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The AOC Electronic Warfare Publication
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JED
The Journal of Electronic Defense

Advancing TWT Technology

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News

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GOING IT ALONE?

Over the past couple of months, I have traveled to a number of events, such as the EW 2009 Symposium in London, the International Microwave Symposium in Boston and the Paris Air Show. During these shows, I have been fortunate to meet with many military and industry leaders from around the world, who have offered some excellent insight about where EW is headed in terms of policy, requirements, new programs and technology.

One thing that is becoming very clear is that no one country (or company) can do it all in EW these days. International cooperation in EW (at the government-to-government level and at the industrial level) is becoming more important than ever in the face of new and evolving threats enabled by commercial technology. We simply need to find a better way to develop EW technology, acquire EW systems and train EW professionals in order to keep up with this threat.

Today, any military leader who thinks his forces are well prepared for the future threat ought to visit his local electronics shop to get a better sense of what is coming. In 2003, for example, who would have thought their mobile phone was soon to become part of a weapon that would be responsible for thousands of casualties and generate political and military effects on a strategic level? Apparently Al Qaeda and Iraqi insurgents did. So, what's next?

I am increasingly convinced that the commercial technology pattern we have seen in the IED world is already occurring in the laser world, and it will soon begin to occur in the radar world. If we don't start to think about the threat in new terms and respond with a new approach to EW, we will eventually find ourselves again investing billions of dollars to defeat an electromagnetic (EM)-enabled adversary who is investing tens-of-thousands of dollars to leverage commercial electronics technology. That's a losing proposition for the warfighter, who will be forced to find another way (outside EW) to defeat these threats.

Faced with this problem, I don't think any nation is going to be able to address future EM-enabled threats independently. More and more, countries are cooperating on their EW programs. Look at what Israel has achieved in countries like India and Singapore. Europe is not missing many opportunities either. Think about relationships such as the UK and Saudi Arabia, or Sweden and South Africa or Italy and the UAE. Although the US has experimented with cooperative development in selected countries, it is much further behind in this trend.

Clearly, there needs to be more robust trans-Atlantic cooperation if the global EW community is to have any expectation of keeping up with new threats. That cooperation needs to begin with policy makers. So far, I haven't heard much from them on the subject of EW. I'm concerned that we're going to have to learn some tough lessons before they realize what we're seeing in Iraq isn't an anomaly, but rather the tip of the iceberg.

– John Knowles

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JULY

7th EO/IR Conference
July 15-17
Shrivenham, UK
www.cranfield.ac.uk

EW Modeling and Simulation Conference
July 28-31
Las Vegas, NV
www.crows.org

AUGUST

Directed Energy Test and Evaluation Conference
August 10-12
Albuquerque, NM
www.deps.org

Unmanned Systems North America
August 10-13
Washington, DC
www.auvsi.org

TADTE 2009
August 13-16
Taipei, Taiwan
www.tadte.com.tw

MAKS 2009
August 18-23
Moscow, Russia
www.aviasalon.com

11th Annual Space Protection Conference
August 25-27
Kirtland AFB, NM
www.crows.org

2009 Homeland Security Conference
August 31-September 4
Monterey, CA
www.crows.org

SEPTEMBER

DSEi
September 8-11
London, UK
www.dsei.co.uk

AFA National Convention
September 12-13
Washington, DC
www.afa.org

C4ISR Symposium
September 14-17
Atlantic City, NJ
www.afcea.org

Passive Covert Radar Conference
September 15-17
Verona, NY
www.crows.org

11th Defense Operational Applications Symposium
September 30-October 2
São Paulo, Brazil
www.sige.ita.br

OCTOBER

2009 AUSA Annual Meeting & Exposition
October 5-7
Washington, DC
www.ausa.org

Worldwide EW Infrastructure Conference
October 6-8
Atlanta, GA
www.crows.org

AOC 46th Annual Convention
October 18-21
Washington, DC
www.crows.org

NOVEMBER

2nd Annual Navy EWIIP Conference
November 3-5
Virginia Beach, VA
www.crows.org

Low Probability of Intercept ELINT/SIGINT Conference
November 17-19
NPGS, Monterey, CA
www.crows.org

For more information on AOC conferences, visit www.crows.org.

JULY

Developing RF Prototype Hardware
July 21-23
Atlanta, GA
www.pe.gatech.edu

A Primer in EW Modeling and Simulation
July 27-28
Las Vegas, NV
www.crows.org

A Primer in Deception History and Techniques
July 28-30
Alexandria, VA
www.crows.org

AUGUST

Fundamentals of Airborne Electronic Combat Test and Evaluation
August 10-14
Atlanta, GA
www.pe.gatech.edu

IR/Visible Signature Suppression
August 18-21
Atlanta, GA
www.pe.gatech.edu

EMC/EMI for Engineers and Engineering Managers
August 18-21
Las Vegas, NV
www.pe.gatech.edu

SEPTEMBER

TEMPEST Threat Management
September 9-10
Fairfax, VA
Clearance: Secret/US only
www.afcea.org

Advanced RF EW Principles
September 14-18
Atlanta, GA
www.pe.gatech.edu

Antenna Engineering
September 14-18
Boulder, CO
www.pe.gatech.edu

Phased Array Antennas and Adaptive Techniques
September 15-17
Atlanta, GA
www.pe.gatech.edu

The US Intelligence Community
September 15-17
Fairfax, VA
Clearance: Secret/US only
www.afcea.org

Basic RF EW Concepts
September 15-18
Atlanta, GA
www.pe.gatech.edu

Infrared Technology and Applications
September 15-18
Atlanta, GA
www.pe.gatech.edu

Transmit/Receive Modules for Phased Array Radar
September 22-24
Atlanta, GA
www.pe.gatech.edu

Digital Radio Frequency Memory (DRFM) Technology
September 22-24
Atlanta, GA
www.pe.gatech.edu

Principles of Radar Electronic Protection
September 29-October 1
Atlanta, GA
www.pe.gatech.edu

Fundamentals of TEMPEST Security
September 30-October 2
Fairfax, VA
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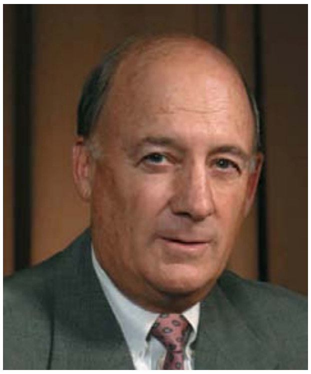

SECURITY COOPERATION

This month, I am writing about electronic warfare (EW) exports. Although I will discuss US EW exports (an area in which I have been working for the past 25-plus years), the issues I raise truly apply to most nations that export or buy EW equipment.

In terms of the global EW market, the US, Europe and Israel account for most export sales. These EW export deals are typically part of a larger weapons buy (fighter aircraft, helicopters or ships, for example). For the supplier and the customer, these export sales are ultimately part of a larger national strategy to develop relationships with allies, help to ensure their security and build a stronger domestic EW industry. International sales also play an important role in developing strong coalition partners in regional theaters.

Today, DOD Security Cooperation includes many players – the DOD leadership and individual Services, combatant commanders (COCOMs), industry, and the customer nations who buy the EW equipment. Each of these stakeholders has a different (and I would say distinctive) view about what security cooperation really is and is not.

The DOD leadership and the Services are engaged in a broad program of developing partners for peace and maintaining a strong industrial base that can develop and deliver EW systems at the lowest possible cost to domestic customers. From the COCOM's perspective, I believe security cooperation is primarily about developing strong military allies for coalition operations in future conflicts. It is primarily the COCOMs who focus on developing those "export customers" into potential "coalition partners" and who must think in terms of interoperability. Industry has its own perspective in security cooperation, which is to manufacture and deliver EW systems and earn enough profit to help fund future research and development efforts. It would be refreshing if industry, in a collective sense, was more in line with the DOD, the Services and the COCOMs on requirements for interoperable systems, partnerships and coalition-capable allies. And then there are the international customers. I believe their perspective on security cooperation programs is simply to acquire weapons systems, technology and training to protect the homeland. They, too, need to think about coalition partnership and interoperability.

From my perspective, it would be interesting if the four groups mentioned above could understand the common goal they are striving to achieve. (Too often, in my experience, this does not seem to be the case.) In the world of EW, I believe the AOC is the one place where the various stakeholders in security cooperation (regardless of which country is selling or buying) can come together and explore the possibility of making this, to some degree, a reality. Join AOC if you are not a current member and let's explore together the possibilities (at least in EW) of deploying interoperable systems that provide western nations and their international partners with the ability to fight as one force to defend freedom.

– Kermit Quick

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USAF STAND-IN JAMMER PROGRESSES

The US Air Force reported last month that Raytheon's Miniature Air-Launched Decoy-Jammer (MALD-J) program had successfully completed its Preliminary Design Review milestone. MALD-J adds a radar-jamming payload to the basic MALD, a cruise missile-like, turbojet-powered, expendable maneuvering decoy with a range of 500 nautical miles. MALD is in low-rate production at Raytheon Missile Systems (Tucson, AZ) and is slated to become operational this fall. The service's MALD program manager at Eglin AFB, FL, Ken Watson, said he had cleared the MALD-J program to proceed with final design activities and prepare for a Critical Design Review by early next year. MALD-J recently completed captive-carry testing, he said. Raytheon will conduct a free-flight demonstration later this year and begin engineering and manufacturing development in 2010. A production decision is planned in early 2011, Watson said. MALD-J will provide "stand-in" jamming close to enemy air defenses.

Harry Schulte, vice president for air warfare systems at Raytheon Missile Systems (Tucson, AZ), told reporters at the Paris Air Show on June 15 that the UK is interested in acquiring the basic MALD vehicle, dubbed MALV. He said the US and UK governments had recently signed a technical assistance agreement for a MALD demonstration, and that Raytheon had been cleared to talk to British defense officials about the MALV. Under this agreement, the UK would integrate its own payloads into the MALV – *G. Goodman*

NEW US BACKPACK IED JAMMER

Sierra Nevada Corp. (Sparks, NV) emerged last month as the winner of a three-company competition to manufacture new Joint Counter Radio-Controlled Improvised Explosive Device Electronic Warfare (JCREW) 3.1 dismounted backpack jammers for the US military services. Naval Sea Systems Command (NAVSEA) awarded the company an initial $36.5 million contract for 200 of its Thor III systems, with options for an additional 2,300 that could bring the contract's cumulative value to $248.3 million. Sierra Nevada, ITT Advanced Engineering and Sciences (Annapolis Junction, MD) and Northrop Grumman Mission Systems (San Diego, CA) had each been awarded a contract in December 2007 to provide seven off-the-shelf JCREW 3.1 engineering prototypes for test and evaluation. (ITT, Northrop Grumman and SRCTec of Syracuse, NY, are competing for a separate five-year NAVSEA contract to supply up to 5,000 new JCREW 3.2 vehicle-mounted jammers.)

The vast preponderance of the jamming systems that have been in use by US Army and Marine Corps units in Iraq and Afghanistan are vehicle-mounted. The US military has fielded far fewer man-portable counter-IED systems for dismounted soldiers, particularly due to the demanding size, weight and power requirements of those systems. They must be much smaller and lighter than vehicle-mounted systems, while including a battery pack for power and an antenna. They also must provide an effective level of jamming performance – as many watts as possible – without endangering the safety of the soldier carrying the system from the emitted radiation. Vehicle-mounted systems are less constrained by size and weight compared with dismounted systems, and they draw on the vehicle's power instead of batteries to achieve greater jamming power and range.

While man-portable systems are typically carried in a backpack, the first to be deployed in Iraq in August 2005 was actually a hand-held system called Warrior Blue, which resembled a "walkie-talkie" radio. Produced by northern California-based Tyco Electronics, the portable jammer was used by infantrymen on foot patrols or at checkpoints. However, the half-watt system quickly became obsolete, because it was designed to counter a low-power radio threat and insurgent bomb makers soon moved to more powerful radio triggers. The device also used eight lithium batteries, which required frequent replacement.

The first backpack-mounted counter-IED jamming system to be fielded with US Army and Marine forces was Guardian. More than 1,000 were deployed in Iraq and Afghanistan in 2006-2007. The US Department of Defense procured the systems from BAE Systems (Nashua, NH), whose principal subcontractor was Finmeccanica subsidiary Selex Communications (Christchurch, Dorset, UK), which developed and manufactures the Guardian family of man-portable jamming systems.

Guardian is a re-programmable jammer with a vertical antenna and features integrated forced-air cooling. It is powered by a lithium-ion battery that can operate up to four hours. Guardian provides continuous coverage capability from 25 MHz to 2.5 GHz and provides 10 watts of jamming power, according to Selex. The system can provide either broadband barrage jamming or spot jamming of particular frequencies in its coverage area.

The JCREW 3.1 requirements called for improved performance – including longer range – and reduced size and weight compared to Guardian. Sierra Nevada bid the latest version of its Thor backpack jammer family – Thor III. Its Thor IA system won a US Special Operations Command competition in mid-2006. The company delivered 161 systems and was awarded a contract to develop an improved Thor II system, which is now in production. According to a company data sheet, Thor IA weighs 15 pounds (6.8 kilograms) with its rechargeable lithium-ion battery pack and achieves up to 70 watts of jamming power. A Sierra Nevada representative said Thor IA provides "Band A" coverage, while Thor II, about 2.2 pounds (one kg) heavier and a little thicker, covers Bands A and B. Due to weight limitations, Thor III features three interchangeable modules that cover Bands A, B and C. – *G. Goodman*

TURBOPROP SIGINT AIRCRAFT INTRODUCED

The US Air Force's new twin-engine turboprop MC-12W Project Liberty aircraft flew its first combat sortie over Iraq, a four-hour daylight mission from Balad air base, on June 10. The MC-12W is a twin-turboprop Hawker Beechcraft King Air 350 outfitted with intelligence, surveillance and reconnaissance (ISR) sensors, including a signals-intelligence (SIGINT) payload. Deploying a number of the aircraft quickly to Iraq and Afghanistan to augment unmanned RQ-1 Predator and RQ-9 Reaper drones has been a high priority of Defense Secretary Robert Gates and an ISR Task Force he stood up last year.

The Air Force plans to field 37 of the unarmed aircraft by 2010. It acquired seven used C-12 King Airs for modification and plans to order 30 new extended-range King Airs from Hawker Beechcraft. The company delivered the first new-build aircraft in April. L-3 Communications

Integrated Systems (Waco, TX) is the prime contractor and is doing the aircraft modifications and sensor/mission payload installations. L-3 delivered the first MC-12W – one of the used aircraft – only seven months after contract award. The Air Force hopes to have six MC-12Ws deployed in theater by next month.

The MC-12W has a crew of four – a pilot, copilot/mission commander, a sensor operator and a SIGINT specialist. The sensor is an L-3 Wescam MX-15 ball turret with daylight and infrared cameras that provide full-motion video. The previously undisclosed SIGINT payload, according to a USAF official quoted in *Air Force Times*, is dubbed "Pennant Race," which he said is an upgraded version of the SIGINT package that has been used on Predators and Reapers in addition to their mainstay Raytheon Multi-spectral Targeting System (MTS) ball turret video cameras. The used MC-12Ws can fly missions of up to four hours; the extended-range new-build versions can stay aloft for six hours.

Mission qualification training for the pilots and enlisted airmen is currently conducted by a combined active USAF and Air National Guard detachment embedded in the 186th Air Refueling Wing of the Mississippi ANG at Key Field in Meridian, MS. The MC-12Ws in Iraq are assigned to the 362nd Expeditionary Reconnaissance Squadron of the 332nd Air Expeditionary Wing. – *G. Goodman*

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INTEGRATED TOPSIDE CONTRACTS AWARDED

In late May, the Office of Naval Research (ONR) awarded a five-year, indefinite delivery-indefinite quantity (ID/IQ) task order contract to 18 different companies under its Integrated Topside (InTop) technology project, one of the research efforts under the US Navy's Innovative Naval Prototype program. InTop aims to reduce the number of topside radio-frequency (RF) apertures present on Navy surface ships through the use of integrated, multi-function, multi-beam, shared transmit and receive antenna arrays.

US Navy surface combatants currently employ large numbers of federated, stand-alone, RF systems and associated antennas to perform electronic warfare (EW), communications and radar functions. Each separate system has its own aperture, electronics, operator and logistics/maintenance tail. This approach has resulted in electromagnetic interference and compatibility problems that degrade individual system performance and increase ship life-cycle costs while making it difficult to reduce a ship's signature and radar cross section.

Under the InTop ID/IQ awards, the contractors will compete for task orders to investigate and adapt new technologies supporting affordable multi-function capabilities and will build advanced development models to test and demonstrate the new capabilities. The first task order is a Surface Ship EW/Communication System study. It calls for identifying issues associated with developing a combined system that would provide both an electronic attack capability and line-of-sight communications (via the Tactical Common Data Link) and could be integrated with the electronic support system on new and existing Navy surface ships.

ONR's InTop vision is to develop a common set of open-architecture hardware and software that will make possible a scalable family of multi-function electronic warfare, radar and communications equipment to support multiple classes of ships. ONR and the contractors will define the RF form, fit, function and interface standards, pursue different array architectures and support development of component technology to reduce the cost of arrays.

The 18 companies that received an InTop ID/IQ contract were: ATK Space Systems (Dayton, OH); Argon ST (Fairfax, VA); BAE Systems (Nashua, NH); Ball Aerospace (Broomfield, CO); Boeing (Seattle, WA); Cobham Defense Systems (Landsdale, PA); Colorado Engineering Inc. (Colorado Springs, CO); DRS Signal Solutions (Gaithersburg, MD); FTL Systems (Rochester, MN); General Dynamics Advanced Information Systems (Fairfax, VA); HYPRES Inc. (Elmsford, NY); ITT Electronic Systems & Radar Systems (Van Nuys, CA); ITT Force Protection Systems (Thousand Oaks, CA); Lockheed Martin (Moorestown, NJ); Northrop Grumman (Baltimore, MD); Raytheon (Tewksbury, MA); S2 Corp. (Bozeman, MT); and Southwest Research Institute (San Antonio, TX). – *G. Goodman*

USMC EA-6B TRAINING SQUADRON PLANNED

A US Marine Corps spokesperson told the *Sun Journal* of New Bern, NC on May 31 that her service will convert one of its four Marine Tactical Electronic Warfare Squadrons (VMAQ-4 through VMAQ-4), equipped with EA-6B Prowler support jamming aircraft, to a Fleet Replacement (training) Squadron (FRS) next year. All four Marine squadrons are located at MCAS Cherry Point, NC, and have five aircraft each. The Navy has begun to deactivate its Prowler squadrons as it shifts to the new Boeing EA-18G Growler aircraft by the end of 2012. The Marine Corps plans to keep flying EA-6Bs until 2018-2012, so it needs to create its own training squadron to replace the Navy's FRS, VAQ-129 at NAS Whidbey Island, WA.

Maj. Aisha Bakkar, the Public Affairs Officer at MCAS Cherry Point, told the newspaper, "The total number of U.S. Marine Corps EA-6B Prowlers aircraft at Cherry Point will increase to 27 by FY2013. That's the plan right now. As the Navy transitions out of EA-6Bs, some of its existing Prowlers will be redesignated as USMC aircraft." She said the Marine Corps will have a total of

32 aircraft by 2013, consisting of those assigned to the squadrons, about four being overhauled at any time and a single test aircraft to be located at NAS Patuxent River, MD. The Corps' Prowler squadrons will remain at Cherry Point, she said, and the new FRS will produce seven pilots and 15 electronic countermeasures officers (ECMOs) per year. Each Prowler is flown by a pilot and three ECMOs.

The Navy's EA-18G Growler has picked up an operational nickname, *Navy Times* reported on June 9. A spokesperson at NAS Whidbey Island told the publication that the names Growler and Prowler were "too close to be safe," so the EA-18G will be known as a "Grizzly" in operational situations to avoid confusion with its predecessor. Growler will remain as the aircraft's primary nickname, but Grizzly will be considered the formal operational name, similar to the F/A-18E/F Super Hornets' operational title, "Rhino." – *G. Goodman and J. Pasierb*

ROBUST SURFACE NAVIGATION MOVES FORWARD

The Strategic Technology Office (STO) of the Defense Advanced Research Projects Agency (DARPA) has awarded a $6.5 million contract for Phase 2A of the Robust Surface Navigation (RSN) program to Argon ST (Fairfax, VA).

The RSN program is designed to give the warfighter the ability to effectively geolocate and navigate when GPS signals are unavailable (either due to hostile activity, such as jamming, or because of signal blockage by buildings or foliage). Leveraging advanced SIGINT technologies, the RSN program will enable navigation by exploiting the availability of other radio frequency emitters, such as communications satellites, cell phone towers and TV transmitters – that can be geolocated via an RF receiver and then exploited as a virtual network of RF navigation beacons.

In 2008, Argon ST received a $2.4 million contract for Phase 1, competing against a team from Boeing, to evaluate the feasibility of the project and to assess the signals environment. According to the company, achievements during that phase included new algorithms for reducing multi-path signal errors and signal blockage found in "urban canyons and indoor environments."

Phase 2 of the RSN program involves building prototype receivers that can receive positioning signals and use other signals available in the environment without adding too much additional weight or bulk for soldiers. By Phase 2B, the goal is to equip the services with GPS-level navigation ability in GPS-denied areas using radio frequency signals of opportunity. The Phase 2A contract also includes options for Phase 2B and 2C. Argon ST has already named the following companies as supporting software and engineering partners for the project: Honeywell Laboratories (Minneapolis, MN), Ticom Geomatics (Austin, TX) and The Charles Stark Draper Laboratory (Cambridge, MA). – *E. Richardson*

ONR TO DEVELOP MULTIFUNCTION EW/RADAR/ COMMS TECHNOLOGIES

The Office of Naval Research (Arlington, VA) is soliciting applied research proposals to develop a low-band, multi-function RF system that can be used in future airborne missions. ONR's Surface and Aerospace Surveillance Program is managing the Multi-Function Airborne Surveillance Technology (MAST) program, which will develop key technologies that can support multiple missions, including electronic intelligence (ELINT), electronic attack, radar and communications.

According to the solicitation, "Future MAST-enhanced platforms, a mixture of manned and unmanned, would support multiple current, and future, radio frequency (RF) requirements and missions via a single flexible wide-band electronically scanned aperture. MAST platforms would operate effectively as a stand-alone platform or as a member of a networked sensing system." The program will focus on several technology areas, including broadband antenna apertures; RF front ends; high-speed analog-to-digital and digital-to-analog converters; digital beamforming; and resource allocation management.

Funding for the four-year (FY10-13) discovery and invention project is estimated at $4.8 million. The program point of contact is Dr. Michael Pollock, e-mail michael.a.pollock@navy.mil. White papers are due August 5. Full proposals are due September 16. Awards will be announced in February 2010. – *J. Knowles*

IN BRIEF

The US Air Force named Maj Gen Richard Webber on June 4 to become the commander later this year of the new 24th Air Force, which was formerly known as Air Force Cyber Command and will fall under Air Force Space Command at Peterson AFB, CO. Webber is currently the Assistant Deputy Chief for Air, Space and Information Operations, Plans and Requirements, Headquarters USAF. The Air Force plans to locate the 24th Air Force at Lackland AFB, TX.

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The US Army named Maj Gen David B. Lacquement, commanding general of the Army Intelligence and Security Command at Fort Belvoir, VA, to become the deputy director, Signals Intelligence Directorate, National Security Agency, Fort Meade, MD.

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DRS Technologies (Parsippany, NJ) announced in May that, through a subsidiary, it had entered into an agreement to purchase all of the outstanding stock of Soneticom, Inc. (West Melbourne, FL), a leading provider of precision geo-location systems and communications products that are used in communications intelligence, EW and radio spectrum-management applications.

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Raytheon (Goleta, CA) was awarded an $84 million contract on May 27 to continue production of its ALR-67(V)3 digital radar warning receiver (RWR), which is going on US Navy and Royal Australian Air Force F/A-18E/F Super Hornets and F/A-18 Hornets of Switzerland and Canada. This was the 11th

full-rate production lot awarded; orders now total 594 of the RWRs.

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Kilgore Flares Company (Toone, TN) was awarded three contracts for decoy flares totaling $39 million from the US Navy, Air Force and Army. The $15.1 millon Navy contract is for MJU-32A/B IR decoy flares for the self-protection systems on numerous Navy and Marine Corps rotary-wing aircraft. The $6.8 million Air Force contract is for MJU-53/B IR decoy flares for aircraft such as the C-17. The Army's $17.1 million delivery order is for M212 IR decoy flares for the Advanced IR Countermeasure Munition (AIRCMM) suite used to protect helicopters.

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Alloy Surfaces Co. (Chester Township, PA) was awarded a $74.2 million contract from the US Air Force last month to supply MJU-50/B IR decoy flares. The US Navy also awarded the company a $7.2 million contract for MJU-49/B decoys. The special materials decoys will protect fighter, transport aircraft and helicopters form IR-guided missiles.

✪ ✪ ✪

Armtec Countermeasures Co. (Coachella, CA) was awarded a five-year $46.6 million US Navy contract for the manufacture of RR-196/AL and RR-196/AL (T-1) expendable chaff cartridges, which are dispensed by tactical aircraft to defeat radars and RF-guided threats.

✪ ✪ ✪

Boeing (St. Louis, MO) was awarded a $38 million contract to develop and test a nonlethal, high power microwave (HPM) airborne demonstrator for the US Air Force Research Laboratory's Counter-electronics HPM Advanced Missile Project (CHAMP). The CHAMP Joint Capability Technology Demonstration (JCTD) program will be the first to evaluate a counter-electronics HPM aerial demonstrator. Boeing will provide the airborne platform and serve as the system integrator. The program, "Phantom Ray," will use as a test bed the prototype vehicle Boeing originally developed in 2006 for the DOD's Joint Unmanned Combat Air System (J-UCAS) program.

✪ ✪ ✪

Orbit/FR (Horsham, PA) was awarded a contract to provide a series of systems for use in EW testing of vehicles in an anechoic chamber.

✪ ✪ ✪

Herley Industries (Lancaster, PA) announced June 9 that it won a $1.2 million contract from an undisclosed US contractor to produce additional complex integrated microwave assemblies to be installed on US Navy electronic attack aircraft.

✪ ✪ ✪

Georgia Technical Applied Research Corp. (Atlanta, GA) was awarded a US Air Force contract to improve the modeling and simulation capabilities within the product manager IR Counter Measures Office for the Advanced Threat IR Countermeasures/Common Missile Warning System (ATIRCM/CMWS).


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washington report

HASC PASSES FY10 DEFENSE AUTHORIZATION

Last month, the House Armed Services Committee (HASC) passed its version of the FY10 Defense Authorization Bill. A notable addition to this year's bill was an electronic warfare (EW) amendment that requires the DOD to submit an annual report outlining its EW strategy.

The text of the amendment requires the annual report to include a list of all EW acquisition programs and research and development projects along with a description of how each supports the DOD's EW strategy. In addition, the report must include the following:

- Whether or not validated requirements exist for each program and if so, the date on which the requirements were validated and by which authority.
- The total amount of funding appropriated, obligated and forecasted for the program.
- The development or procurement schedule.
- An assessment of the cost, schedule and performance of the program as relates to the current baseline and the original, if the baselines aren't the same.
- The technology readiness level of each critical technology in the program.
- Whether or not the program or project is redundant or overlaps with the efforts of another military department.
- What capability gap the program or project is being developed or procured to fill.

US Reps Joe Pitts (R-PA) and Rick Larsen, (D-WA), co-chairmen of the Electronic Warfare Working Group (EWWG) both lauded the HASC's decision. "We have learned time and time again that EW saves lives. We need to develop the right technology; train our troops to use the capability; field the capability quickly; operate jointly; and stay ahead of the curve." Pitts said in a statement. "To stay ahead of the curve, we need a plan. We need a strategy. And Congress needs to know and understand how the Defense Department is ensuring the future of our EW capability."

Rep. Larsen said in the same statement: "The Navy, Army, Air Force and Marines all engage in Electronic Warfare in some form. This capability plays a more important role than ever in keeping the men and women in our military safe. That is why the Department of Defense needs a comprehensive and unified strategy to control the electromagnetic spectrum, and Congress needs to know what this strategy is.

"I thank my colleague, Rep. Pitts, for his leadership on electronic warfare, and my colleagues on the Armed Services Committee, in particular and Reps. Akin, Nye and Wittman for cosponsoring this amendment to strengthen our electronic warfare capabilities across the Armed Services."

Other notable EW items in the HASC defense bill include:

- Noting concern about extending the service life of the existing F/A-18A-D aircraft, the committee mentioned its expectation for the Navy to enter into multi-year procurement on the F/A-18E/F and EA-18G.
- $127.7 million for the F/A-18E/F, including an increase of $108 million for advance procurement of items that would be used to build aircraft beyond FY10.
- An increase of $56 million for support items associated with the EA-18G.
- $6 billion for 28 F-35s, a reduction from the budget request of one aircraft each for the Air Force and Navy, but twice the number authorized in FY09. The total covers 15 F-35Bs for the Marine Corps, four F-35Cs for the Navy and nine F-35As for the Air Force.
- An increase of $369 million for advance procurement of 12 F-22s in FY11. Overall reduction of $338 million for F-22 modifications due to the fact that after FY09 money was budgeted for advance procurement of 20 aircraft the Air Force changed its procurement to four.
- $100 million, a reduction of $327 million, for termination of the Future Combat System (FCS) Manned Ground Vehicle Program.
- An increase of $100 million for surface ships, including multi-year procurement authority and construction of one DDG-51 class warship. – *E. Richardson*

world report

INDIA FIGHTER CONTEST HEADED FOR FLIGHT TRIALS

Published reports from the Paris Air Show indicate that the Indian Air Force (IAF) will begin flight trials this month for the six jets vying to become the country's new medium multi-role combat aircraft (MRCA).

According to the reports, letters of invitation have been sent to all manufacturers whose jets are up for consideration, which include the Dassault Rafale, Saab Gripen, Boeing F/A-18, Lockheed Martin F-16, the MiG-35 and the Eurofighter Typhoon. Though trials were set to be complete by March of 2010, some manufacturers may not be able to send aircraft to the region until September, which means hot weather tests to be done in Indian desert conditions would have to wait until July 2010.

IAF Chief of Air Staff, Air Chief Marshal P.V. Naik said the trials schedule would be constrained, as humidity checks would be done in Bangalore before aircraft were moved to Jaisalmer for hot weather tests and then to Leh for cold weather and height tests.

"The evaluations would be in sequence, one after the other, starting from Bangalore." Naik said in one report. "In India, the aircraft would be subjected to performance trials which would include takeoff and landing characteristics, aircraft maneuvering, and checks of certain systems in the air. Evaluation of its maintainability, mission support equipment, operations at high altitude and in specific environments will also be conducted. Analyses of some aspects operations of its avionics, radar and Electronic Warfare (EW) systems along with live firing of long range weapons would be conducted at vendor-specific locations."

The Indian MRCA replacement jet has been highly competitive because even at the base order of 126 aircraft, and even with requested offsets and technology transfer requirements, it's still valued at nearly $10 billion – perhaps more with additional options for add-on aircraft that might be needed because the IAF hasn't made any significant combat acquisitions since the 1980s. The timeline for aircraft selection is 2013-2014, with initial planes being provided within three years. – *E. Richardson*

SHIP-LAUNCHED DECOY REMAINS IN DEMAND

BAE Systems Australia received its 11th successive annual production order from the Australian government last month for Nulka anti-ship missile offboard decoy rounds, extending production to 2012. They will be used by the Australian, US and Canadian navies.

Nulka is a highly effective, ship-launched, rocket-propelled active decoy. Developed under a joint Australian-US program, it employs a broadband radio-frequency repeater mounted atop a hovering rocket. After launch, the 6.5-foot-long, 8-inch diameter decoy radiates a large ship-like radar signature while flying a trajectory that lures incoming radar-guided anti-ship missiles away from the target ship.

BAE Systems Australia developed the hovering rocket; Lockheed Martin Sippican provides Nulka's electronic payload and fire-control system, and Aerojet supplies its rocket motor. To date, a total of about 860 Nulka rounds have been produced by BAE and installed on more than 125 surface combatant ships of the three navies. – *G. Goodman*

IN BRIEF

- The government of **Egypt** has requested the purchase of 12 Block II AH-64D Apache Longbow helicopters, along with associated equipment, parts, training and support at an estimated cost of $820 million. The sale includes 14 ALQ-144(V)3 infrared jammers and 14 APR-39B(V)2 radar signal detecting sets.
- **Norway** announced that it intends to purchase six radar electronic support measures (ESM) systems for its ULA-class submarines and issued an invitation to industry for pre-qualification. Requests to participate were due late last month. The program point of contact is Kristina Ringheim, +47 55 50 30 63, kringheim@mil.no.
- **Lockheed Martin** (Marietta, GA) has signed a contract with Oman for a C-130J to be delivered in 2012. Oman, which currently operates a fleet of three C-130Hs purchased in the early 1980s, is adding the new aircraft the longer C-130J-30 configuration.
- The French company **Etienne Lacroix Tous Artifices S.A.** (Muret, France) will be awarded a sole-source contract by the Naval Surface Warfare Center Crane Division (Crane, IN) for expendable countermeasure flare decoys to be evaluated under the US DOD's Foreign Comparative Testing (FCT) program. On May 18, DGA (France's defense procurement agency) awarded the company a contract worth $18.8 million, funded under the nation's economic recovery plan, to produce flare decoys for French military helicopters.

Advancing TWTs

The Traveling Wave Tube Lives On… and On

By Barry Manz

For generating truly impressive amounts of radio frequency (RF) power, especially over broad bandwidths at frequencies from 4 GHz to 100 GHz, nothing beats a vacuum electron device (VED) and, in particular, a traveling wave tube (TWT). As a result, while the markets for VEDs (vacuum tubes in the vernacular) are flat according to most reports; klystrons, crossed-field amplifiers, gyrotrons, magnetrons, inductive output tubes (IOTs) and TWTs will continue to generate hundreds of millions of dollars in revenue thanks to their use in defense, scientific and medical applications.

While solid-state RF power transistors are slowly creeping upward in efficiency, output power and frequency, their ability to produce the megawatts of power from a klystron at 40 GHz or 250 kW from a TWT remains far out on the horizon. RF power transistors based on gallium arsenide (GaAs), silicon (typically bipolar junction transistors or BJTs and LDMOS FETs) or gallium nitride (GaN) – the defense industry's compound semiconductor technology – are being deployed in improvised explosive device (IED) jammers and other comparatively low-power electronic warfare (EW) systems.

However, in many EW systems, performance over very broad bandwidth is paramount and tubes reign supreme and likely will remain so for years. In short, industry prophets and the media have predicted for years that VEDs of all sorts would soon be relegated to microwave lore, victims of the inexorable march of semiconductor technology. But as we move toward the second decade of the 21st century, VEDs still are not just viable but essential for military and commercial applications alike.

A TUBE, YOU SAY?

Vacuum tubes are not in the vocabulary of almost anyone born after about 1970, unless they happen to be amateur radio operators or audiophiles seeking that "tube sound." Even to designers in the commercial wireless industry, vacuum tubes either are archaic or irrelevant. However, designers of EW systems, satellite communications transponders or broadcast transmitters are well-acquainted with the unique benefits provided by TWTs. For proof, consider that there currently are at least 300,000 TWTs and other VEDs employed in nearly 300 US defense systems of various types, with radar, EW and satellite communications systems being the largest consumers.

Even though government funding of VED development has been spotty in recent years, TWT development is hardly standing still, not just in the United States but in many countries. This year's International Vacuum Electronics Conference (IVEC) in Rome, sponsored by the European Space Agency, included papers from the United States, Russia, China, Korea, Germany, Israel, Switzerland, France, Italy, Ukraine, Norway, India,

TWT and MPM Manufacturers

CPI	www.cpii.com
dB Control	www.dbcontrol.com
e2v	www.e2v.com
ELTA Systems Ltd.	www.iai.co.il
L-3 Electron Devices	www.l-3com.com/edd
L-3 Electron Technologies	www.l-3com.com/eti
NEC	www.nec-mwt.com
Teledyne MEC	www.teledyne-mec.com
Thales Electron Devices	www.thales-electron-devices.de
TMD	www.tmdtechnologies.co.uk
Triton	www.tritonetd.com

Brazil, the Netherlands, Belgium, Canada, Taiwan and even Belarus. US TWT manufacturers spend considerable sums every year to advance TWT technology and manufacturers like dB Control (as well as L-3 Communications and others) are refining TWT and power supply integration to increase frequency coverage, efficiency and reliability and reduce TWT assembly size, weight and cost.

This is not to say that TWTs have short operating lifetimes; many can operate for 100,000 hours (more than 11 years) of continuous service at their rated RF output powers. While not a patch for conservatively operated solid-state power amplifiers, this is well-matched to the lifetime of satellite communications transponders, as well as radar and EW systems that can remain in service for decades. Replacing a TWT also is relatively easy and cost-effective, which cannot be said for amplifiers based on transistors, as the sheer number of them required to match TWT-level output levels makes for a complex design challenge.

THE TWT DEMYSTIFIED

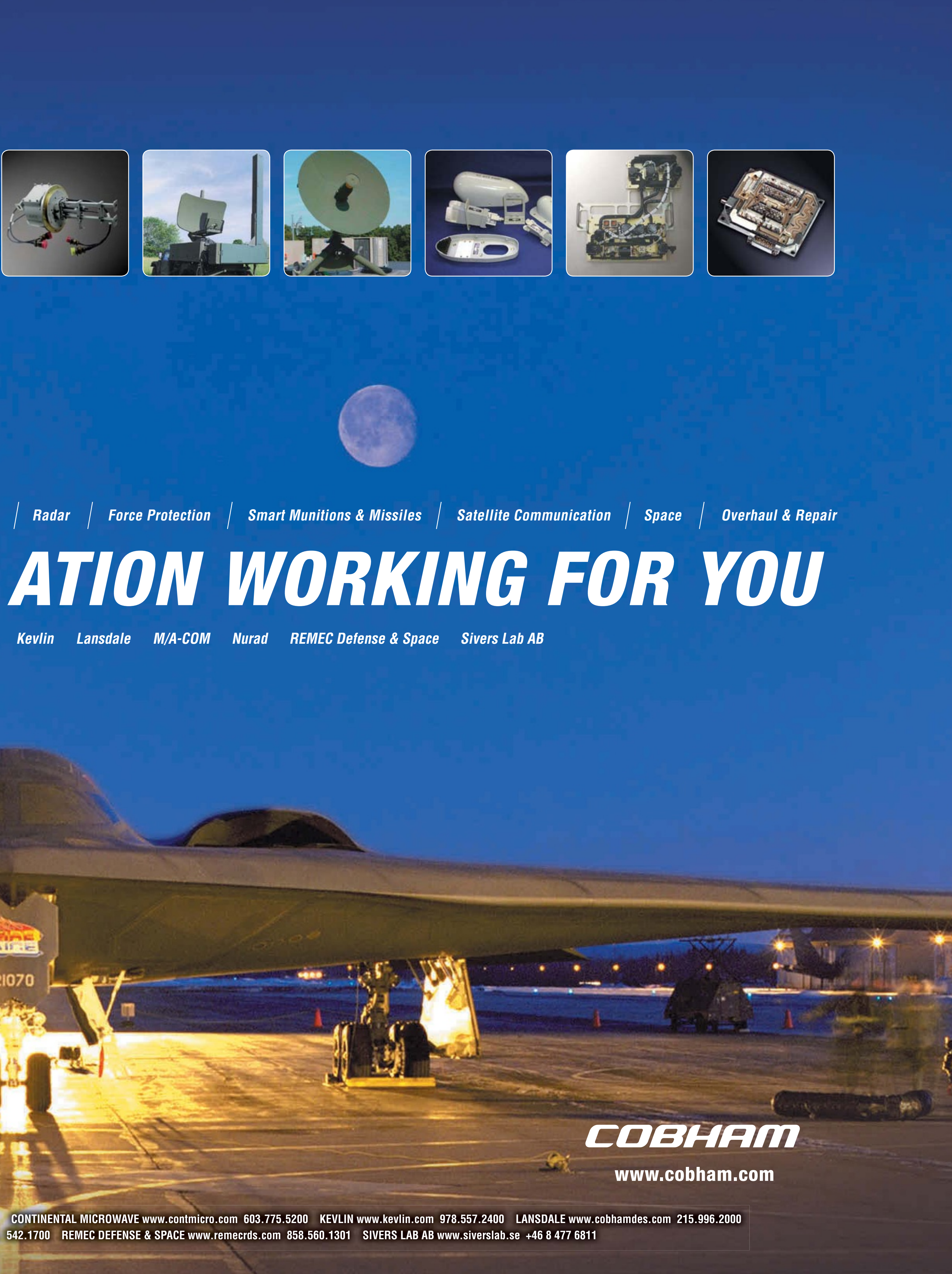
A TWT is an inherently high-gain, low-noise amplifier that can operate over greater bandwidths than a klystron. It uses a slow-wave structure (either a helix or coupled-cavity circuit) that creates an interaction between a high-energy electron beam and an RF wave in a vacuum envelope. A heated cathode generates electrons in an electron gun assembly and launches them into the interaction region. An electrode turns the beam on and off by switching the bias of the control electrode either to positive or negative with respect to the cathode. The modulator in the transmitter switches the bias voltages that produce a transition from conduction to cut-off states.

The electron beam itself is focused by magnets that are placed along the axis of the TWT and is accelerated by a high potential between the cathode and the anode (collector). The result is that the RF wave propagates from the input to the output of the device through the slow-wave structure, the electron beam transferring energy to the RF wave as it travels along the tube's axis. This produces a high level of amplification at the TWT's RF output.

Critics point to the TWT's need for kilovolt-level power supplies that can be large, heavy and costly, an indisputable fact at least in TWT amplifiers (TWTAs) employed in very high-power EW and radar systems. But to be fair, the comparatively-low RF output of even state-of-the-art RF power transistors designed for high microwave or millimeter-wave frequencies means that dozens or even hundreds of them would have to be power-combined, suffering enormous combining losses in the process. In addition, they operate at low DC voltages, so a solid-state amplifier delivering the same RF output as a TWTA would devour large amounts of current, which either would require a large power supply or place considerable demands on the prime power source of the platform in which they are deployed.

SMALL WONDERS

The TWT got an enormous boost two decades ago when the US Department of Defense (DOD) recognized the continuing need for TWTs in defense systems, especially if they could be miniaturized and use lower-voltage power supplies. A panel supported by the Naval Research Laboratory (NRL) and populated by prime contractors and TWT manufacturers was created with the goal of meeting a demanding set of technical requirements focused on EW and radar applications over a frequency range of 6 GHz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to 18 GHz. Specifications included RF output power up to 100 W, 50 dB of gain, noise power density of -45 dBm/MHz and a package volume of 7.5 in. The program was called the Tri-Service Vacuum Electronics Program and was funded by NRL and the Defense Advanced Research Projects Agency (DARPA).

The five development teams included one from the Hughes Aircraft Electron Devices Division (now L-3 Communications Electron Technologies), Lockheed Sanders and Teledyne Electronic Systems (now BAE Systems and Teledyne MEC), Northrop (today's Northrop Grumman), Raytheon and Westinghouse and Varian Associates (now Northrop Grumman and Communications & Power Industries, or CPI). The result was the Microwave Power Module (MPM), which has been immensely successful in broadening the reach of the TWT into new platforms and bolstering the VED industry as whole.

Development of the "mini-TWT" was arguably the key element in this development. A shorter, lighter and lower-power version of a standard TWT that is about 7 inches long, the mini-TWT does not deliver as high an RF power output as a conventional TWT, nor does it require as large a power supply. For example, an 8-kW, X-band helix TWT typically employs an input voltage of about 14 kV and a 100-kW coupled-cavity TWT requires about 45 kV. A mini-TWT requires 3.7 kV to 7 kV. However, it is limited in RF output power to about 200 W CW (1 kW peak).

The MPM's advantages were (and remain) stunning when compared to its conventional counterparts, delivering a 5:1 reduction in size and weight, 100:1 reduction in noise and 50 percent improvement in efficiency. The success of the program spawned a broad array of other MPMs that today offer a wide

range of waveguide bands. MPMs did not initially find a home in EW systems; this came recently as unmanned aerial vehicles (UAVs) began to incorporate EW systems to complement their sensor and communications payloads.

The MPM is conceptually very straightforward. A solid-state RF power amplifier drives a mini-TWT, and the two amplifiers are integrated with power and control circuits in a very compact enclosure. Like any compact, high-power RF system, the power supply and its power management subsystem are critical components in an MPM, and they employ extremely-dense, intelligent power sources that incorporate various types of protection circuits. Current MPMs are available for continuous wave or pulsed operation from L-3 Communications, Triton, Crane Aerospace Electronics, TMD Technologies and other manufacturers with RF output power up to about 300 W CW (more than 1 kW pulsed) at frequencies from S-band to W-band (100 GHz region) with a 20-percent to 40-percent duty cycle, 100 to 400 μs pulse width and variable pulse repetition frequencies. They are housed in very small enclosures (11 x 2 x 6.5 in. for a dB Control MPM is a good example) and require prime power typically of 28 VDC or 110, 208 or 270 VAC.

TO TERAHERTZ… AND BEYOND

After effectively removing itself from VED development nearly 15 years ago, DARPA once again is tackling VED research, focusing on frequencies of 220 GHz and higher in its High Frequency Integrated Vacuum Electronics (HiFIVE) program. The program team is developing an integrated VED power amplifier circuit that can deliver more than 50 W of RF power with efficiency greater than 5 percent over a bandwidth of at least 5 GHz to 220 GHz. The ultimate goal is to produce an MPM that can operate without degradation for more than 100 hours in a broadband tactical communications link with data throughput comparable to optical fiber. The VED itself bears a resemblance more to a wafer-scale device than a "tube," owing to the minute wavelengths that must be realized using microfabrication techniques. It will incorporate a first-stage microwave monolithic integrated circuit (MMIC) driver circuit that is integrated into the overall amplifier along with the cathode, electron-beam and interaction and collection structures.

Every year, RF power transistors creep upwards in many areas of performance, including RF output power and frequency range. However, they are chasing a moving target because TWTs still have the highest power/bandwidth product of any RF-power-generating device and are annually increasing their abilities. There is no other single RF power source that can match their peak-to-average power and bandwidth. MPMs are a terrific match for UAVs, not just for communications links but increasingly for EW suites as well. This all but ensures their continued use in EW, radar systems and other applications for years to come.

Barry Manz has been writing about the RF and microwave industry since 1982. A former editor of Microwaves & RF Magazine *and co-founder of* MIL/COTS Digest*, he is the owner of Manz Communications. He can be reached at barry@manzcomm.com.*

TECHNOLOGY SURVEY

SAMPLING OF COMINT AND DF RECEIVERS

By Ollie Holt

This month's technology survey takes a look at communications intelligence (COMINT) and direction-finding (DF) receivers. As you review the results, you will notice it is mostly a review of COMINT receiver systems. The receivers' capability to perform DF is listed in one of the columns under the type of DF it performs.

Most receivers provide a DF solution as long as they have more than one parallel receiver channel. For a receiver to generate a DF solution, all that is needed are two measurements of the signals parameters made by two similar receiver systems at the same time but from two different receiving locations. By comparing the received signals phase, amplitude or time of arrival, a DF solution can be generated. The accuracy of the DF solution is dependent on how well the system can measure the phase, amplitude or time, and how much information is known about the receiving antennas, their locations with respect to each other and the number of parallel channels.

In terms of what is new with COMINT receivers, you first will notice that this survey contains complete receiver systems and also receivers that are simply VME cards ready to be configured into complete receiver systems. These same VME cards or similar ones from other manufacturers can be used in the complete COMINT receiver systems listed in this survey. The VME cards contain all the necessary hardware and firmware/software to receive, digitize and demodulate the signals, but do not contain the power source, control structure and mechanical housing provided by other systems. A COMINT receiver manufacturer either would have to supply or purchase these additional items to complete the COMINT system.

The days of a COMINT receiver manufacturer specifying the correct amplifier, mixer or local oscillators and installing them into a receiver system quickly are going away. Today, the COMINT receiver manufacturer simply can purchase a set of VME or the new emerging higher-speed and denser-format standard cards that contain a complete receiver channel with RF as the input and digits as the output. In some configurations, the digits already have been processed into demodulated digital representations of the information being transmitted. In other cases, the output simply is a digital representation of the radio frequency (RF) signal ready for additional processing required to retrieve the desired information. So the task of developing a COMINT or almost any type of receiver is becoming one of preconditioning the RF signals and then presenting them to RF-to-digital receiver cards and providing the correct firmware or software to demodulate the signal to retrieve the needed information. The science then becomes one of developing the processing schemes to retrieve the information and present it in a usable manner.

COMINT AND DF RECEIVER SAMPLING

This survey was performed in the same manner as the previous surveys, with a set of questions sent to known COMINT and DF receiver manufacturers. The surveyed companies were asked to provide information for up to five of their receiver products for inclusion in this survey. Only information supplied by the survey respondents was used in this compilation.

UPCOMING SURVEYS: SIGINT Antennas and ELINT Systems

Our next survey, in the August 2009 *JED*, will cover signals intelligence (SIGINT) antennas. Our final 2009 survey, in the November edition, will cover electronic intelligence (ELINT) systems – please e-mail editor@crows.org to request a survey questionnaire.

TECHNOLOGY SURVEY: COMINT/DF RECEIVERS

MODEL	REC TYPE	OP FREQ	INST BW	TYP INST SENS	DYN RANGE
Applied Signal Technology, Inc.; Sunnyvale, CA; +1-408-749-1888; www.appsig.com					
Model 1240 TITAN	dig channelizer	0.5-30 MHz and 20-3,000 MHz.	30 MHz per RF channel.	-110 dBm (0.5-30 MHz) and -114 dBm (20-3,000 MHz).	85 dB (0.5-30 MHz) and 80 dB (20-3,000 MHz).
Model 570X SIREN	superhet	TX: 421-495 MHz and 869-894 MHz. RX: 411-495 MHz, 824-849 MHz and 869-894 MHz.	1.23 MHz	-102 dBm	84 dB
Model 650 ROGUE Manpack Signal Surveillance System	dig channelizer	20-3,000 MHz	50 MHz	-100 dBm	90 dB
Model 660 HYDRA Airborne COMINT Payload	dig channelizer	20-3,000 MHz	200 MHz	-100 dBm	90 dB
Model 680 RAIDER High-Capacity Signal Surveillance System	dig channelizer	20-3,000 MHz	200 MHz	-100 dBm	90 dB
Argon ST; Fairfax, VA; +1-703-828-2217; www.argonst.com					
Extreme Bandwidth Receiver	Superhet followed by a 3-stage dig channelizer.	20 MHz-6 GHz	1 GHz	-110 dBm (10 dB in 5 KHz).	Attenuation range of 40 dB in 1-dB steps.
CDES – M/A-COM SIGINT Products; Hunt Valley, MD; +1-410-329-7900; www.macom-sigint.com					
TU-6400 System	superhet	0.5-18 GHz	500 MHz at 1 GHz IF output.	-100 dBm in 1 MHz IF BW	≤90 dB, RF to IF, 1 MHz BW.
MCS-1000	Superhet. Set-on receiver.	0.5-20 GHz	100 MHz at 1 GHz IF output.	-97 dBm in a 1 MHz IF BW	82 dB in a 1 MHz IF BW.
DRX-5571 Digital Receiver	superhet	0.5-20 GHz	Analog: 100 MHz at 1 GHz IF output. Dig: 57 MHz BW.	-99 dBm in a 1 MHz IF BW	84 dB in a 1 MHz IF BW.
SMR-5550i Low Cost Microwave Receiver	Superhet. Set-on receiver.	0.5-20 GHz	100 MHz at 1 GHz IF output.	-99 dBm in a 1 MHz IF BW	84 dB in a 1 MHz IF BW.
DRS Codem Systems Inc.; Merrimack, NH; +1-603-429-0111; www.drs.com					
ZS-4015E VHF/UHF Integrated Intercept & DF System	Superhet with dig channelizer.	20-3,000 MHz	12.8 MHz	-100 dBm max	100 dB min
CDF-9200 Single-Channel HF/VHF/UHF DF Processor	superhet	300 kHz-30 MHz (HF). 1.5 MHz-3 GHz (V/UHF).	*	antenna-dep	*
DRS Signal Solutions; Gaithersburg, MD; +1-301-948-7550; www.drs-ss.com					
SI-8616-3	superhet	20 MHz-3 GHz	140 kHz, 500 kHz or 1.23 MHz	-122 dBm. MDS in 10kHz RBW	*
DSPCon, Inc.; Bridgewater, NJ; +1-908-722-5656; www.dspcon.com					
SIARRA	IF input of 60 MHz BW	0-250 MHz	60 MHz	70 dB SNR	89 dBc
BroadFlex-3800	dig drop receivers	0-350 MHz	62 MHz	69 dB	89 dBc
Eclipse Electronic Systems Inc.; Richardson, TX; +1-972-699-8580; www.sigint.com					
R3031	preselected direct conv	0.1-30 MHz	2 MHz	-128 dBm (1 kHz)	154 dB (AGC)
R4031	preselected superhet	0.1-3,000 MHz	10 or 30 MHz	-114 dBm (25 kHz)	144 dB (AGC)
R4000	preselected superhet	20-3,000 MHz	10 or 30 MHz	-114 dBm (25 kHz)	144 dB (AGC)
R5000	preselected superhet	20-3,000 MHz	2, 5, 10 or 30 MHz	-114 dBm (25 kHz)	144 dB (AGC)

INST DYN RANGE	MOD TYPES	SUPPORT DF	# REC CHANNELS	PWR (in W)	SIZE (in in./cm)	PLATFORM
60 dB	AM, FM, SSB, PAM, CW, FSK, BPSK, QPSK, pi/4 QPSK and GMSK.	phase interferometer	1-64	60-100 per channel	14U rackmount. 24.5 x 19 x 19 in.	air
60 dB	modern signal	TOA	1 duplex	12	1.23 x 5.6 x 8.2 in	air/grd
65 dB	FM, AM, LOG and pulse.	external DF subsystem	2 RF channels	29	4 x 8.5 x 7.5 in	grd
65 dB	FM, AM, LOG and pulse.	8-element phase interferometer	8 RF channels	250	7.5 x 7.6 x 19.6 in. 3/4 ATR chassis.	air
65 dB	FM, AM, LOG and pulse.	external DF subsystem	8 RF channels	250-300	5.25 x 19 x 24 in	grd
67 dB (nom)	Supports a broad range of client demodulators.	Freq coherent dig I/Q synchronized to 1 pps can support a broad range of DF applications.	User-defined N channel	66 W/GHz	2 standard 3U VPX slots	air/grd/shp/sub
≤90 dB, RF to IF, 1 MHz BW.	Tuner, no demodulated outputs. FM, AM, SSB, pulse position, suppressed carrier, etc.	time	16	<34	VME 2-slice and VME single slice for each channel.	air/grd/shp/spc
82 dB in a 1 MHz IF BW.	FM, AM, SSB, pulse position, suppressed carrier, etc.	time	2-16	100 W per channel	1.75 x 17 x 20.16 in per channel. Mounts in standard 19-in rack.	air/grd-fix/shp/sub
84 dB in a 1 MHz IF BW.	BPSK, QPSK, SQPSK, 8-PSK, QAM, FM-FDM, MSK, 2-FSK, 3-FSK, 4-FSK, FM, AM, SSB, pulse position, suppressed carrier, etc.	no	not channelized	130 W for a single receiver.	1.75 x 17 x 23.16 in. Mounts in standard 19-in rack.	air/grd-fix/shp/sub
84 dB in a 1 MHz IF BW.	FM, AM, SSB, pulse position, suppressed carrier, etc.	no	not channelized	100 W for a single receiver.	1.75 x 17 x 20.16 in. Mounts in standard 19-in rack.	air/grd-fix/shp/sub
75-85 dB	AM, USB, LSB, FM and OOK (energy-based).	phase	5	*	15.75 H x 19 W x 22 D in	air/grd/shp/sub
*	AM, CW, USB, LSB and FM.	amplitude	1	*	5.25 H x 19 W x 17 D in for rackmount version. 5.25 H x 11 W x 11 D in for mobile version.	air/grd
*	AM, FM, CW, SSB and ISB	amplitude	1	20 max	1-slot, 6U VME	air/grd/shp/sub
89 dBc	FM, AM and SSB	no	2	125 W per channel	10.5 x 17.7 x 20.2 in	air/grd/shp/sub
89 dBc	*	no	4	17.5 W per channel	22.75 x 19 x 20 in	air/grd-fix/shp/sub
90 dB (1 kHz)	Pre-D, AM, FM, CW and SSB.	N channel coherent	2 RF and 32 DDR	45	6U VME/VXS	*
80 dB (25 dHz)	Pre-D, AM, FM, CW and SSB.	N channel coherent	2 RF and 32 DDR	65	6U VME/VXS	*
80 dB (25 dHz)	Pre-D, AM, FM, CW and SSB.	N channel coherent	2 RF and 32 DDR	65	6U VME/VXS	*
85 dB (25 kHz)	Pre-D, AM, FM, CW and SSB.	N channel coherent	2 RF and 32 DDR	85	6U VME/VXS	*

MODEL	REC TYPE	OP FREQ	INST BW	TYP INST SENS	DYN RANGE
Elcom Technologies; Rockleigh, NJ; +1-201-767-8030; www.elcom-tech.com					
SIR 1000	Superhet and dig SDR.	0.01-30 MHz	30 KHz	-117 dBm, 15 dB SINAD and 300 Hz BW.	Input IP3:30 dBm min
SIR 2000	Superhet and dig SDR.	20-3,000 MHz	3.2-500 KHz	AM: -104 dBm for SNR of 10-dB signal. FM: -107 dBm for SNR of 17-dB signal.	Input IP3:10 dBm
SIR 3000	Superhet, dig SDR and adaptive squelch (NRT).	20-3,000 MHz	3.2 KHz-40 MHz	AM: -104 dBm for SNR of 10 dB signal. FM: -107 dBm for SNR of 17-dB signal.	Input IP3:20 dBm
Elettronica S.p.A; Rome, Italy; +39-06-41541, www.elt-roma.com					
ARIES COMINT subsystem	dig	HF+ V/UHF	2-20 MHz and 100-500 MHz/3 GHz	VH	*
ELT/332 COMINT subsystem	dig	HF+ V/UHF	1.5-30 MHz and 20-3,000 MHz	H	*
NELTIS COMINT subsystem	dig	V/UHF	20-500/3,000 MHz	H	*
ELT/131 COMINT subsystem	dig	V/UHF	20-3,000 MHz	H	*
Elisra; Israel; +1-972-3-5577278; www.elisra.com					
TSR 2040	superhet	100 kHz-3,000 MHz	up to 340 kHz	AM: 1µV - 2µV for SNR of 10 dB at 6 kHz BW. FM: 1µV for SNR of 17 dB at 15 kHz BW. CW: 0.3µV for SNR of 10 dB at 500 Hz BW.	130 dB
TSR 2300	superhet	20 MHz-6,000 MHz	Analog: 50 MHz. Dig: 40 MHz.	10 kHz: -105 dBm. 20 kHz: -102 dBm. 50 kHz: -98 dBm. 100 kHz: -95 dBm. 300 kHz: -90 dBm. SB at 6 kHz IF (S+N)/N=10 dB -112 dBm. CW at 6 kHz IF (S+N)/N=10 dB -112 dBm.	120 dB
TWR 3000-U	superhet	20 MHz-3,000 MHz	2.5 MHz, 5 MHz, 10 MHz and 20 MHz	1µV signal level at antenna input produces IF signal of 10 dB SNR IN 6 KHz filter BW.	120 dB
General Dynamics Advanced Information Systems; Annapolis Junction, MD; +1-240-456-5458; www.gd-ais.com/tss					
DFSR-3000 Compact DF system	PLL superhet SDR	2MHz-30 MHz for HF and 20-1,200 MHz for V/UHF.	50 kHz	0.35 uV/12 db SINAD	70 dB
WolfScout - Tactical Collection Package (TCP-1)	SDR	500 Hz-30 MHz	190 kHz	-127 dBm at 500 Hz BW	>100 dB
Wolftrap	superhet dig channelizer	2 MHz-20 GHz	60 MHz	-114 dBm at 30 kHz BW	100 dB
Grintek Ewation; South Africa; +27-(0)-83-286-0231; www.gew.co.za					
MRD5000w7/9	Wband DF, HF, interferometric and ultra-fast scanning.	500 kHz-30 MHz	0.3, 1, 2, 4 and 8 MHz.	-129 dBm at 125 Hz, mode- and resolution-dep.	≥150 dB
MRD7050C	Wband DF and monitoring H/V/UHF and DF interferometric.	1.5-3,000 MHz	20 MHz V/UHF	<-115 dBm, resolution-dep.	>135 dB total
MRR7000	multi-channel	L/H/VUHF models: 9 kHz-3,600 MHz. V/UHF models: 20-3,600 MHz.	HF channels: 0.1-20 kHz. V/UHF channels: 0.3-160 kHz (325 kHz I/Q).	HF models: <-125 dBm, mode-dep. V/UHF models: <-125 dBm, mode-dep.	>140 dB total for HF. >120 dB for VUHF.
MRR/S8000	Combined wband and multiple nband DDR models.	HF models: 1-30 MHz. V/UHF models: 20-3,000 MHz.	HF models: 2.5 and 5 MHz. V/UHF models: 10 and 20 MHz.	<-125 dBm, mode-dep.	>125 dB total.

INST DYN RANGE	MOD TYPES	SUPPORT DF	# REC CHANNELS	PWR (in W)	SIZE (in in./cm)	PLATFORM
80 dBFS	AM, FM, PM, SSB and ISB	Opt common LOs for phase-matched DF.	2-4	40	1U	air/grd/shp
80 dBFS	AM, FM, PM and SSB	Opt common LOs for phase-matched DF.	2-4	60	1U	air/grd/shp
80 dBFS	AM, FM, PM and SSB	Opt common LOs for phase-matched DF.	2-4	80	1U	air/grd/shp
*	*	*	3	*	*	air
*	*	yes	5	*	*	grd
*	*	yes	3 or 5	*	*	shp
*	*	yes	3 or 5	*	*	grd-fix
65 dB	AM, FM, SSB and CW	all	2 channels for DF. Up to 8 channels for COMINT.	25 max	standard long PCI card	air/grd/shp/sub
75 dB	AM, FM, ISB, USB, SSB and CW	Amplitude, phase interferometer and time of arrival.	1, 4, 5, 7 and 8 channels	65 max	14 x 19 x 23.5 in	air/grd/shp/sub
80 dB (A/D)	*	no	1-2	65 max	5.25 x 19 x 23.5 in	air/grd/shp/sub
50 dB	FM, AM and SSB	pseudo Doppler	1	12	Receiver processor: 3.1 x 6.2 x 7.7 in.	grd/shp
>90 dB	FM, AM, SSB, LSB, USB, 2-FSK, 4-FSK, 8-FSK, BPSK, QPSK, 8-PSK and others.	Paired with DFSR-3000 Compact DF system (pseudo Doppler).	1 channel for monitoring. 1 channel for DF (paired with DFSR-3000 Compact DF system).	14 W per channel	*	grd
70 dB	FM, AM, SSB, suppressed carrier, pulse position, OOK, 2-FSK, 4-FSK, 8-FSK, BPSK, QPSK, 8-PSK, QAM, OQPSK and others.	Amplitude and phase N-channel DF using MUSIC algorithm.	5-8 channels	50	10 RU standard rackmount chassis (17.5 x 19 x 21 in).	grd
≥85 dB. 90 dB SFDR typ.	All. DF process not modulation-dep.	7- to 9-channel DF.	*	560	Receiver: 4RU x 19 in x 494 mm. Dig processor: 8RU x 19 in x 430 mm.	grd
>135 dB total.	SSB, CW, AM and FM	2-channel V/UHF DF. 1-channel monitoring.	2 DF channels and 1 monitoring channel.	40 W per channel	3RU x 19 in x 309 mm (excluding notebook).	grd
>140 dB total for HF. >120 dB for VUHF.	SSB, CW, AM, FM, FSK and dig I/Q	no	Typ 1-4 (VU4), (LU2: 2xHF and 2xVUHF) and (C-LU: 1xHF and 1xVUHF).	27 W for HF. 34 W per RF channel for V/UHF.	3RU x 241 mm x 467 mm (compact) and 3RU x 19 in x 467 mm.	grd
>125 dB total.	SSB, CW, AM, FM and dig I/Q	no	Typ 1 wband. 4-16 nband.	80	2RU x 19 in x 480 mm.	grd

TECHNOLOGY SURVEY: COMINT/DF RECEIVERS

MODEL	REC TYPE	OP FREQ	INST BW	TYP INST SENS	DYN RANGE
Indra Sistemas, S.A.; Madrid, Spain; +34-670-873-880; www.indra.es					
IN/TRD-100	superhet wband dig	1-30 MHz	800 KHz	-112 dBm	125 dB
IN/TRD-200	superhet wband dig	20-3,000 MHz	20 MHz	-105 dBm	115 dB
IN/TSD-900	superhet wband dig	1-30 MHz	800 KHz	-112 dBm	125 dB
IN/TSD-950	superhet wband dig	20-3,000 MHz	20 MHz	-105 dBm	115 dB
Innovationszentrum Telekommunikationstechnik GmbH IZT; Erlangen, Bavaria, Germany; +49-9131-4800-100; www.izt-labs.de					
IZT R3000 series	Dual conversion superhet with dig IF for V/UHF and direct sampling for HF.	9 kHz-3,000 MHz. An extended freq range up to 18 GHz will be released in fall 2009.	24 MHz	9-15 dB, dep on freq	60 dB analog AGC range
Innovative Signals Technology, LLC; Scottsboro, AL; +1-256-259-8050; www.isigtech.com					
ENCORE (model No. ENC-11)	SDR. Wband RF channelizer with dig baseband IF output.	DC-2.6 GHz	500 kHz, 1 MHz, 2 MHz, 4 MHz and 8 MHz.	-135 dBm	85 dB
ITT - EDO Reconnaissance and Surveillance Systems Inc.; Morgan Hill, CA; +1-408-201-6735; www.ittrss.com					
ES-5080/5060A	dig 500 MHz BW superhet	0.5-18 GHz (40 GHz opt)	500 MHz (multiple channels can be “gang-tuned” to provide additional BW).	>-90 dB	90 dB
L-3 Communications - Applied Signal & Image Technology; Linthicum Heights, MD; +1-443-457-1111; www.l-3com.com/asit					
RDF-110 DF Sensor	Dual channel, coherent and superhet.	20-3,000 MHz	6.5 MHz	-104 dBm (25 kHz BW and 20 dB SNR)	99.3 dB
L-3 Communications - Linkabit Division; San Diego, CA; +1-800-331-9401; www.l-3com.com					
MD-405A (Receiver from PRD-13(v)2)	superhet	100 KHz-2 GHz	up to 200 KHz	FM: 15 KHz, 12 dB SINAD 0.9 uV. FM: 50 KHz , 12 dB SINAD 1.9 uV. FM: 200 KHz, 12 dB SINAD 3.2 uV. AM: 6 KHz , 12 dB SINAD 1.5 uV. SSB/CW: 3 KHz. 10 dB SINAD 0.4 uV.	*
SIGpac	superhet	100 KHz-3 GHz	6.4 MHz	FM: 15 kHz, 12 dB SINAD 0.7 uV. FM: 200 kHz, 12 dB SINAD 2.5 uV. AM: 6 kHz , 12 dB SINAD 1.8 uV. SSB/CW: 3 kHz, 10 dB SINAD 0.3 uV.	130 dB
MEDAV GmbH; Uttenreuth, Germany; +49-9131-583-0; www.medav.de					
CCTNG-D2	direct sampling HF	9 kHz-30 MHz	up to 24 MHz	For SNR of 10 dB = 500 Hz: -128 dBm. 3 kHz: -120 dBm. 25 kHz: -111 dBm.	156 dB
CCTNG-D3	IF sampling	30 MHz-3 GHz	up to 24 MHz	For SNR of 10 dB = 3 kHz: -114 dBm. 25 kHz: -105 dBm. 500 kHz: -92 dBm.	133 dB
CCTNG-D4	direct sampling HF	9 kHz-3 GHz	up to 24 MHz	For SNR of 10 dB at 100 kHz-30 MHz = 500 Hz: -128 dBm. 3 kHz: -120 dBm. 25 kHz: -111 dBm. For SNR of 10 dB at 30 MHz-3,000 MHz = 3 kHz: -114 dBm. 25 kHz: -105 dBm. 500 kHz:-92 dBm.	9 kHz-30 MHz: 156 dB. 30 MHz-3 GHz: 133 dB.

INST DYN RANGE	MOD TYPES	SUPPORT DF	# REC CHANNELS	PWR (in W)	SIZE (in in./cm)	PLATFORM
80 dB	*	phase and amplitude	3	125	19 in x 7U x 540 mm	air/grd-mob/shp
70 dB	*	phase and amplitude	up to 8	340	19 in x 4U x 544 mm	air/grd-mob/shp
80 dB	*	phase and amplitude	3	230	19 in x 6U x 570 mm	air/grd-mob/shp
70 dB	*	phase and amplitude	3-5	250-350	19 in x 6U x 640 mm	air/grd-mob/shp
approx 90 dB	FM, AM, SSB, pulse position and suppressed carrier.	Interferometric DF (phase and amplitude) and TDOA DF.	2 or more	50	19 in x 1U x 560 mm, 19 in x 2U x 320 mm (R3000 and R3200 stand alone versions) and 19 in x 4.5U x 560 mm (R3300 chassis-based version).	grd/sub
95 dB	FM, AM and SSB (USB and LSB).	amplitude DF	16 channels are implemented on a commercial general-purpose laptop.	<0.05 W per channel	2.03 x 6.5 x 8.67 in	air/grd/shp/sub/spc
60 dB	CW - pulse	yes	1 or 2 (expandable)	>300 (dep on number of channels)	7-in VME chassis (sufficient for 2 channels).	varied
74.3 dB	CW, AM, FM, SSB and other conventional signals.	amplitude and phase interferrometry	two self-contained channels	15	13.5 D x 7.3 H in (without antennas)	grd
*	FM, AM, SSB and CW	single-channel interferometer	1 DF, 2 monitor	9.5 typ	5.2 x 11.5 x 12.2 in	air/grd
75 dB or more	FM, AM, SSB, CW and ISB	single-channel interferometer	1 or 2	1 channel: 12.5 W. 2 channel: 15 W.	3.2 x 11.1 x 10.1 in	air/grd
90 dB SFDR	AM, FM, CW, LSB, USB and more than 200 dig transmission modes.	Watson Watt, interferometer and hyperbolic position finding.	3 RF paths for DF with Watson Watt. 5 RF paths for DF with interferometer.	50	1 RU x 19 in x 560 mm	air/grd/shp/sub
75 dB SFDR	AM, FM, CW, LSB, USB and more than 200 dig transmission modes.	Watson Watt, interferometer and hyperbolic position finding.	3 RF paths for DF with Watson Watt. 5 RF paths for DF with interferometer.	50	1 RU x 19 in x 560 mm	air/grd/shp/sub
9 kHz-30 MHz: 90 dB SFDR. 30 MHz-3 GHz: 75 dB SFDR.	AM, FM, CW, LSB, USB and more than 200 dig transmission modes.	Watson Watt, interferometer and hyperbolic position finding.	3 RF paths for DF with Watson Watt. 5 RF paths for DF with interferometer.	50	1 RU x 19 in x 560 mm	air/grd/shp/sub

MODEL	REC TYPE	OP FREQ	INST BW	TYP INST SENS	DYN RANGE
MEDAV GmbH; Uttenreuth, Germany; +49-9131-583-0; www.medav.de *continued*					
LANReceiver LR2 (in the variants D2, D3, and D4)	HF dig tuner with integrated wband A/D converter.	LR2-D2: 100 kHz-30 MHz. LR2-D3: 30 MHz-3 GHz. LR2-D4: 100 kHz-3 GHz.	up to 500 kHz	100 kHz to 30 MHz = AM: 6 kHz, Mi: 0.5, FM: 1 kHz, -108 dBm for 10 db/SNR. SSB: 2.7 kHz for 10 dB/SNR: -116 dBm. 5 kHz deviation: FM: 0.4 kHz for 20 dB/SNR.	100 kHz-30 MHz: 115 dB
PLATH GmbH; Hamburg, Germany; +49-(0)-40-23-73-40; www.plath.de					
Radio Direction Finder DFP5050	3-channel Watson Watt	(0.01) 0.3-30 MHz	20 kHz	-135 dBm (SNR = 10 dB)	165 dB
Radio Direction Finder DFP5400	3-channel Watson Watt	1-30 MHz	Selectable: 200 kHz or 2 MHz.	-139 dBm (SNR = 0 dB)	169 dB
Digital Broadband Tuner DBT5400	2 receivers in one cabinet	1-30 MHz	Selectable for each receiver: 200 kHz or 2 MHz.	-137 dBm (600 Hz BW)	167 dB
Radio Direction Finder DFP2400	7-channel correlative interferometer (full parallel).	20-3,000 MHz	20 MHz	-132 dBm	169 dB
QRC Technologies Inc.; Stafford, VA; +1-540-446-2121; www.qrctech.com					
ICS	superhet	869-1,990 MHz	5 MHz	-110 dBm	100 dB
ICS-2	superhet	80 MHz-3 GHz	5 MHz	-131 dBm	111 dB
Rockwell Collins, C3I, EW&IS; Richardson, TX; +1-972-705-1438; www.rockwellcollins.com					
XG Sensor	superhet and dig sampling	30-3,000 MHz	16 MHz	<-110 dBm	>100 dB
ROHDE & SCHWARZ GmbH & Co. KG; Munich, Germany; +49-89-4129-0; www.rohde-schwarz.com					
R&S®ESMD Widband Monitoring Receiver	superhet (VHF/UHF) and DDR (HF)	20 MHz-3.6 GHz. 9 kHz-26.5 GHz opt.	20 MHz and 80 MHz versions	<-126 dBm	150 dB with 40 dB attn (1-dB steps).
R&S®EM510 HF Digital Wideband Receiver	DDR	9 kHz-32 MHz	10 MHz	<-126 dBm	145 dB with 25 dB attn (1-dB steps).
R&S®PR100 Portable Receiver	superhet (VHF/UHF) and DDR (HF)	9 kHz-7.5 GHz	10 MHz	<-126 dBm	95 dB with 10-dB attn.
R&S®DDF255 Direction Finder	superhet	0.3 MHz-6 GHz	20 MHz	1-2 μV/m	150 dB with 40 dB attn (1-dB steps).
R&S®DDF®0xA Digital HF/VHF/UHF Search Direction Finder	superhet	9 kHz-3 GHz	10 MHz	1-2 μV/m	120 dB (including AGC).
Spatial and Spectral Research, LLC; Bedford, NH; +1-603-472-2575; www.SSRLLC.us					
SSRDF-0901 Ion	superhet and dig	20-3,000 MHz	40 MHz	approx -95 to -105 dBm	RF: approx 120 dB. Dig: approx 82 dB (14-bit digitization).
Tampa Microwave; Tampa, FL; +1-813-855-2251; www.tampamicrowave.com					
RV3500	superhet dig channelizer	9 kHz-3.5 GHz	200 MHz	9-18 dB noise figure dep on freq	80 dB

INST DYN RANGE	MOD TYPES	SUPPORT DF	# REC CHANNELS	PWR (in W)	SIZE (in in./cm)	PLATFORM
100 kHz-30 MHz: 85 dB SFDR	AM, FM, CW, LSB, USB and more than 200 dig transmission modes.	no	1	25	1 RU x 215 mm x 322 mm. Two tuners are mountable in 1 RU 19-in rack.	air/grd/shp/sub
>85 dB (SFDR2)	A1A, A3E, F3E, J3E+, J3E- and B8E.	yes	3	approx 32 W per channel	3 HU x 19 in x 16.6 in	grd
>87 dB (SFDR2)	no audio	yes	3	approx 96 W per channel	6 HU x 19 in x 16.6 in	grd
>90 dB (SFDR2)	no audio	no	2	approx 96 W per channel	4 HU x 19 in x 16.6 in	grd
>80 dB (SFDR2)	AM and FM	yes	7	approx 66 W per channel	7 HU x 19 in x 23.5 in	grd/shp
80 dB	GSM and CDMA	no	1	*	13 x 7.3 x 3.8 in	air/grd/shp
varies	GSM, CDMA and EVDO	no	1	*	10 x 7.5 x 5.25 in	air/grd/shp
*	*	amplitude	1	6.5 W typ, 3.5 W with power management.	3.5 x 5.75 x 0.99 in	air/grd/shp
110 dB	AM, FM, PM, PULSE, I/Q, TV, USB, LSB, CW and ISB.	HF: amplitude (Watson Watt). VHF/UHF/SHF: phase (correlative interferometer).	1	100-250 W	17.6 x 42.6 x 45 cm	air/grd/shp/sub
120 dB	AM, FM, PM, PULSE, I/Q, USB, LSB, CW and ISB.	no	1	33	8.7 x 42.6 x 45 cm	air/grd/shp/sub
85 dB	AM, FM, PULSE, I/Q, USB, LSB, CW and ISB.	Homing functionality with directional handheld antenna.	1	AC (external power supply): 100 V AC-240 V AC, 50 Hz/60 HZ, 700 mA. DC: 15 V DC +/- 10 percent, 2 A.	32 x 19.2 x 6.2 cm	air/grd/shp/sub
110 dB	AM, FM, PM, PULSE, I/Q, TV, USB, LSB, CW and ISB.	Supports DF. VHF/UHF/SHF: correlative interferometer. HF: Watson Watt.	1	100 VA-250 VA	42.6 x 17.6 x 45 cm	air/grd/shp/sub
120 dB (including AGC)	AM, FM, SSB and CW	Supports DF. VHF/UHF/SHF: correlative interferometer, super resolution opt. HF: Watson Watt.	3	430 VA-550 VA	43.6 x 38.4 x 46 cm	air/grd/shp/sub
RF: approx 120 dB (freq band-dep). Dig: approx 82 dB (14-bit digitization).	DF only. CW, AM, SSB, FM, VSB, PSK modulations and GSM format.	Super-resolution correlative interferometric DF (SSR-CIDF) and complex envelope CIDF (CE-CIDF).	2	15	approx 5 x 8 x 10 in	air/grd/shp/sub
45 dB	AM, FM, CW, USB and LSB	no	1 RF channel and 32 dig channelized.	50	16 x 16 x 1.75 in	air/grd/shp/sub

TECHNOLOGY SURVEY: COMINT/DF RECEIVERS

MODEL	REC TYPE	OP FREQ	INST BW	TYP INST SENS	DYN RANGE
TCI; Fremont, CA; +1-510-687-6110; www.tcibr.com					
TCI 802C HF Wideband DF System	Hybrid superhet. Channelized analog/dig receiver.	0.3-30 MHz	500 kHz or 2 MHz (dual BW receivers).	-120 dBm at 1 KHz BW.	130 dB
TCI 803C	Hybrid superhet. Channelized analog/dig receiver.	20-3,000 MHz (opt HFDF monitoring)	2 or 20 MHz (dual BW receivers).	-120 dBm at 1 KHz BW.	130 dB
TCI 902C HF Wideband DF System	Hybrid superhet. Channelized analog/dig receiver.	0.3-30 MHz	500 kHz or 2 MHz for DF. 36 MHz for HF monitoring.	-120 dBm at 1 KHz BW.	130 dB
TCI 903C	Hybrid superhet. Channelized analog/dig receiver.	20-3,000 MHz (opt 6 GHz)	2 or 20 MHz (dual BW receivers). 36 MHz for monitoring.	-120 dBm at 1 KHz BW.	130 dB
TCI 9091C HF Wideband DF System	Hybrid superhet. Channelized analog/dig receiver.	0.3-30 MHz	500 kHz or 2 MHz (or can be stacked up to 12 MHz).	-120 dBm at 1 KHz BW.	130 dB
Thales Group; Neuilly-sur-Seine, France; www.thalesgroup.com					
TRC 6200	DF and superhet receiver	9 kHz-3,000 MHz	2 MHz in HF. 40 MHz in V/UHF.	-125 dBm	120 dB
TRC 6300	DF	20 MHz-3,000 MHz	20 MHz	-125 dBm	120 dB
TRC 6500	DF and monitoring	1 MHz-30 MHz	6, 12 or 24 MHz	-125 dBm	120 dB
Ultra Electronics Telemus; Ottawa, ON, Canada; +011-613-592-2288; www.ultra-telemus.com					
C-EAGLE	superhet	10 kHz: >3 GHz	>30 MHz	>100 dBm	>80 dB
MicroEAGLE	superhet	20 MHz-3 GHz	2 or 16 MHz, others opt	>100 dBm	>80 dB

INST DYN RANGE	MOD TYPES	SUPPORT DF	# REC CHANNELS	PWR (in W)	SIZE (in in./cm)	PLATFORM
85 dB in 2 MHz BW	DF on all modulations	correlative interferometry and Watson Watt	dual-channel receiver	<200	7 x 19 x 20 in	grd
>80 dB at 20 MHz BW. >85 dB at 2 MHz BW.	DF on all modulations	correlative interferometry.	Multi-channel receiver (dep on config).	<200	7 x 19 x 20 in	grd/shp
85 dB in 2 MHz BW	DF on all modulations	correlative interferometry and Watson Watt	Dual-channel receiver for DF and 32, 64 or 96 for monitoring and analysis.	<200	14 x 19 x 20 in	grd
>80 dB at 20 MHz BW. >85 dB at 2 MHz BW.	all	correlative interferometry	Multi-channel receiver (dep on config).	<200	14 x 19 x 20 in	grd/shp
85 dB in 2 MHz BW	DF on all modulations	correlative interferometry	N-channel (can be stacked for instantaneous BW).	<200	28 x 19 x 21 in	grd-fix
80 dB	Non-modulated carrier: (FM and AM) NON. Analog: A3E, F3E , J3E and H3E. Dig: OOK, (FM and AM) BPSK, (FM and AM) QPSK, (FM and AM), PSK8, (FM and AM) p/2DBPSK, (FM and AM) p/4DQPSK, (FM and AM), OQPSK, (FM and AM) QAM8, (FM and AM) QAM16, (FM and AM) FSK, (FM and AM) CPM, (FM and AM) MSK and (FM and AM) OFDM.	Interferometry and Watson Watt, dep on DF antenna.	2	90	47 x 14 x 31 cm	air/grd/shp
80 dB	*	Correlative vectorial interferometer.	*	400	12U	air/grd/shp
80 dB	Non-modulated carrier: (FM and AM) NON. Analog: A3E, F3E , J3E and H3E. Dig: OOK, (FM and AM) BPSK, (FM and AM) QPSK, (FM and AM), PSK8, (FM and AM) p/2DBPSK, (FM and AM) p/4DQPSK, (FM and AM), OQPSK, (FM and AM) QAM8, (FM and AM) QAM16, (FM and AM) FSK, (FM and AM) CPM, (FM and AM) MSK and (FM and AM) OFDM.	super resolution	hundredths	dep on config	dep on config	grd-fix/shp
>80 dB	FM, AM, SSB, CW, DSB-SC, BFSK, MSK-type, BPSK, QPSK, /4 QPSK, 8PSK, MQAM, M16QAM, noise and others.	DF interferometer	1-4	dep on config	6u x EIA 19-in rack x 24 in	air/shp
>80 dB	FM, AM, SSB, CW, DSB-SC, BFSK, MSK-type, BPSK, QPSK, /4 QPSK, 8PSK, MQAM, M16QAM, noise and others.	DF interferometer	1-4	dep on config	1u x EIA 19-in rack	air/grd-mob

Survey Key – COMINT/DF Receivers

MODEL

Product name or model number

REC TYPE

Receiver type

- dig = digital
- superhet = superheterodyne
- IF = intermediate frequency
- BW = bandwidth
- PLL = phase-locked loop
- SDR = software-defined radio
- DF = direction-finding
- HF = high frequency
- RF = radio frequency
- A/D = analog to digital
- DDR = direct digital receiver
- LAN = local area network
- USB = universal serial bus

OP FREQ

Operating frequency

INST BW

Instantaneous bandwidth (if different from operating frequency)

TYP INST SENS

Typical Installed Sensitivity

- MDS = minimum discernible signal
- RBW = resolution bandwidth
- SNR = signal-to-noise ratio
- SINAD = signal-to-noise-and-distortion

DYN RANGE

Total dynamic range

- AGC = automatic gain control

INST DYN RANGE

Instantaneous dynamic range

- SFDR = spur-free dynamic range

MOD TYPES

Modulation types it can process

- FM = frequency modulation
- AM = amplitude modulation
- PM = phase modulation
- SSB = single-sideband
- PAM = pulse-amplitude modulation
- CW = continuous wave
- FSK = frequency shift keying
- BPSK = binary phase shift keying
- QPSK = quadrature phase shift keying
- GMSK = Gaussian filtered minimum shift keying
- SQPSK = staggered quadrature phase shift keying
- QAM = quadrature amplitude modulation
- LSB = lower sideband
- OOK = on/off key
- USB = upper sideband
- ISB = independent sideband
- OQPSK = offset quadrature phase shift keying
- I/Q = in-phase/quadrature
- GSM = global system for mobile
- CDMA = code division multiple access
- EVDO = evolution-data optimized
- DF = decision feedback
- VSB = vestigial sideband
- DBPSK = differential binary phase shift keying
- DQPSK = differential quaternary phase shift keying
- CPM = continuous phase modulation
- MSK = minimum shift keying
- OFDM = orthogonal frequency-division multiplexing
- DSBSC = double sideband-suppressed carrier
- BFSK = binary frequency shift keying
- MQAM = multilevel quadrature amplitude modulation

SUPPORT DF

Does it support DF and with what technology?

- TOA = time of arrival
- LO = local oscillator
- MUSIC = multiple signal classification
- SHF = super high frequency

 # REC CHANNELS

Number of receiver channels (RF paths) to create a complete system

PWR (in W)

Power dissipated in Watts per channel

- AC = alternating current
- DC = direct current

SIZE (in in/cm)

Size by height x weight x length, or diameter, in inches

- ATR = air transport rack
- PCI = peripheral component interconnect
- RU = rack unit
- VME = virtual machine environment
- HU = headset unit

PLATFORM

- air= airborne
- grd= ground
- grd-fix = ground-fixed
- grd-mob = ground-mobile
- shp = shipboard
- sub = submarine
- spc = space

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
Agilent	www.agilent.com
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November 2009 Product Survey: ELINT Systems

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Communications EW – Part 26

Jamming Frequency Hopping Signals *(continued)*

By Dave Adamy

The major problem associated with the effective jamming of frequency hoppers is that the jammed system uses only one (randomly selected) channel at a time, while the jammer needs to deal with all of the channels from which the target transmitter can select.

There are three general approaches to jamming frequency hoppers:

- Barrage jamming
- Partial band jamming
- Follower jamming

Barrage Jamming

A barrage jammer covers the entire frequency range over which the target system hops as shown in **Figure 1**. Thus, any channel chosen by the target transmitter/receiver will be jammed. This approach has the excellent advantage that the jammer need not receive the hopping signal; it eliminates the need for "look through." Because look-through is difficult to achieve in remote jammers, barrage jamming may be the ideal approach.

There are two major disadvantages to barrage jamming. One is "fratricide." Barrage jamming also will jam any friendly communication (fixed frequency or hopping) that is operating in the same geographical area. The second disadvantage is that barrage jamming is notoriously inefficient. Because you need to jam all possible channels, the power per channel is determined from the formula:

Power/channel = Total jammer power/number of hopping channels available

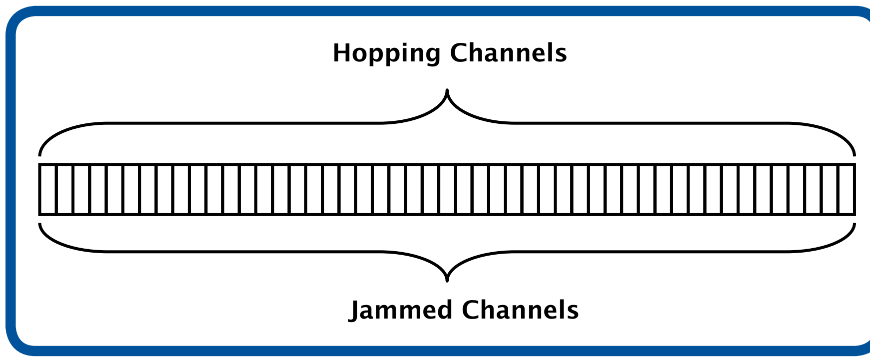

Figure 1: A barrage jammer divides its power among all of the hopping channels.

The solution to both of these problems is to place the jammer near the enemy transmitter. Remember that J/S is the ratio of the *received* jamming signal strength to the *received* desired signal strength – both in the target receiver. The signal strength is reduced by the square or fourth power of the distance from the transmitter to the receiver (depending on the frequency and geometry – see the July-September 2009 "EW 101" columns). Therefore, as the range to the target receiver is reduced, the J/S is increased. If the range to the target receiver is significantly shorter than the range to friendly receivers, fratricide is significantly reduced.

An example is shown in **Figure 2**. A one-Watt ERP, VHF transmitter is 10 km from its intended receiver. Both transmitter and receiver have whip antennas 2 meters above the ground. The signal hops over 1,000 channels. A barrage jammer with 1 Watt ERP is located 2 meters above the ground, 1 km from the target receiver. The propagation mode

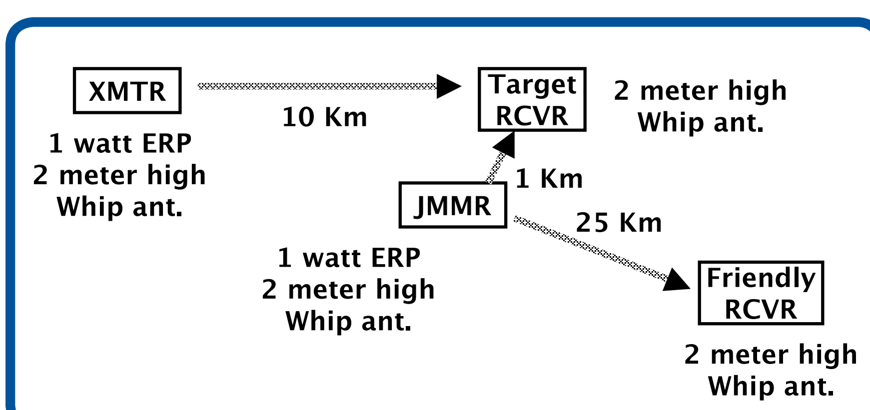

Figure 2: A barrage jammer 1 km from the target receiver and 25 km from a friendly receiver provides excellent J/S while avoiding fratricide.

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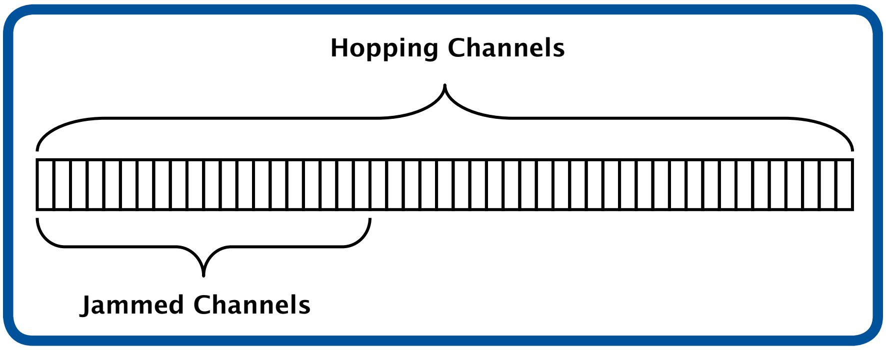

Figure 3: Partial band jamming distributes jamming over the number of channels, which can be subjected to 0 dB J/S per channel.

for both links will be 2-ray. Using the formulas found in the January 2009 "EW 101," the ratio of total jammer power to received desired signal power (which occupies only one channel at a time) is 40 dB. Dividing the jamming power over the 1,000 hopping channels reduces the power per channel by a factor of 1,000 (i.e., 30 dB). Thus the effective J/S in the target receiver is 10 dB. (Remember from the May 2009 "EW 101" that only 0 dB is required for effective jamming.) If a friendly receiver is 25 km from the jammer (operating over a similar 10 km link), it will be jammed with a J/S of -16 dB. If it is hopping over 1,000 channels, the effective J/S will be reduced to -46 dB.

Partial Band Jamming

Partial band jamming covers only part of the hopping range as shown in **Figure 3**. The amount of frequency range covered by the jammer is determined by:

- First, determine the overall J/S (in dB), which is the total received jamming power divided by the received desired signal power.
- Second, convert the J/S (in dB) into the linear form. For example, 30 dB is a ratio of 1,000.
- Third, spread the jamming frequency over a band determined by:
  Non-dB J/S ratio x hopping channel bandwidth.

In the above example, dividing the signal into 1,000 channels reduces the J/S by 30 dB, producing 0 dB J/S in each of the hopping channels covered by the jamming.

Because the target signal randomly hops over its whole hopping range, the jamming duty cycle is calculated by dividing the number of jammed channels by the total channels in the hopping range.

The required duty cycle is generally accepted as 33 percent for digitized voice, although some EW writers convincingly argue that 20 percent or even much less can be effective under many circumstances.

Here is a partial band jamming example: suppose that a frequency hopper with 25-kHz channel bandwidth hops over 58 MHz. If a jammer can provide 29 dB total J/S, it would be spread over 794 channels (19.9 MHz) for 0 dB per channel. The total number of hop channels is:

58 MHz / 25 kHz = 2320

The jamming duty factor is:

794 / 2320 = 34.2 percent

A few important points about partial band jamming:

- Because 0 dB jamming and 33 percent duty cycle produce effective jamming, this is the most efficient use of a jammer (i.e., maximum jamming effectiveness for the amount of jammer ERP available).
- The required jamming duty factor must be in every second of transmission. Otherwise, useful information could get through.
- The jammed band must be moved around the hopping range. Otherwise, the target system can reduce its hopping range to avoid the jammed channels.
- If error correction codes are used by the target system, the jamming duty factor will need to be increased to provide effective jamming.

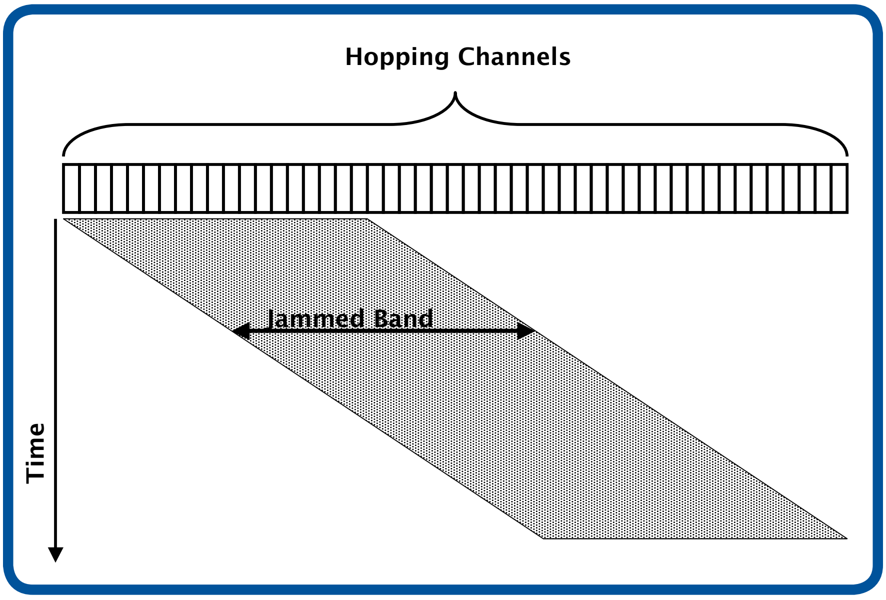

Figure 4: Swept spot jamming covers all of the hopping channels with a less than 100 percent duty cycle.

Swept Spot Jamming

A swept spot jammer covers part of the hopping range, but sweeps its "spot" over the whole range as shown in **Figure 4**. This is a special application of partial band jamming, and can be very effective in remote jammers.

What's Next

Next month, we will complete our discussion of frequency hopper jamming. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

AOC association news

HIGHLIGHTS: **INFOWARCON 2009**

Hundreds of enthusiastic attendees gathered April 22-24 for the AOC's InfoWarCon 2009, a conference dedicated to the development of information operations (IO), the discussion of IO concepts and the strengthening of the IO community. Held just outside of Washington, DC, at the Gaylord National Resort in National Harbor, MD, the event marked the revival of InfoWarCon, which began in the 1990s and returned after a brief lapse.

Its first year being supported and managed entirely by the AOC, this year's InfoWarCon featured an impressive lineup of speakers and panels. Delivering the keynote address on Thursday was LTG Thomas F. Metz of the US Army, acting director of the Joint IED Defeat Organization (JIEDDO), who spoke on the status of IO as "the great enabler." Other speakers and panelists covered topics including IO's future, cyberwar, homeland psychological defense and information warfare in China and Arab countries. Friday's keynote speaker was James Glassman, former US Undersecretary of State for Public Diplomacy and Public Affairs, and the closing address was given by the DOD's Senior Advisor for IO, Office of the Director, IO & Strategic Studies, Jake Schaffner, who thanked the AOC for reestablishing a meeting place for information operators.

Accompanying InfoWarCon 2009 was the April launching of the AOC's *IO Journal*, a publication about IO written by and for information operators. An on-line version of the inaugural issue of *IO Journal* can be accessed at www.crows.org.

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