Signal Technology, DRS Technologies, L-3 Communications, and AdamWorks. Finland's Patria group will provide aircraft modification support and maintain the mission and ground systems.

The SIGINT suite that Lockheed Martin will provide to the Finnish Air Force will leverage work that it has done for its Airborne Multi-Intelligence Laboratory (AML). The mission system will feature an open and modular architecture to allow future system upgrades for evolving mission needs, according to the company. Lockheed Martin will also use the AML to perform risk reduction and early mission testing for the C-295M. The Finnish Air Force already flies two C-295M aircraft in a transport role. – *L. Peruzzi*

NORWAY OUTLINES EW PROCUREMENT PLANS

Norway's Ministry of Defense has released "Future Acquisitions for the Norwegian Armed Forces 2010-2017" (FANAF 2010-2017) in which it outlines its major new programs for the next several years. The document was updated in February, but was only recently made public by the MOD.

In the FANAF report, the government outlines the MOD's long-term materiel plans. These include three major EW projects. One program, designated P 7509, is the Norwegian Air Force's effort to upgrade the radar warning receivers on its F-16 aircraft. This is scheduled for an approval decision this year, with a contract for 57 RWRs, as well as spare parts, to be awarded in 2010 or 2011. Delivery is scheduled for completion in 2014. This project is estimated to cost NOK 100-300 million (US$15-45 million).

Another Air Force project is the upgrade of its DA-20 Falcon aircraft. One is used as a VIP aircraft to transport government officials and the royal family. Two others are operated by 717 Squadron based at Rygge Air Station and are used for EW training. Project P 7644 would provide new self-protection equipment (including the ALQ-213 EW Management System), multi-band radios and an internal communications system. This project will undergo an approval decision in 2011, with a contract scheduled for 2012 and completed delivery in 2015. The estimated cost is NOK 100-300 million (US$15-45 million). The point of contact for P 7509 and P 7644 is the MOD's Air Systems Advisor, André Sørli, at +47 23 09 80 00.

The Norwegian Army is considering a counter-IED program (P 2551) that is yet to be defined, but is likely to include several components for portable and vehicle-mounted applications. Also estimated at between NOK 100-300 million (US$15-45 million), this project is listed a "possible" rather than "planned." It is scheduled for contract award in 2011, and deliveries are to be completed by 2014. The point of contact for this effort is the Logistics Systems Program Manager, Maj Tom Juliussen, at +47 23 09 80 00. – *J. Knowles*

FRENCH ARMY AND NAVY BUY EW PROGRAMMING STATIONS

France's military procurement agency, Direction générale pour l'armement (DGA), has ordered 50 EW programming stations from Thales Airborne Systems (Elancourt Cedex, France) for seven families of helicopters in service in the French Army and the French Navy.

The programming stations will be used for two main functions. They will support pre-mission upload of threat libraries into the helicopters' self-protection systems. They will also provide post-mission collection and analysis for recorded data from the helicopters' RWRs. This will enable threat libraries to be updated for future operations.

The French Army will receive 26 EW programming stations, which it will use to support the EW systems on its EC 725 HUS Cougar, Tiger Standard 1&2, NH90, Gazelle and Puma helicopters. The French Navy will receive 24 stations, which will be used to support the EW systems on its Panther helicopters. Both services previously used different EW programming stations for each helicopter model.

Thales will deliver the programming stations for customer qualification in late 2011, with final deliveries scheduled for early 2012. – *J. Knowles*

SIGINT for Special

Small ISR turboprops fill a niche in

When the US Army's planned Enhanced Medium-Altitude Reconnaissance and Surveillance System (EMARSS) enters service as early as next year, it will join a plethora of other rapidly fielded small fixed-wing Army and Air Force turboprop aircraft that are flying intelligence, surveillance and reconnaissance (ISR) missions over Iraq and Afghanistan today.

The bulk of these unarmed "Special Mission Aircraft" are modified versions of King Air twin-engine turboprop business aircraft built by Hawker Beechcraft (Wichita, KS) and subsequently fitted with two onboard ISR sensors, two sensor operator/analyst workstations and communications equipment. The two ISR sensors on the Army and Air Force turboprops are a communications-intelligence (COMINT) payload and a down-looking, rotating ball turret with electro-optical and infrared (E-O/IR) full-motion video cameras.

These relatively simple tactical intelligence support aircraft are a far cry from the costly larger ISR jet designs with advanced sensors that the US military services have favored in the past. The small turboprops are intended not only to augment the surveillance missions flown by unmanned aerial vehicles (UAVs), such as Predators and Reapers, over Iraq and Afghanistan but

Mission Aircraft

irregular warfare

By Glenn Goodman

also to put human "eyes in the sky" providing more direct and responsive real-time ISR support for US ground combat units engaged in irregular warfare operations.

The Army was the first to field the small ISR turboprops in limited numbers in Iraq in 2007 under Quick-Reaction Capability (QRC) programs. Those efforts supported the Army's Task Force ODIN, which has used the manned aircraft along with UAVs to help counter the emplacement of improvised explosive devices by insurgents.

Defense Secretary Robert Gates, impressed by the Army's successful use of the low-cost turboprops, pressed the Air Force to launch a similar effort on an accelerated basis to provide additional overhead intelligence support for US troops on the ground in Iraq and Afghanistan. As a result, last year the Air Force began fielding 37 MC-12W Project Liberty ISR turboprops – seven King Air 350s and 30 (extended-range, heavier payload) new King Air 350ERs – with the bulk of them now delivered.

FILLING A NICHE

The small turboprops, though relatively limited in payload, offer a number of advantages that can complement the use of larger ISR aircraft and UAVs. These include their low airframe cost, low fuel consumption and operating cost, and small logistical tail and deployment footprint, according to Terry Harrell, Hawker Beechcraft's vice president for Special Mission Aircraft. An unmodified new King Air 350ER costs about $7.5 million, he told *JED*. The ubiquitous King Air family has long been one of the most popular brands of business aircraft and benefits from Hawker Beechcraft's extensive support infrastructure around the world, he noted.

Small turboprops can also offer relatively high mission endurance or "persistence." Depending on mission equipment and atmospheric conditions, the twin-engine King Air 350ER can stay aloft for 6-8 hours with 5-7 hours of mission on-station time, Harrell said.

Lt Gen David Deptula, the Air Force's deputy chief of staff for ISR, has lauded the Project Liberty King Airs for their high reliability in the harsh conditions in Iraq and Afghanistan and for having the highest mission utilization rate of any USAF aircraft – 93 percent.

Size, weight and power constraints and cooling requirements, as with other ISR aircraft, limit the payloads that a small turboprop can accommodate. The Project Liberty aircraft, for example, cannot carry a ground-moving-target-indication (GMTI)/synthetic aperture radar in addition to its E-O/IR and COMINT payloads for that reason. To make room for the radar, one of the other payloads would have to be removed. However, the overall reductions in the size of ISR sensors that have occurred to date have benefitted the small turboprops and enabled their use in the persistent ISR role.

Of course, unchallenged US air superiority and the lack of an air-to-air threat in the southwest Asia region has made effective use of the small Army and Air Force ISR turboprops possible. The aircraft do carry self-protection equipment, but it has been limited to a missile warning system and an expendable countermeasures dispenser, primarily for protection against shoulder-fired IR-guided missiles.

The biggest advantage offered by the small turboprops for the Army and Air Force applications, as recognized by Defense Secretary Gates, has been their ability to be outfitted with sensors and communications equipment and fielded quickly. And, in the ISR role, they have carved out a niche. They have proven to be well suited for fighting insurgents in irregular warfare, particularly because they maintain direct communications with ground forces while using their sensors to identify and monitor pockets of enemy activity.

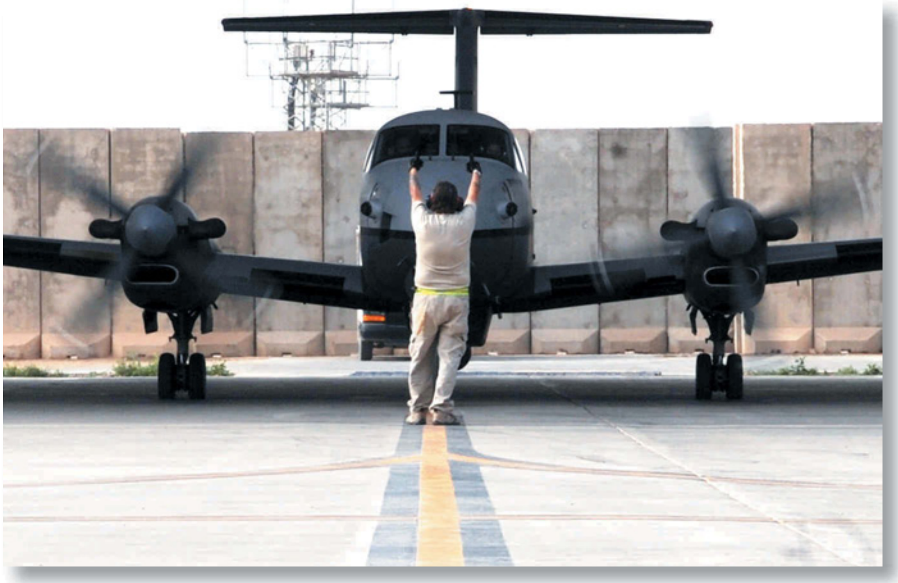
ARMY QRC TURBOPROPS

The first small turboprops fielded by the Army in Iraq beginning in 2006-2007 for Task Force ODIN – ultimately about 10 – are called Aerial Reconnaissance Multi-Sensor (ARMS) aircraft, which are King Air B200s. They were joined subsequently by Medium-Altitude Reconnaissance and Surveillance System (MARSS) aircraft – King Air 300s. The ARMS and MARSS aircraft were modified under a teaming arrangement between Telford Air Cargo Carriers (Bangor, ME) and Sierra Nevada Corp. (Sparks, NV).

The Army has flown a King Air-based, dedicated signals-intelligence (SIGINT) aircraft for many years in the form of the RC-12 Guardrail, a modified B200 with a pilot and co-pilot and fitted with COMINT and electronic-intelligence (ELINT) collection systems. It has

a maximum altitude of 35,000 feet and can spend about five hours on station. Guardrail's SIGINT payload is remotely controlled by operators in a ground processing station as the aircraft loiters in a stand-off position more than 180 km from its target area, and the SIGINT data are transmitted to the ground station for analysis.

The Army's ongoing Guardrail Modernization program is extending the service lives of 33 operational RC-12s by about eight years and standardizing their configurations and adding new hardware and software to improve their sustainability. Each aircraft is being taken out of the field and having its interior gutted and a new digital cockpit installed by Steven Aviation (Greenville, SC). The modernization program also is installing a suite of advanced COMINT payloads on the RC-12 with increased capability against the irregular warfare threat. Delivery of the revamped aircraft by prime contractor Northrop Grumman begins this summer.



PROJECT LIBERTY

In September 2008, the Air Force awarded L-3 Communications' Mission Integration Division a contract to deliver the first seven MC-12W turboprops, and the company's industry team delivered all seven in less than 10 months. The first combat sortie flown by a Project Liberty aircraft took place over Iraq in June 2009. The Air Force ordered an additional 30 of the Liberty aircraft, the bulk of which L-3 has delivered. The first seven MC-12Ws were used King Air 350s with a low number of flight hours; the Air Force opted to modify pre-owned aircraft initially to speed fielding because the sensors were readily available. The remaining 30 MC-12Ws are new 350ERs. Hawker Beechcraft delivered the aircraft with bare shell interiors to L-3, which has modified them with help from ATK (Ft. Worth, TX) to add the sensor and communications systems.

The MC-12W has a crew of four – a pilot, a copilot/mission commander, a sensor operator and a COMINT specialist – all trained at the Mississippi Air National Guard's Key Field (Meridian,

MS). The first seven MC-12Ws can fly missions of up to four hours, and the extended-range new-build versions up to six hours.

The aircraft's E-O/IR ball turret is the 15-inch-diameter MX-15i or MX-15Di built by L-3 Wescam (Burlington, Ontario). It produces high-resolution day or night imagery from long ranges, and the newer MX-Di has an integrated laser designator. The COMINT payload, dubbed "Pennant Race," is reportedly an upgraded version of the system that has been used on Predators and Reapers and was developed by the National Security Agency (NSA). When the COMINT system detects enemy activity on the ground in a particular area, the information can be used to cue the E-O/IR turret to view that location.

EMARSS COMPETITION

As stated in an FY11 Army budget document, "EMARSS is the Army's future force manned airborne intelligence collection, processing and targeting support system. EMARSS is a manned multi-INT airborne ISR system that will provide a persistent capability to detect, locate, classify/identify and track surface targets in day/night, near-all-weather conditions with a high degree of timeliness and accuracy."

As its name implies, EMARSS will be an enhanced version of the QRC-built MARSS. EMARSS also is the latest iteration of the Army's original Aerial Common Sensor (ACS) SIGINT aircraft development program. The planned ACS platform evolved from a modified commercial regional jet with many ISR sensors in 2004 to a large regional turboprop last summer to a small turboprop with only two sensor payloads last fall. Like the Air Force's Liberty aircraft, EMARSS will carry a COMINT payload and an E-O/IR ball turret. In addition, it will have a classified Aerial Precision Geo-location (APG) sensor system developed by NSA. EMARSS does not have a requirement for a GMTI/synthetic aperture radar. Its mission endurance threshold requirement at an altitude of 25,000 feet is five hours, with seven hours as its objective requirement.

The Army released its EMARSS request for proposals on May 21, and the competing industry teams submitted their bids last month. The service plans to award a single 42-month engineering and manufacturing development

(EMD) contract, with an option for low-rate initial production (LRIP) of four EMARSS, in September. The winning team will deliver four EMD prototypes for test and evaluation.

Instead of leaving the choice of turboprop up to the bidders, the Army specified the Hawker Beechcraft King Air 350ER as the EMARSS platform to help simplify and speed the procurement. The industry teams were required to propose a specific E-O/IR ball turret and COMINT system for integration on the 350ER in their bids.

US Army COL Robert Carpenter, the Project Manager for Aerial Common Sensors under the Program Executive Officer for Intelligence, Electronic Warfare and Sensors at Ft. Monmouth, NJ, told *JED* that the Army is shooting for a DOD Milestone C go-ahead for LRIP in September 2011 – only a year after the EMARSS contract award – due to the maturity of EMARSS sensor technology and prior industry experience in integrating sensors and communications systems on the King Air aircraft.

He said the Army leadership tasked his organization with fielding an EMARSS early operational capability within 18 months of contract award, but added, "Our current schedule is actually much more aggressive than that. The early operational capability would not be Milestone C-dependent and could be

EMD systems made available for a Forward Operational Assessment. We are waiting for the industry proposals and contract award to get a better idea of our schedule risk."

The Army plans to acquire a total of 36 EMARSS aircraft, Carpenter said, but some of those could end up being MARSS aircraft upgraded to a near-EMARSS capability. EMARSS, for example, will likely feature an advanced E-O/IR ball turret, potentially with high-definition imagery, as well as enhanced data links. He said the Army has about seven MARSS aircraft deployed, two others are

used for training, and an unspecified small number are supporting US Special Operations Command. The Army could receive supplemental funding from Congress or from the DOD to procure an additional 2-5 MARSS aircraft (new 350ERs this time) over the next two years, Carpenter noted.

In addition to its work on the Project Liberty MC-12Ws, ATK's Integrated Systems Division (Ft. Worth, TX) has been supplying modified single-engine Cessna 208 Grand Caravan turboprop aircraft to the US Iraq Training and Advisory Mission for use in rebuilding the Iraqi Air Force. The company has delivered RC-208B reconnaissance and AC-208B "Combat Caravan" light attack variants, in addition to training aircraft. The Combat Caravans are fitted with an E-O/IR ball turret with an integrated laser designator, Hellfire laser-guided missiles, air-to-ground and air-to-air data links and aircraft self-protection equipment.

The Iraqi Air Force also operates ISR versions of the King Air 350ER modified for Hawker Beechcraft by an undisclosed integrator. A total of 10 of the aircraft are reportedly slated to be in service by the end of this year.

LAYERED APPROACH

Both the US Army and Air Force are implementing a multi-layered approach to solving their ISR requirements that encompasses using a mix of small and large UAVs and manned aircraft, i.e., "layering ISR and collection capabilities over several different kinds of aircraft," in Colonel Carpenter's words.

As Dale Little, Director for Next-Generation ISR at L-3 Communications' Mission Integration Division (Greenville, TX), told *JED*, "The small manned turboprops have filled an unforeseen gap in those layers. Given their utility and their low cost/mission ratio, they have proven to be ideal for meeting US irregular warfare requirements in Iraq and Afghanistan while complementing the employment of other ISR platforms such as UAVs. And, even better, they have lent themselves to rapid fielding."

Their effectiveness as tactical intelligence support aircraft, perhaps foreseen by Defense Secretary Gates, has come as a surprise to many. As Colonel Carpenter told *JED*, "These small turboprop aircraft have really become very capable. Three years ago, you would have never heard me say, 'We like these small airplanes,' because ACS was going to take over those missions. But the world has changed, and we've seen the merits of these airplanes in this type of environment."

"Top Tier" Special Mission Aircraft

The US focus on irregular warfare has opened up a new tier in the special mission aircraft market – one that is focused on less expensive, mid-sized turbo-prop manned ISR solutions. However, the "top tier" of the special mission aircraft market – for larger jet-powered aircraft – is still very strong. This is primarily because this type of aircraft is well suited to more conventional ISR and AEW&C duties in which long-range sensors, large onboard mission crews and maximum on-station time are essential requirements.

In the past, some countries have acquired special mission aircraft based on large commercial airframes, such as the Boeing 707. The US Air Force flies the RC-135 series, which includes the Rivet Joint (RC-135V/W), Cobra Ball (RC-135S) and Combat Sent (RC-135U). L-3 Communications Integrated Systems (Greenville, TX) is the prime integrator for the RC-135 program and has been supporting the program for several decades. The Royal Air Force has elected to buy three Rivet Joint aircraft to replace its Nimrod R.1 SIGINT aircraft beginning in 2013.

Israel Aerospace Industries (IAI) has converted several Boeing 707 airframes for use as Phalcon AEW&C platforms, which are in service with the Israeli Air Force, as well as the Chilean Air Force. In addition to the aircraft's ELTA radar system, the Phalcon also integrates ELINT and COMINT sensors supplied by the company.

Under a more recent Israeli program, IAI is in the process of delivering two special mission aircraft variants, based on the Gulfstream G550 business jet, to the Israeli Air Force's (IAF's) "Nachson" Squadron. These aircraft have a mission time of about nine hours. The Conformal Airborne Early Warning (CAEW) variant, known within the IAF as the Eitam aircraft, features ELTA's EL/W-2085 AEW system, as well as ESM, ELINT and COMINT systems. The Shavit variant is a dedicated ELINT platform. The Republic of Singapore Air Force has also ordered the G550 CAEW aircraft, and India is reportedly interested in the aircraft, as well.

Gulfstream's main rival in the special mission aircraft market is Bombardier, which has been successful with its Global Express aircraft (selected by the RAF for the ASTOR program), as well as its older Challenger series. The company's Q400 was a possible contender for the US Army's ACS/EMARSS program, until the Army specified the King Air 350ER from Hawker Beechcraft. The Q400's main advantage as a special mission aircraft is its relatively clear lower fuselage, which provides a large area for mounting sensors. The United Arab Emirates selected Bombardier's Dash 8 Q300 for its Maritime Patrol Aircraft program in 2008. Thales is integrating the mission system for two Q300 aircraft, which includes the company's Ocean Master 300 radar and an ESM system and self-protection system from Elettronica.

Gulfstream and Bombardier are expected to compete for South Korea's upcoming tender for two SIGINT aircraft, which could be released this month. According to industry sources, South Korea's LIG Nex 1 and Samsung Thales will compete for the mission system integration role. – *J. Knowles*

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Fighter Aircraft EW: Defense to

By Gàbor László Zord

Classic EW reprogramming has historically focused on defensive systems. With the F-35, however, mission data is required for the offensive capabilities to operate at a new level of execution. This short statement, borrowed from Col Kevin J. McElroy, commander of the USAF's 53rd Electronic Warfare Group, at the activation ceremony of the 513th Electronic Warfare Support squadron, Eglin AFB, FL on April 23 could be used as well to remind us of the path that fighter EW has travelled over the past few decades and the direction that it is taking toward ever greater integration and sensor fusion in the cockpit.

OFFENSIVE OR DEFENSIVE?

When the first EW equipment on fighters began to see widespread service during the 1960s, these were standalone devices without much connection to other onboard systems (or to each other) aside from the power supply. They were used to alert the crew to the very few types of radar-guided threats existing at that time, like the Fire Can and Fan Song fire-control radars associated with 57-mm S-60 anti-aircraft artillery (AAA) and SA-2 (SA-75 Dvina) surface-to-air missile (SAM) systems. As operational experience and sophistication increased, a few threat operating modes became discernible as well, though mostly through audio output, with the crew acting as "signal processor." Auxiliary receiver channels in the UHF band were used to alert crews to missile uplink signals, which warned them of immediate threats. They used dedicated indicators and controllers, which were stuffed into the already cramped fighter cockpits of those days.

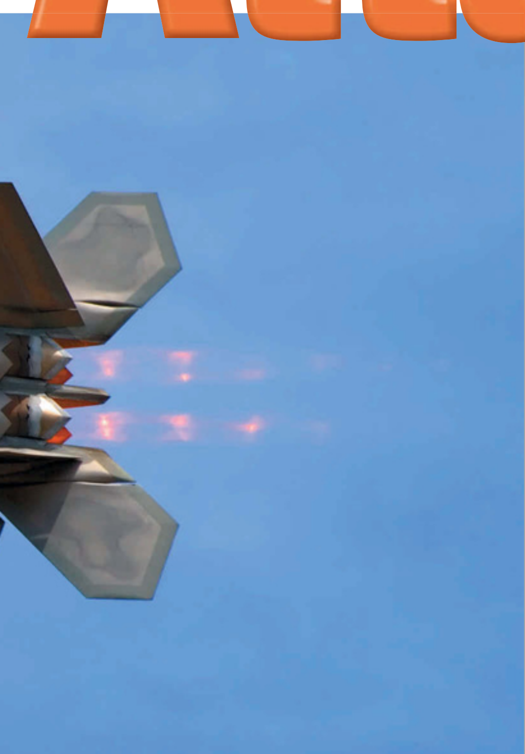
Jammer pods of the era were tuned preflight to threat frequency bands as dictated by experience, intelligence data coming from higher levels or as a result of pioneering EW testing. The primary tactic for aircrews was to begin jamming at a certain point of their mission, maintain prebriefed flight formations to optimize coverage and, of course, hope for the best.

Compared to early US solutions, the Soviet approach exemplified by the standard Sirena-3 warning receiver showed that even much simpler user interfaces (small lights for left/right, high/low threats) could fulfill the goal to the extent it was needed then.

For decades this initial *defensive* functional utilization of EW equipment (mostly radar warning receivers) and the basic requirements regarding threat warning remained the same. However, it must be noted that even the development of early fighter-borne EW systems was not without an *offensive* intent. In the Southeast-Asia theater, same or similar devices (APR-25/26) were used (a few months before their widespread installation on ordinary fighter-bombers) to equip the first Wild Weasel aircraft dedicated to SAM-hunting. For these aircraft the goal was not how to *avoid* the threats, but rather how to *find* them.

It is useful to consider this functional approach when investigating the driving forces behind EW integration. When the EW system is used solely in a

Shifting from Attack



defensive role, the need for sophistication and integration with other onboard systems (other than basic compatibility) is certainly lower. In case, however, it is intended to contribute to the mission as a targeting sensor equal to radar and electro-optical channels, the reqirement to work closely with other systems becomes indipensible.

NO NEED, NO SOLUTION

In practice this division between defensive and offensive EW characterized the development of EW systems in terms of quality and capability, as well as in the level of integration, for many decades. On the one hand (except for specialized defense suppression aircraft) there was no operational need for EW systems to become highly integrated sensors on fighters. On the other hand, technological and cost constraints meant that it was difficult to achieve that level of functionality and integration on fighters. In general, it was not just the poor quality of information supplied by EW equipment that prevented further integration, but also the lack of avionics architectures that could enable the successful fusion of EW information with other information coming from the radar, electro-optic sensors, IFF and navigation systems. The limitations of the one- or two-member fighter crew became obvious quite early, with higher and higher cockpit workloads coming with each new indicator added to the control panel.

Therefore, for quite a long time after EW's baptism of fire over Vietnam, many integration efforts focused on compatibility. As the spectrum of AAA and SAM threats became more diverse, the chances for incompatibility among the fighter aircraft's various electronics systems also increased. To avoid false alarms, filters and "cooperation logic" were included in relevant systems, as a further step in integration. Sometimes these efforts were successful, while in others it caused serious degradation of sensor and communications performance. Oral history of EW does not lack for stories about crews chased around by "ghost" MiGs, only to realize at the final approach to home base that what they encountered was incompatibility between the RWR and the radio-navigation system. The complex problem of compatibility is clearly illustrated by the most widely used (but still not programmable) RWR type of the Warsaw Pact, the L-006 (SPO-15) set. On the MiG-29 for example, the pilot had to choose between operating either the RWR or the N019AE (Slot Back) radar. The warning system became useless if the radar (the main targeting sensor of the fighter) was radiating. (Some sources claim, however, that these restrictions existed only on export aircraft and that aircraft manufactured for Soviet use had a "cooperation" switch).

Altough intended to retain EW effectiveness in the face of ever-changing threat characteristics, the advent of reprogrammable EW systems, which appeared in the West during the 1970s, also made it easier to address these EW-radar compatibility issues. In terms of the RWR's potential to become an equal part of the fighter's sensor suite, the ability of these receiver systems to classify or identify an increasing number of threats with decreasing ambiguities (to improve the quality of information output, so to speak) assisted the crew in building a more accurate and detailed situational awareness (SA) picture.

EMERGING ARCHITECTURE

Maturing avionics technology opened the door for closer integration. When fourth-generation fighters (first of all the US teenager series – F-14, F-15, F-16, etc.) from the 1970s began to employ multiplex buses (MIL-STD-1553B for example) controlled by a central processor, the structural enviroment needed for better integration began to emerge. This opportunity was utilized to a varying degree, but for most fighters of this generation EW system management and EW indications continued to rely on discreet lines and dedicated displays. In others, one of the several MUX buses was dedicated to EW integration. This drove the question: What impact would a frequenly reprogrammed subsystem have on overall system stability and performance, and at the same time how could classified EW data be protected in such an environment? The answer was to maintain a clear division between EW and other parts of the avionics systems.

Generally it meant that information, data, and offbaord cueing was allowed to flow in, but the information gathered by the EW systems was not fed back into the mission avionics suite. What really happened in the so-called federated systems was the closer integration of the different elements of the EW-suite – the RWR, jammer and countermeasures dispensers. This development enabled the automation of countermeasures, freeing up the crew to perform other mission-critical tasks and reducing reaction time. Such an approach resulted, for example, in the Tactical Electronic Warfare Suite (TEWS) of the F-15, which was (and still is) by any standard a massive part of the aircraft's electronics and critical in fulfilling its air superiority sweep missions deep into hostile airspace densely populated with threats. Compared to contemporaries, the increased reliance on this sytem is readily apparent by taking a look into the (original) F-15A/B/C/D cockpit. On the front panel, the TEWS indicator has the same area assigned on the right side as the display of the APG-63/70 radar on the left. But still, the pilot remained the principal integrator of information coming from these two sources, and the situational awareness picture came together only inside his brain, not in a computer and on a multi-function display.

PIONEERING WEASELS

Further along the road, the development of later Wild Weasel defense suppression (SEAD) aircraft allowed a glimpse into the future. The still respected, but long withdrawn F-4G and its replacement, the F-16CJ, had to rely on an onboard passive EW system component capable of ensuring the most effective employment of their High-speed Anti Radiation Missiles (HARMs), while in the Phantom, the specialized all-around APR-38/47 and the Weapon Systems Operator (WSO) did the job. In the case of the single seat F-16CJ, a more automatized and integrated HARM Targeting System (HTS, ASQ-213) was used for this task, as well as increasing reliance on information from data links (initially the Improved Data Modem – IDM). While these systems perfectly supported the task of suppressing air defenses with HARMs, as experience in combat operations showed (for example, Operation Allied Force over Serbia in 1999), a further step in the quality of information (geolocation) and integration was needed to develop Destruction of Enemy Air Defenses (DEAD) capablility.

"Noncooperative targets" operating under strict emission control (EMCON) made it important to act instantly on information coming from whatever sensor, otherwise the enemy could redeploy well within the targeting and weapons engagement cycle of the day. Altough other time-sensitive targeting capabilities have emerged in the past decade, the DEAD mission has become a reality in its own right. For a few years now, with Release 7 (R7) of the HTS, it is possible to use passive RF information to cue an electro-optical targeting pod (a Sniper pod, for example) onto the target and strike it with laser- or GPS-guided bombs. This has become a standard combination on US Block 50 F-16s dedicated to this mission. Though this actual mechanism is probably far from perfect because of the constrained Man-Machine Interface (MMI) environment (lack of display area) of the platform, the realization of offensive functional utilization of the EW system through improved integration is


When you've got less than a second.
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The surface-to-air threat to rotary-wing aircraft continues to escalate, putting the lives of aircrew at risk as never before. Our advanced defensive aids systems help redress the balance by giving helicopter crews an integrated and fully automated self-protection capability that dramatically increases survivability. Scalable to suit the requirements of every helicopter platform, they combine multi-spectral threat warning sensors, advanced control system logic and optimised countermeasures deployment to counter incoming threats without the need for crew intervention.
Detect, protect and survive. Tomorrow's technology is here today.

unquestionable. The use of a passive RF sensor as a targeting channel is readily apparent as well.

STAYING RELEVANT THROUGH INTEGRATION

The latest versions of the 4th-generation fighters, also known as 4+ or 4.5. generation (European aircraft like the Rafale, Typhoon, Gripen, late-model F-16s and F-18s, as well as suitably outfitted Russian and Chinese platforms), now have all the means to have an integrated EW suite that is an equal part of the mission avionics, contributing to offensive operations (targeting) and platform protection. Although architectures differ, and new means of fast, high-volume communication between elements of the avionics (glass fiber networks) have found their way to fighters beyond the original MUX buses, the point is that information from sensors can be fused onboard in a way previously unknown.

For a passive RF system to be useful in such an environment, the long-established qualities of information supplied by them has to be improved upon. For example, to cooperate closely with the onboard radar, which usually has about 1-degree accuracy in measuring azimuth and elevation, a similar level of angle-of-arrival (AOA) measurement is needed with appropriate antenna arrays and signal processing. This means phase-comparison techniques. Otherwise it would be difficult to hand off targets from one sensor to the other or correlate targets between different sensors. As autonomous passive range measurement is still problematic (for approximation, a power gain descriptor is used in threat data), such an accurate angular measurement allows the pilot to use the radar only briefly as a ”spotlight” or within a very narrow search volume to confirm range and dynamic target parameters before missile launch. Alternatively, exchanging AOA measurement through intraflight datalinks between two or more aicraft can result in a track that can be used to initiate a silent missile attack.

Passive RF targets (either on the ground or in the air) can be handed off to EO targeting pods for identification or, in the case of a ground threat, for coordinate-generation fine enough for a precision attack. In some cases, such as the SPECTRA suite of the Rafale, the angular location performance even makes it possible to geolocate and prosecute targets directly without EO ”refinement.” As integrated EW suites on fighters began to include missile warners (like on Rafale, Eurofighter and Gripen NG), the information they supply is added to this equation, and it is clear that in the long run it will be used not only for self-protection but as a further provision for SA.

From an MMI viewpoint, such a level of integration can easily be identified in the cockpit, as dedicated diplays (the circular little Plan Position Indicator of a typical RWR) are missing and controls are kept to a minimum. Instead, different EW pages selectable from multi-function display menus give acess to the EW system even down to details (depending on software configuration) that were never open to crews before. While traditional RWR information can be displayed (some types even have the possibility to project a simple equivalent of this to the Head Up Display – HUD), the best situation is

when a target detected by the EW system can be represented on the Horizontal Situation Display (HSD) and overlayed on a moving map, along with radar targets, threat data, etc. The symbol assigned may designate it as a consolidated target (the information from different sensors represented on the same threat) or a target that comes from only a single source. Targets identified from the library will receive an appropriate threat ring. As with all targets on the HSD/moving map, EW targets can be designated by the cursor for prosecution. Besides destruction, this could mean jamming as well, as these functions can also be initiated from the presented menus.

EW system manufacturers are envisioning further steps. Saab speaks about the next generation EW suite for Gripen, which will be designed to operate in the threat scenarios beyond 2020, featuring increased frequency ranges, improved jamming capabilities, precision DF and MAW/LWS. The system will be based on a multi-function architecture, which provides for seamless integration of radar, comms and EW.

Thales emphasizes the data fusion among all onboard sensors like the RB2E radar (soon to get an AESA front end), Damocles targeting pod, the front-sector optronic sensor and the EW sytem. This allows "the pilot to access a global situation awareness and therefore to be a true tactical decider, instead of a simple sensors operator." The core of the enhanced capabilities of the Rafale lies in the Thales Modular Data Processing Unit (MDPU). Data fusion is carried out in three steps:

1. Establishing consolidated track-files and refining primary information provided by the sensors.
2. Overcoming individual sensor limitations related to wavelength/frequency, field of regard, angular and distance resolution, by sharing track information received from the sensors.
3. Assessing the confidence level of consolidated tracks suppressing redundant track symbols and de-cluttering the displays.

Experience in recent Rafale operations showed that the synthetic tactical situation established onboard was a valuable contributor to the theater Common Air Picture as the data was networked with ground and/or airborne Command and Control Systems.

The Eurofighter, with the Praetorian Defensive Aids Subsystem (DASS), has three active matrix LCDs to present information (including EW) to the pilot, which eliminate the need for a separate indicator and controls. Sensor fusion was part of the concept from day one. According to the "no need, no show" philosophy, the system automatically selects the information that is really needed in a certain situation, like a threat warning display, EW action and options. Eurofighter's unique Voice Throttle and Stick (VTAS) system, which includes Direct Voice Input (DVI), allows access to the DASS as well. As the system was designed from early on to cover lower-band (surveillance) emitters as well as threat radars, the potential contribution to situational awareness and offensive missions is clear. As a unique example of integration, the fighter's EW system compensates angle of arrival information for wing flexing, as DASS pods are located out on the wingtips.

It is known that most late-model F-16s as well as upgraded aircraft deliver various degrees of EW integration. For example, European Mid-Life Upgrade, the USAF's Common Configuration Implementation Program or AIDEWS equipped Polish Block 52+ retain dedicated displays and controls. Terma's widely fielded EW Management System (EWMS), which acts as an integration tool, adds a color LCD Tactical Threat Indicator instead of the original CRT RWR azimuth indicator, as well as 3D threat audio output. While the latest EW systems could interface seamlessly with the avionics systems of these versions, the limited number (2) and area (4"x4") of the multi-function displays (as well as their limited menu system) in most F-16 aircraft makes it difficult to find a place for EW indications and control while retaining enough space for radar display, targeting pod imagery, etc. The only operational exception known is the United Arab Emirate's unique Block 60 Desert Falcon configuration (fitted with Northrop Grumman's Falcon Edge EW suite), which finally moved beyond the two small display configuration and replaced them with three large (5"x7") LCDs, allowing for EW data to be fused and displayed in the cockpit. While it is believed that Block 60 is the closest a 4.5-generation fighter could get to the F-22 and F-35 (using related technologies), it isn't just because of the performance of the unique EW suite, but because of the way it is integrated with the fighter's avionics.

Just like the F-16, the F/A-18 (which was the first to introduce the three-MFD cockpit layout at the end of the 1970s) retained a dedicated RWR display in all but the latest Super Hornet Lots. Given the fact that US Navy and Marines have used Hornets and Super Hornets for SEAD since their appearance in the 1980s, the requirement to hand off targets to HARMs was present from the beginning.

While most of the time Western fighters have standard EW equipment on board with certain integration levels, current Russian production of Su-27 (Flanker) derivatives lack such standards, and EW solutions vary from customer to customer. However, as competition forces the manufacturer to include Western EW solutions (Russia's MiG-35 proposal for India includes the ELT/568(V)2 jammer from Elettronica), the design of the avionics architecture (MIL-STD-1553B) provides for close integration of these and other equipment like Western-sourced targeting pods. Also, cockpit simulators shown at trade shows by Sukhoi included EW pages and controls on MFDs, while dedicated displays were missing. It is also worth noting that even on new MFDs of modernized Su-27SMs destined for the Russian Air Force, they graphically replicated the L-006 RWR indicator with its small azimuth/elevation/emitter category lights (just as it looked like in the Su-27's old analog cockpit). This suggests that to bridge funding shortfalls, it is also possible to build avionics interfaces for old EW equipment to allow their integration into new cockpit displays.

FIFTH GENERATION ADVANTAGE

While the increasing integration of onboard avionics (EW systems included) can keep fourth-generation fighters relevant, there can be no question that fighters designed with full integration in mind from the outset will have an advantage. Both the F-22 and F-35 were designed with large, distributed, but at the same time low observable (LO), apertures in mind, while their predecessors were not. The same is true for Active Electronically Scanned Array (AESA) radars, which are being retrofitted to earlier fighter aircraft. Together with overall LO characteristics and supercruise, the ALR-94 and the ASQ-239 Barracuda EW systems embedded into the avionics of the only fifth-generation fighters will face emerging high-technology threats. Although a few years ago stealth was thought to be the main factor in the survival of these aircraft, it may be that the electronic attack capabilities integrated into the mission system will have an equal or even stronger role.

Although there isn't much debate as to whether increasing integration will make fighters more lethal, practical questions other than combat value remain, which may influence decisions of potential operators. If the price for such a high level of integration is to give up reprogramming authority or the integration opportunity of national sub-systems, some may find it overly expensive, and not just in terms of money.


TAKING YOUR MISSION TO
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TECHNOLOGY SURVEY

Radar Jammers

By Ollie Holt

This month's survey will focus on airborne radar jammers, in both podded and internal installations. In airborne applications, radar jammers are typically designed to be part of a self-protection suite (on a fighter for example) or they can be used in a support jamming role to protect a larger strike package.

For our survey, we asked radar jammer manufacturers to provide information on the following parameters: installation (internal or podded), operational frequency range, installed sensitivity of the receiver within the jammer, effective radiated power (ERP)/gain of the jammer, modes, antenna type provided if part of the jammer system, jamming techniques supported and the weight, power and size.

The first parameter – internal or pod is self-defining. The next parameter is the operational frequency range. Most of the support jammers cover frequencies as low as 500 MHz, and some go as low as 100 MHz (and a few even lower). The jammer's transmit in these lower frequencies because that is the operational range of most early warning radars. In order to disrupt an enemy's integrated air defense system, it is important to start by degrading or confusing the early warning and acquisition elements of the system. Most self-protection jammers usually start around 2 GHz and cover up to around 18 GHz, providing complete coverage of the frequency range from 7 to 12 GHz, where the majority of the tracking radars operate.

The installed receiver sensitivity defines the ability of the radar jammer to detect the radar signal and provide the necessary jamming techniques. The lower the installed sensitivity value, the greater the detection range of the jamming system. This is important for self-protection jammers because of the need to begin jamming before the host aircraft is within the threat system's missile launch range. Usually an installed sensitivity of between -45 dBm and -60 dBm is adequate to support self-protection needs. A low sensitivity has to be balanced with the jammer ERP to prevent interference between receive and transmit antennas. Different blanking techniques are used to optimize the sensitivity and ERP for maximum performance. Some support jammers, depending on the mode of operation, can be preprogrammed to transmit techniques without actually observing the radar signals. These techniques are usually a form of high power noise that degrades the radar system's detection performance. For this type of support jammer, installed sensitivity is not that important. For more advanced support jamming concepts that require the detection of the radar signal, the lower the installed sensitivity performance, the greater the distance the jammer can stand-off and obtain the desired results.

The next parameter is ERP/Gain. For this survey most of the responses are ERP. The ERP is the maximum output power of the jammer system. For support jammers using noise techniques, the larger the ERP, the more disruption it will cause. For self-protection jammers, the ERP required is a balance between the radar cross section of the host platform and the detection range of the threat radar system. The goal is to generate greater jamming power than signal power (the power of the radar signal as reflected from the target aircraft). This is referred to as the jamming-to-signal (J/S) ratio. Keeping the J/S ratio higher than 1 makes the jammer signal a more attractive signal to the radar system. Note: for coherent radar systems, additional signal constraints must be met for this rule to be true.

The next parameter addresses jammer modes. In this case the survey was simply looking to determine if the jammer had the ability to provide a coherent response. Many of the current generation of radar systems integrate some form of coding in the radar signal for both signal processing improvements and jamming detection and protection. By generating a coherent response to the radar, the jammer can overcome these jamming protection schemes. The typical method of providing a coherent response is through the use of a digital RF memory (DFRM) that can capture a sample of the radar signal and then modify the captured RF signal with deception techniques and retransmit the signal at the correct time.

The antenna parameter simply address whether or not the antenna is part of the jammer system and, if so, what type of antenna is used. The technique category provides information on the different types of techniques each jammer can provide. Most support jammers will provide different types of techniques, including wide and narrow band noise, sweep noise, barrage noise and blinking. The self-protection jammers will typically provide coherent and non-coherent range, velocity and angle techniques along with combinations of these techniques. The final set of parameters addresses the jamming system's weight, size and power. If the jammer comprises more than one line replaceable unit (LRU), each LRU is listed individually.

JED's next survey, covering RF power sources for IED and communications jammers, will appear in the September edition. E-mail JEDeditor@naylor.com to request a survey questionnaire.

TECHNOLOGY SURVEY: RADAR JAMMERS

MODEL	CONFIGURATION	JAMMER TYPE	FREQ RANGE	SENSITIVITY	ERP/GAIN	MODES
BAE Systems E&IS; Nashua, NH, USA; +1-603-885-6065; www.baesystems.com/eis						
ALQ-196	internal	self protection	*	*	*	*
EADS Defence Electronics; Ulm, Germany; +49 731-392-2861; www.eads.com						
MFJS	pod	self protection	2-18 GHz	*	*	all
Elettronica; Rome, Italy; +3906 4154 745; www.elt-roma.com						
ELT/553 & ELT/558	internal	self protection	E to J and B to D bands	high	medium	coherent/noncoherent
ELT/703	pod	support jammer	B to J bands	very high	very high	coherent/noncoherent
ELT/555	pod	self protection	E to J bands	medium	medium	coherent/noncoherent
ELT/560 ELT/561 ELT/568	pod/internal	self protection	E to J bands	very high	high	coherent/noncoherent
ELTA Systems Ltd.; Ashdod, Israel; +972 8 857 2190; www.elta.co.il						
ELL- 8212	pod	self protection	6.5 -18 GHz	*	*	*
ELL- 8222	pod	self protection	6.5 -18 GHz	*	*	*
ELL- 8251	pod/internal	escort jammer	1 -18 GHz	*	*	*
ELL- 8246	internal	self protection	2 -18 GHz	*	*	*
ELL- 8248	internal	self protection	2 -18 GHz	*	*	*
Indra; Madrid, Spain; +34-91-480-50-01; www.indra.es						
ALQ-500 (Export Version)	internal	self protection or support jammer	6-18 GHz	-40 dBm	•	coherent/noncoherent
Rafael; Haifa, Israel; +972-4-879-4444; www.rafael.co.il						
Sky Shield	pod	support jammer	1-18 GHz	-70 dBm	70 dBm	coherent
Saab, business area Electronic Defese Systems; Järfälla, Sweden; +46-8-580-840-00; www.saabgroup.com						
BOQ-X300	pod	self protection	2-18 GHz	-60 dBm	300 W-3 kW	coherent, noise, CW repeater.
SELEX Galileo; Luton, UK; +44 (0) 1 58 28 86 000; www.selexgalileo.com						
Modular Counter Measure System	pod/internal	self protection or support jammer	E to J bands	high	20 W (low) to 10 kW (very high)	coherent/noncoherent
Sky Shadow III	pod	self protection	G to J bands	high	medium	coherent/noncoherent
EuroDASS / Praetorian	internal	Self protection jammer	G to J bands	high	medium	coherent/noncoherent
Thales Airborne Systems; Elancourt CEDEX, France; +33 (0)1 34 81 60 00; www.thalesgroup.com						
PAJ-FA (Podded Airborne Jammer)	pod	self protection	H to J bands	*	*	coherent/noncoherent
HBJ (High Band Jammer)	internal	self protection	H to J bands	*	*	coherent/noncoherent
SPECTRA	internal	self protection	G to J bands	*	*	*
TJR Electronics Inc; Rockledge, FL, USA; +1-321-632-1130; www.tjrelectronicsinc.com						
Threat Radar Jammer	pod/internal	self protection	5.25-10.5 GHz and 9-18 GHz	variable	68.8 dBm	coherent/noncoherent
Ultra Electronics Telemus; Ottawa, Ontario, Canada; +631-592-2288; www.telemus.com						
Raven	pod/internal	self protection or support jammer	0.8-18 GHz	-65 dBm	*	coherent/non-coherent; deception/denial

ANTENNA	TECHNIQUES	POWER (W)	SIZE (HxWxL inches/cm)	WEIGHT (lb/kg)	FEATURES
array	*	*	*	*	*
*	all	*	23 x 15 x 106 cm	280kg	Coherent and non coherent ECM techniques; Learjet configuration.
directive	any technique for both pulsed and CW threats	*	2 ATR(3/4) +antennas	110 kg	TWT TX
active solid state array	any technique for both pulsed and CW threats	*	29 D x 157 L in.	650 kg	Solid State TX
directive	any technique for both pulsed and CW threats	*	14 D x 118 L in.	140 kg	TWT TX
active solid state array	any technique for both pulsed and CW threats	*	1 ATR + active arrays	65 kg	Solid State TX
*	multi	2000 W	18 x 24 x 234 cm	100 kg	Power managed jamming regime
*	multi	2000 W	24 x 19 x 243 cm	105 kg	Power managed jamming regime
*	multi	*	*	*	Power managed jamming regime
*	multi	*	*	*	Power managed jamming regime
*	multi	*	*	*	Power managed jamming regime
horn	noise and deception	1 kW	19.7 x 94.5 in.	115 kg	Multiple techniques; multi-threat capability.
array (ESAT)	multi	8000 W	380 x 56 x 86 cm	650 kg	Fully autnomoous and accurate jamming against several targets, includes accurate direction finding. One certified pod that contains the entire system.
horn; array opt	noise, doppler and coherent (DRFM) techniques.	4-6 kW	16.9 D x 160.2 L cm	270-330 kg	Option for 0.5-40 GHz; integrated with towed radar decoy.
horn or array	range of DRFM based techniques	150 W to 5 kW	one or more 1/2 ATR profile chassis	from 4 kg	UsesiIndustry standard modules and racks. Customer selectable frequency range, receiver type, sensitivity, DRFM configuration and transmitter.
horn, forward and aft;	range of DRFM based techniques	Approx 6 kW	420 mm D x 3.6 m L	330 kg	Upgrade to Sky Shadow II standard; installed on Tornado GR4.
fore and aft phased array transmitters	range of DRFM based techniques	Approx 5 kW	Approximately 15 avionics units with various dimensions	170 kg	Fully integrated DASS including ESM, ECM and active MAW; part of Eurofighter Typhoon.
beam on antenna axis	DRFM	*	135 L x 6.3 D in.	85 kg	In service on Mirage-F1 and Super Etendard.
beam on antenna axis	DRFM	*	*	62 kg	In service on Mirage 2000.
solid state beam steered	DRFM	*	*	*	In servie on Rafale.
polar circular	Noise and deception	7.5 kW	Cockpit: 1/4 ATR; Pod: 6.7 x 15 x 17 cm, excluding hardback	Pod 175 kg	Jammer Scenario Switch; Transmit Command Switch; Forward/Aft Switch; Horizontal Vertical Test Switch; range of DRFM based techniques.
omni, horns, array	Coherent and non-coherent programmable techniques	*	*	*	Raven EW suite available in ESM or ELINT configurations; operator in the loop “point and shoot”; Windows MMI.

Survey Key – Radar Jammers

On-Board Jamming Systems

MODEL
Product name or model number

CONFIGURATION
Jammer configuration (internal, pod or both)

JAMMER TYPE
Type of radar jammer (Self Protect or Support Jammer)

FREQ RANGE
Operating frequency range (in GHz)

SENSITIVITY
Typical receiver installed sensitivity

ERP/GAIN
ERP or Gain (whichever is applicable to the system)

MODES
Coherent, non coherent, both

ANTENNA
Omni or Array

TECHNIQUES
Techniques
- CW = continuous wave
- DRFM = digital radio frequency memory

POWER
Power dissipated in Watts

SIZE
H x W x L/D in inches or centimeters

WEIGHT
Weight in lb/kg

FEATURES
Additional features
- TWT = travelling wave tube
- PRI = pulse repetition interval
- RF = radio frequency
- IBW = instantaneous bandwidth
- DASS = Defensive Aids Sub-System
- ESM = electronic support measures
- MAW = missile *approach warner*

OTHER ABBREVIATIONS USED
- opt = option/optional
- dep = dependent
- config = configuration
- wband = wideband
- nband = narrowband
- < = greater than
- > = less 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
Bharat Electronics Ltd.	www.bel-india.com
ITT	http://es.itt.com
Northrop Grumman	www.es.northropgrumman.com
Raytheon	www.raytheon.com

September 2010 Product Survey: RF Power Sources for IED/Comms Jammers
This survey will cover RF power sources for IED and communications jammers. Please e-mail JEDeditor@naylor.com to request a survey questionnaire.

EW Against Modern Radars – Part 8A*

Monopulse Radar and Anti-CrossPol EP

Monopulse radars get direction-of-arrival information from every skin-return pulse. Because this makes certain kinds of deceptive jamming ineffective, it can be considered an electronic protect (EP) technique. Cross polarization (CrossPol) is one of the techniques specifically recommended for use against monopulse radar. Thus, anti-CrossPol EP approaches deserve careful attention.

Monopulse Radar

Jamming techniques, such as range gate pull-off or cover pulses, provide range deception, but because they generate strong pulses from the direction of the target, they enhance angle tracking by monopulse radars. Angle-deception techniques like inverse gain jamming, which generate strong pulses to fool radar tracking algorithms, likewise enhance monopulse angle tracking.

In general, angle deception is more powerful than range deception. A radar can typically reacquire in range in milliseconds, while a significant pull-off in angle will require a return to the radar's acquisition mode. This may cause an angle reacquisition time of seconds.

A chaff cloud or a decoy, which creates an actual, trackable object, works well against monopulse radars.

Monopulse radars point their antennas toward targets by adjusting in angle to balance the power received by multiple antenna feeds as in **Figure 1**. Effective angle jamming forces the radar to move its antenna in an improper direction in response to jamming signals, which distorts the balance of the antenna feeds. For example, CrossPol jamming causes a radar to point one of its cross-polarized Condon lobes at the target.

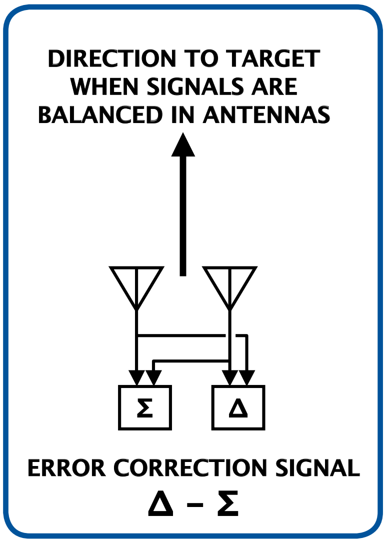

Figure 1: A monopulse radar has multiple antenna feeds and generates antenna pointing corrections from the difference of the two received signals normalized to the sum.

Cross Polarization Jamming

CrossPol jamming was covered in the April 2010 "EW 101," but to better understand Condon lobes, try this:

Hold a pencil in your hand oriented 45 degrees to the right and move your hand toward a wall at a 45-degree angle until the pencil touches the wall. Then move your hand in the direction that the pencil would move if it were "reflected" from the wall. You will notice that the pencil is now oriented 45 degrees left in the direction of travel. The forward geometry of the wall and the angle of the diagonal angle of the pencil have caused the angle of the pencil relative to the forward motion of your hand to change 90 degrees.

Now consider the vertically polarized signal arriving in the upper right portion of the parabolic dish reflector in **Figure 2**. The forward geometry of the dish causes a (weak) horizontally polarized reflection toward the antenna feed because this part of the dish is about 45 degrees to the signal polarization. This effect causes each Condon lobe.

In his excellent but very technical (and now out of print) set of three books on applied electronic countermeasures, Leroy Van Brunt provides detailed discussions of CrossPol jamming. He points out that CrossPol jamming can be used with either on-frequency or noise jamming and is effective against both acquisition and tracking radars, including the two-beam SA-2 track-while-scan radars in which the beams are cross polarized to each other.

In addition to the two-path repeater type CrossPol jammer described in the April 2010 "EW 101," there are jammers that sense the polarization of arriving radar signals and create a cross polarized response with a signal generator as shown in **Figure 3**.

If a two-channel repeater CrossPol jammer cannot achieve adequate antenna isolation, Mr. Van Brunt points out that time gating can be used to isolate the

***Editor's Note:** Due to an editorial error, the June 2010 "EW 101" installment was misnumbered as the eighth article in the "EW Against Modern Radars" series. It should have been titled "EW Against Modern Radars – Part 7." The articles themselves have been published in the correct sequence. The June "EW 101" was simply misnumbered. *JED* regrets the error.

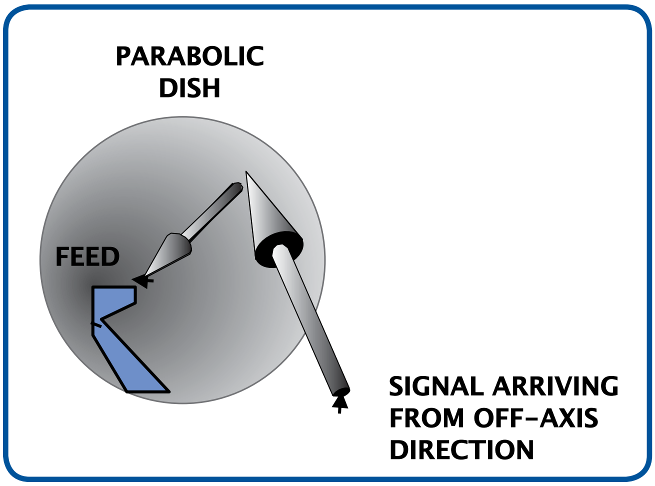

Figure 2: The forward geometry at the edges of a parabolic dish reflector cause off-axis signals to change polarization by 90 degrees when reflected into the antenna feed.

two cross polarized signals from each other. The timing he suggests in his text predates the availability of modern, extremely fast switches like those presented in the discussion of Cross-Eye jamming in the April 2010 "EW101." The time-gated CrossPol technique should work even better with today's technology.

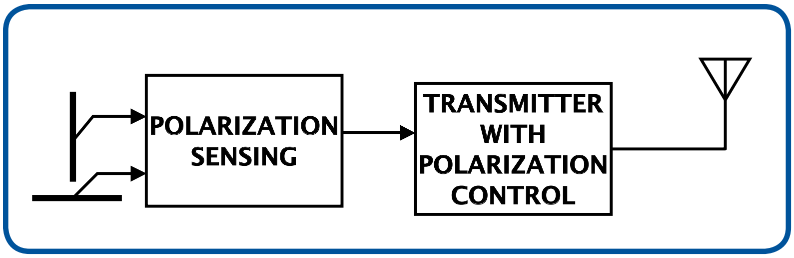

Figure 3: One technique for creating a cross-polarized jamming signal involves sensing the polarization and generating a return signal with the proper polarization.

Anti-CrossPol

Radars that include features to reduce their sensitivity to cross polarized signals or to reduce their Condon lobes are said to have Anti-CrossPol EP. As shown in **Figure 4**, a radar with "CrossPol" isolation has very small Condon lobes. A radar antenna reflector that is a small part of a large parabolic surface will have its feed far from the reflector – relative to the reflector diameter – and the reflector will have little forward geometry (hence low Condon lobes). If the reflector is a larger part of a smaller parabolic surface, its feed will be relatively close to the reflector and the reflector will have more forward geometry, hence higher Condon lobes. If the radar antenna is a flat phased array, it will typically have almost non-existent Condon lobes because it has no forward geometry to create the cross polarized response. However, if there is differential gain in its array antenna elements for beam shaping, it can have Condon lobes. The antenna geometry impact on Condon lobes is illustrated in **Figure 5**.

Another way to implement Anti-CrosPol EP is with a polarization filter across the throat or feed of the antenna or across the phased array.

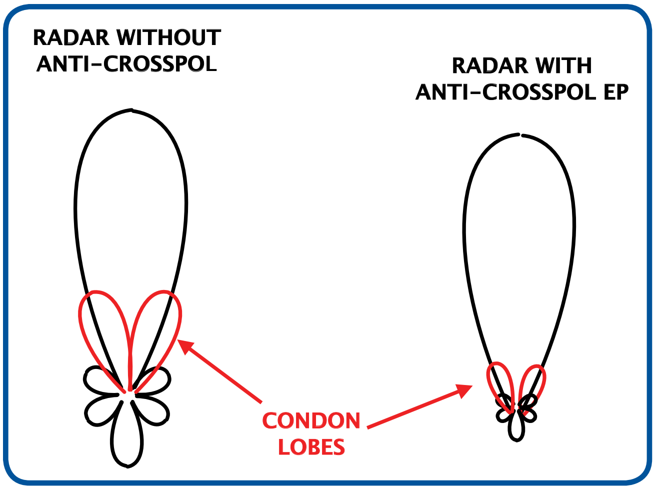

Figure 4: A radar with anti-CrossPol EP has greatly reduced Condon Lobes.

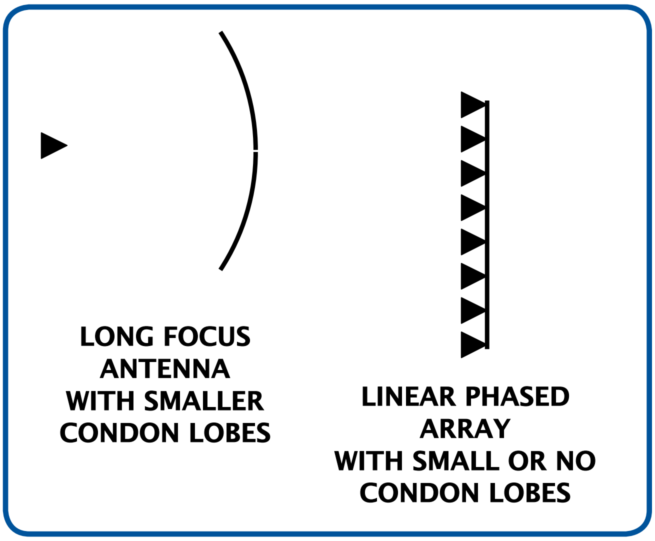

Figure 5: The geometry of a radar's antenna impacts the strength of its Condon lobes.

Polarization Canceller

This related EP technique is also described in Mr. Van Brunt's series (book 2). It involves use of two orthogonally polarized auxiliary antennas, and can be very effective against a single circularly or diagonally polarized jammer. Its circuitry discriminates against the component of the jamming signal that is not co-polarized with the radar but passes the radar's skin return signal. Mr. Van Brunt notes that dual cross-polarized jamming channels (as described in the April 2010 "EW101") will defeat this EP technique.

What's Next

Next month, we will continue our discussion of Radar EP with pulse-compression techniques. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

MUGU CROWS AWARD SCHOLARSHIPS

The Mugu Crows Chapter has completed its 2009-2010 scholarship program. Six $1,000 scholarships were given out this year to graduating high school seniors or engineering and technical students already attending a college or university. This year's recipients were:

For the **Commander William J. Coffey Memorial Scholarship,** given to four graduating Seniors from Ventura County High Schools:

Shannon Esswein a graduate of Simi Valley High School will be attending the University of California at Los Angeles with a major in Electrical or Bio Medical Engineering. She enjoys the hands-on aspects of science and continually researchers the science behind the experiments in physics, biology and chemistry.

Garret Squire a graduate of Simi Valley High School will be attending a four-year university with a major in computer science. He wants to apply his technical expertise to helping others live a better life.

Ciera Lowe a graduate of Santa Susana High School will be attending a four-year university with a major in engineering. While she is still determining what area of engineering she wants to major in, she has the potential to be a leader in the technical arena.

Talmage Jones, a graduate of Newbury Park High School, will be attending Brigham Young University with a major in mechanical engineering. Talmage has a love for building things and wants the engineering background that will allow him to follow his dreams.

For the **Robert L. Nielson Memorial Scholarship,** given to an engineering student attending a California University:

Travis Miller will be entering his third year at California Polytechnic State University at San Luis Obispo. Travis is an Aerospace Engineering major with a major interest in rocket science. He is currently building his own rocket with Cal Poly Space Systems and working with a team of engineering students working on the propulsion fuel for an 18-foot rocket.

For the **Point Mugu Missile Technology Historical Association (MTHA) engineering scholarship,** given to a student attending a junior college or a four-year university. The MTHA is a group of technical personnel dedicated to the preservation of the history of missile development at Point Mugu, California:

Myles Cupp will be in his third year as an engineering student and will be attending California State University at Fullerton. Myles is a transfer student from Fullerton Junior College. He is pursuing an electrical engineering degree and has maintained his academic record while working to defray his college expenses. In addition to his academic record, he has shown an exceptional capability to explain complex scientific principles to others. Myles feels that to maintain our society and our standard of living it is important to develop our engineering and scientific talent.

DIXIE CROWS MOURN BUEL DYER'S PASSING

Former Dixie Crow Chapter President Buel A. Dyer, CMSgt, USAF (Ret.), died in April, in Warner Robins, GA, at the age of 78.

Dyer served as President of the AOC Dixie Crow Chapter five times and spent 27 years on that chapter's board of directors. He also served on the board of the Warner Robins Chamber of Commerce and spent time volunteering at the Warner Robins Museum of Aviation. As a member of the US Air Force, Dyer attained the rank of Chief Master Sergeant and was a veteran of both the Korean War and Vietnam War.

Dyer was born November 29, 1931, in Morganfield, KY. He is survived by his sister, Eva Clara Stone and brothers, Joseph B. Dyer and James Perry Dyer.

A funeral mass was held April 27 at Sacred Heart Catholic Church in Warner Robins. Donations in Dyer's memory can be made to the church at 300 S. Davis Drive, WR, GA (www.sacredheartwr.com).

VIEWS FROM INFOWARCON 2010

AOC's InfowarCon 2010 was held May 12-14 at the Washington Convention Center, drawing close to 300 attendees from throughout the Information Operations and Cyber Warfare arenas. High-level government and military officials came together with leading experts from across industry and academia for thought-provoking sessions designed to foster important discussions among the participants and the agencies and organizations they represent.

The opening keynote address was delivered by InfowarCon's founder Winn Schwartau, who presented an eye-opening outlook on "4G Warfare," referring to the smart phone as the new computer, and pointing to these mobile, prolific devices as a huge risk to military and government operations. From that point on attendees knew they were in for something fascinating, as they were taken through a spectrum of presentations and panel discussions, which covered topics ranging from the role of social media in shaping the future of mass communication to the convergence of electronic warfare and IO/Cyber in military operations. Through this rare blend of sessions, the event provided an ideal forum for the sharing of ideas and constructive, spirited debate.

The conference proved to be an exciting international partnership as well, with professionals from the United States, Australia, Canada, Israel, South Africa and the United Kingdom getting a chance to offer their own unique perspectives on pressing issues within information operations, media and public affairs and cyber intelligence.

Corporate sponsorship for InfowarCon was provided by some of the leading innovators in the world of IO, including Northrop Grumman, SAIC, SOSi (SOS international Ltd.), Visible Technologies, ConStrat, TASC, S4, SRC, Leonie and General Dynamics. Without the support of these companies, the event could not have been so successful. – *Jon Pasierb*

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