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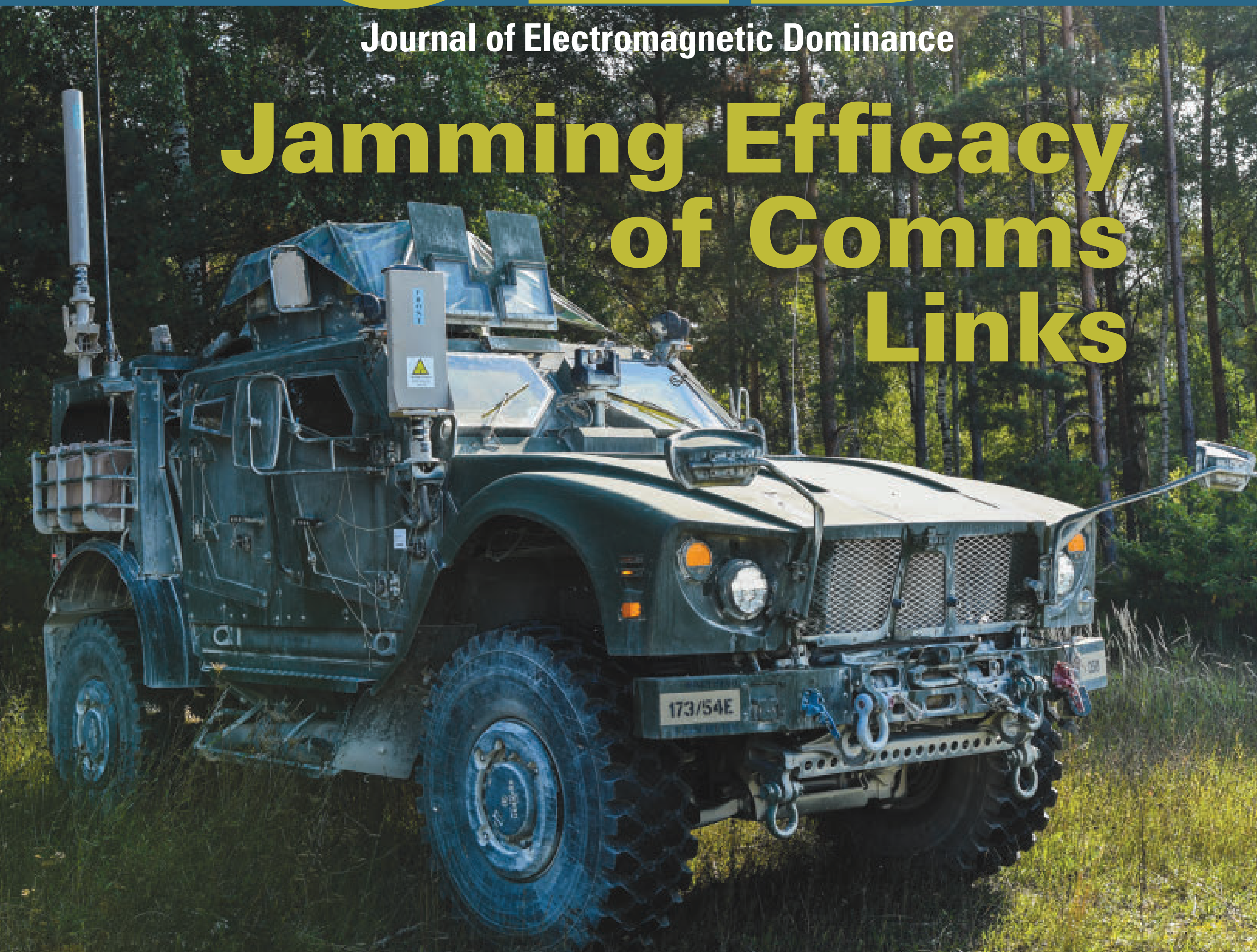
# JED
Journal of Electromagnetic Dominance




# Jamming Efficacy of Comms Links

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JED
Journal of Electromagnetic Dominance

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*When jamming communications, great emphasis is placed on the jammer's signal strength at a victim receiver's location, when in fact there should be an equal emphasis placed on the space, or "link distance," between the transmitter and receiver.* US ARMY



### AOC Industry Member Guide

This month, *JED* is publishing the AOC Industry Member Guide on our web site at www.JEDOnline.com. Listing company descriptions and contacts for more than 200 organizations, the AOC Industry Member Guide is a valuable resource for all EMSO professionals. You can access it at www.JEDOnline.com.

COVER PHOTO COURTESY OF US ARMY


*Operation SPACECAT: In late 2021, Cougars from the US Navy's Electronic Attack Squadron 139 (VAQ-139) flew from NAS Whidbey Island, WA, to Cape Canaveral, FL, at the invitation of the US Air Force's 114th Space Control Squadron (SPCS). Known as the Thundercats, the 114th SPCS operates the Counter-Communications System (CCS), a ground based systems that denies communications on satellites. "The purpose of this operation was to bring two Electromagnetic Attack Squadrons together," said Lt Col Anthony Surman, assistant operations officer, 114th SPCS, in an Air Force news release. "We wanted to create a forum where our teams could hear directly from other tactical Electromagnetic Warfare experts about the capabilities of our systems and also learn a little bit about space missions and the many activities going on at Cape Canaveral." Because the two squadrons share two feline identities, the two-day event was dubbed Operation SPACECAT. "From our initial discussions, we knew there would be a close relationship and bond between attack-minded operators," said CDR Kevin Jones, Executive Officer of VAQ-139. "From my perspective, the most inspiring part of the day was sharing our respective capability briefings and getting the Growler crews on our operations floor," said TSgt Evgenie Borchers, electromagnetic warfare operator, 114th SPCS. "We speak the same language. We want to be on the attack, we share similar challenges and we each have missions that are critical to success in a high-end fight."* US AIR FORCE

## Departments

# GAINING PERSPECTIVE

**Sometime this month,** the White House is expected to release its FY2023 Budget Request, which includes the DOD's proposed budget. Will it be higher than the FY2022 DOD budget proposal? Will it be lower? Does it matter all that much, especially when Congress holds the power of the purse strings and can adjust the budget request up (as it usually does) or down. Does a budget increase matter very much if there is a political stalemate that only yields a series of continuing resolutions that freeze the budget at previous levels for half of the fiscal year?

For many, this top-line number seems important because they use it "heuristically" as a barometer for the state of national defense. Defense companies (rightly) care about this number because it signals stability (or instability) in their future program funding. Politicians care about this number, especially if they have defense companies or military bases in their district or state. But for most other purposes, the defense budget's topline number is a poor way to measure the overall health of national defense.

Let's look at EMSO as a more specific example of this. Even if we do the hard work of pulling together all of the various EMSO-related budget lines in the FY2023 budget, what will it tell us? If we try assess the state of EMSO from a Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities (DOTMLPF) paradigm, the defense budget can only give a somewhat meaningful indication about just one of these elements: future materiel development and procurement. The DOD budget doesn't indicate how many EMSO professionals are in the Department or what their level of competence is. The budget doesn't tell us how well various units are trained in contested EMS environments. It says nothing about the health and status of EMSO organizations or how much political clout senior EMSO leaders have in the Pentagon. It is pretty obvious that the DOD budget doesn't provide much information about EMSO DOTMLPF, because this is not its purpose. So why do so many people ascribe so much meaning to the budget? Probably because it's the only document we can rely on in an information-starved environment.

So, what sort of document (or set of documents) do provide a better insight into the overall status EMSO? How can EMSO DOTMLPF be measured in a way that can be communicated? Some of these questions were being asked by the EMSO Cross-Functional Team (CFT) as part of its effort to develop the EMS Superiority Strategy. But that organization is slated to disband this year, and it's not clear if the DOD CIO or the Joint Electromagnetic Warfare Center (JEWC) will take the same holistic look at EMSO as the CFT tried to do.

In the meantime, the FY2023 DOD budget will be released, and many of us will try (as usual) to extract some overblown sense of meaning from that document. *JED* will report on it. However, we'll try to remind ourselves what the DOD budget is, and what it isn't. – *J. Knowles*

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# Calendar *Conferences & Trade Shows*

## MARCH

**AFA Aerospace Warfare Symposium**
March 2-4
Orlando, FL
www.afa.org

**World Defense Show**
March 6-9
Riyadh, Saudi Arabia
www.worlddefenseshow.com

**Modern Threats: Surface-to-Air Missile Systems Conference**
March 8-9
Huntsville, AL
www.crows.org

**Defexpo 2022**
March 11-13
Gandhinagar, Gujarat, India
www.defexpoindia.in

**Dixie Crow Symposium 46**
March 20-23
Warner Robins, GA
www.dixiecrowsympsoium.com

**DIMDEX 2022**
March 21-23
Doha, Qatar
www.dimdex.com

**Satellite 2022**
March 21-24
Washington, DC
www.satshow.com

**IEEE Radar Conference**
March 21-25
New York, NY
www.radarconf2022.org

**Defence Services Asia**
March 28-31
Kuala Lumpur, Malaysia
www.dsaexhibition.com

## APRIL

**AAAA Mission Solutions Summit**
April 3-5
Nashville, TN
www.quad-a.org

**Navy League Sea-Air-Space**
April 4-6
National Harbor, MD
www.seaairspace.org

**37th Space Symposium**
April 4-7
Colorado Springs, CO
www.spacesymposium.org

**SPIE Defense + Commercial Sensing**
April 5-7
Orlando, FL
www.spie.org

**FIDAE 2022**
April 5-10
Santiago, Chile
www.fidae.cl/en

**Annual Directed Energy S&T Symposium**
April 25-29
Mobile, AL
www.deps.org

## MAY

**Cyber Electrometric Activities (CEMA) 2022**
May 3-5
Secret/US Only, TS/SCI
Aberdeen, MD
www.crows.org

**AOC Europe**
May 10-12
Montpellier, France
www.aoceurope.org

**Electronic Warfare Capability Gaps and Emerging Technologies**
May 10-12
Crane, IN
www.crows.org

## JUNE

**AOC Kittyhawk Week**
June 14-16
Dayton, OH
https://kittyhawkaoc.org

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

# Calendar *Courses & Seminars*

## MARCH

**Advanced Radar**
March 7-11
Shrivenham, Swindon, UK
www.cranfield.ac.uk

**AOC Live Virtual Professional Development Course: Microwave Photonics**
March 7-28
10 Sessions, 3hrs. each
www.crows.org

**Principles of Millimeter Wave Radar EW**
March 9-10
Atlanta, GA
www.pe.gatech.edu

**AOC Virtual Series Webinar: How to Use Simulation to Align Your Work Team**
March 10
2-3 p.m. EST
www.crows.org

**Aircraft Survivability**
March 14-18
Shrivenham, Swindon, UK
www.cranfield.ac.uk

**SIGINT Fundamentals**
March 15-16
Denver, CO
www.pe.gatech.edu

**Adaptive Arrays: Algorithms, Architectures and Applications**
May 17-20
Atlanta, GA
www.pe.gatech.edu

**Counter IED Capability**
March 21-25
Shrivenham, Swindon, UK
www.cranfield.ac.uk

**Infrared/Visible Signature Suppression**
March 22-25
Atlanta, GA
www.pe.gatech.edu

## APRIL

**AOC Live Virtual Professional Development Course: Tactical ISR Principles, Systems, and Techniques**
April 4-27
8 Sessions, 3hrs. each
www.crows.org

**AOC Virtual Series Webinar: EW and the Moscow Criteria**
April 7
2-3 p.m. EDT
www.crows.org

**Basic RF Electromagnetic Warfare Concepts**
April 12-14
Atlanta, GA
www.pe.gatech.edu

**Infrared Countermeasures**
April 12-15
Atlanta, GA
www.pe.gatech.edu

**AOC Virtual Series Webinar: Space EW**
April 21
2-3 p.m. EDT
www.crows.org

## MAY

**AOC Live Virtual Professional Development Course: EW Against a New Generation of Threats**
May 2-25
8 Sessions, 3hrs. each
www.crows.org

**AOC Virtual Series Webinar: Solutions for Quantum Computing and Communications**
May 5
2-3 p.m. EDT
www.crows.org

**Electromagnetic Warfare Data Analysis**
May 10-11
Atlanta, GA
www.pe.gatech.edu

*AOC courses and webinars are noted in **red**. For more info or to register, visit crows.org.*

# WHERE HAVE ALL THE EWOS GONE AND IS THE EMS STILL NEGLECTED?

**I hope my** title got your attention, as it is a question I have been thinking about and have been asked by others. Throughout my career, I have seen EWOs become DSOs, CSOs and WSOs. As I have mentioned in an earlier column, terminology changes and evolves, but my question goes to, are we training and equipping future EWOs with the knowledge, tools and capabilities they need to operate effectively and, gain and maintain superiority within the EMS? Are we funding EMSO to meet the strategy and developing implementation plans to meet the needs of the global EMSO community?

There have been a few recent articles on EMSO and EWOs from the Mitchell Institute, AFA and War on The Rocks; in fact the Mitchell Institute held a panel on Spectrum Warfare on February 17 discussing EMSO and EWOs. Maj Gen Ken Israel, USAF (Ret.), AOC Past President and Gold Medal awardee, recently wrote an article for the Mitchell Institute on “Drip Feeding Improvements in EMSO Will Not Work.” He highlights that while the United States has an EMS Superiority Strategy Implementation Plan, it is in a bureaucratic process to achieve the five goals o: develop superior EMS capabilities; evolve to an agile, fully integrated EMS infrastructure; pursue total force EMS readiness; secure enduring partnerships for EMS advantage; and establish effective EMS governance. I believe the EMSO strategy is a good one, but the challenge with implementing it is that our government and Department of Defense do not move at the speed of technology, so we are continually trying to catch up.

General Israel discussed six recommendations based on his experiences as an EWO and leader. We need: a cadre focus; build a professional EWO base; skills matching; tactics orientation; Intergovernmental Personnel Act (IPA) surge; and EW/EMSO training. Some of the challenges that he highlighted, and I agree with, are that we need to start early with recruiting and STEM is key, as well as formal EMSO training – as it takes years for someone to become a Subject Matter Expert. We also need to open the aperture to and realize that the EMSO community is not just a military community. We must also remember that EMSO not only crosses and links all the domains, but also the global community. I would also like to remind you that the AOC has established a professional certification program which we are growing over the coming months and years. This is a valuable resource for EMS professionals and will help to educate and build up the professional EMSO/EWO community.

As we enter into March, conferences are planned to ramp up with in-person events; I am optimistic that we will have successfully made it through the latest pandemic surge and are moving on to normal times once again. My fellow Crows, stay safe out there, spread the news, welcome new Crows, mentor young Crows and look to help the AOC grow and improve. – *Glenn “Powder” Carlson*


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## DARPA SOLICITS PROPOSALS FOR HEL SOURCE TECHNOLOGY

The Defense Advanced Research Projects Agency (DARPA) has issued a Broad Agency Announcement (BAA HR001122S0017) for the development of high energy laser (HEL) source technology that can be used in next-generation laser weapons systems. Under the aptly named Modular Efficient Laser Technology (MELT) program, DARPA's Microsystems Technology Office (MTO) is seeking industry proposals for a five-year, $60 million effort to "...develop a laser tile as the building block for compact, scalable, panelized HEL sources," according to the BAA.

As described in the solicitation, "Today's Laser Weapon Systems (LWS) are not scalable across the full mission space due to the use of multiple beam-combined high-power fiber amplifiers as the HEL sources and large complex optical subsystems needed to condition and project the laser beam. Alternatively, coherent beam combined tiled array HEL sources are scalable by eliminating the need for these large subsystems. Coherently beam combined tiled arrays offer a path to better HEL sources because of (1) the ability to generate and project the LWS beam directly without bulk optics, (2) the intrinsic scalability of a tiled array with no inherent limits, (3) the ability to perform non-mechanical beam steering for beam jitter corrections, and (4) the ability to apply complex phase corrections to compensate for atmospheric disturbances." With these novel HEL sources, future laser weapons systems can be developed with less complex designs and in smaller, scalable packages that are significantly less expensive than current systems.

MTO program officials anticipate that the MELT program can combine the favorable properties of two solid-state laser technologies: vertical-cavity surface-emitting laser (VCSEL) diodes, and edge emitting laser diodes. As described in the BAA, "Each MELT tile will contain a 2D array of laser emitters whose phase can be continuously sensed and controlled to achieve coherent beam combination. For scalable output power, several to several hundred of these tiles may be arranged as a panelized, gimbal-mounted laser weapon source that produces a directly usable output beam." The BAA adds, "The challenge in adapting these emitter technologies to directed energy applications is maintaining excellent beam quality while scaling power, which requires coherent beam combining (CBC) of the multiple individual emitters."

The MELT BAA spells out several technical tasks to be addressed across three program phases. Technical Challenge 1 calls for "achieving a dense planar tiled array of amplifiers with uniform spacing and emission normal to the 2D surface." The objective of Technical Challenge 2a is "realizing a scalable phase sensing architecture for a panelized HEL source." Technical Challenge 2B addresses "realizing a scalable phase control architecture for a panelized HEL source." Finally, the objective of Technical Challenge 3 is "realizing a compact scalable cooling solution to remove the anticipated thermal load from a panelized HEL source."

As this issue of *JED* went to press, DARPA was planning to hold a MELT Proposers' Day on Feb. 18. Abstracts are due on March 7, with full proposals due on May 2. The technical point of contact is Dr. Thomas Ehrenreich, MTO Program Manager, e-mail HR001122S0017@darpa.mil. – *J. Knowles*

## TERMA, LEONARDO DEMONSTRATE ECIPS-CJS JAMMER ON F-16

Terma (Lystrup, Denmark) and Leonardo (Luton, UK) have revealed first flight demonstrations of a new pylon-integrated self-protection jammer designed for operators of the F-16.

The new installation integrates a Leonardo-developed Compact Jamming System (CJS) with Terma's Electronic Combat Integrated Pylon System (ECIPS). The ECIPS pylon – previously procured by both the Royal Danish Air Force (RDAF) and the Royal Norwegian Air Force for their respective F-16 fleets – was originally designed as a means by which to accommodate a Northrop Grumman AN/ALQ-162(V)6 self-protection jammer without sacrificing an external weapons station.

Terma and Leonardo began discussions in mid-2017 on integrating the latter's CJS payload into ECIPS as a more modern alternative to the AN/ALQ-162(V)6. The CJS is a high-power, small form factor DRFM-based jammer combining a techniques generator, separate transmit/receive antennas fore and aft, and transmitters and power hardware. The ECIPS-CJS installation – designed to fit onto F-16 wing stations 3 or 7 – retains a full weapons carriage capability, and maintains envelope and weight characteristics similar to current standard ECIPS configuration. The system is designed to work in conjunction with Terma's PIDS+ countermeasures dispenser pylon on the opposite wing station.

Last year, Terma and Leonardo completed ground-based testing at their respective system integration laboratories. This was followed in late October by a series of flight demonstrations using an F-16 of the RDAF. According to Terma, several different jamming techniques were successfully employed during performance testing "against an RDAF radar test site with a challenging ground threat emitter". Terma added that the two companies are now ready to provide the integrated ECIPS-CJS solution to potential customers. – *R. Scott*

## INDRA TO PROVIDE SELF-PROTECTION SUITE FOR SPANISH CH-47F CHINOOKS

Spanish systems and sensors house Indra is to supply indigenous defensive aids suite to protect CH-47F Chinook transport helicopters operated by the *Spanish Army* Airmobile Force/Fuerzas Aeromóviles del Ejército de Tierra (FAMET).

Under a €35 million contract awarded by the Ministry of Defence, the company will equip the FAMET's upgraded Chinooks with new threat warning and countermeasures systems. Boeing is upgrading 17 CH-47D helicopters to CH-47F standard.

According to Indra, the aircraft survivability equipment installation for the CH-47F will feature the company's ALR-400FD digital radar warning receiver, the InWarner electro-optical/laser threat warner, and the InShield directed infrared countermeasures system. The upgraded helicopters will additionally be equipped with chaff countermeasure dispensers and flares. – *R. Scott*



## FIRST PRODUCTION MULTI-INT MQ-4C DELIVERED

The first production MQ-4C Triton unmanned air system (UAS) configured to Multi-Intelligence (Multi-INT) configuration has been delivered by Northrop Grumman to the US Navy.

Aircraft B8 was delivered to Naval Air Station Patuxent River (Patuxent River, MD) February 1. The Multi-INT configuration – embodied in the Integrated Functional Capability 4 (IFC-4) standard – will enable the MQ-4C UAS to replace the EP-3 Aries II aircraft for most SIGINT missions.

The Multi-INT kit incorporated in IFC-4 includes sensor, electronics and communication subsystems changes to permit processing of Top Secret and Sensitive Compartmented Information. ArgonST, a Boeing subsidiary, is the designer, developer and integrator of the Multi-Intelligence Sensor Development (MISD) Low Band Sensor Suite, while Sierra Nevada Corporation is taking equivalent responsibility for the MISD High Band Sensor Suite.

Specific air vehicle modifications to support Multi-INT include SIGINT antennas and systems, a new High Gain Common Data Link antenna and associated avionics, addition of a Keyed Broad Area Maritime Surveillance Airborne Recorder (K-BAR), a new Airborne Mission Processor, new airborne network hardware, addition of high assurance internet protocol encryptors, new voice communications, a new cross domain solution (CDS), and air vehicle aircraft modifications to mitigate electromagnetic interference. Associated changes are required to Main Operating Base and Forward Operating Base facilities to support Multi-INT. These include the addition of a K-BAR docking station, addition of mission execution equipment (replaces existing payload hardware), new communication and network equipment, the addition of CDS and addition of a Sensitive Compartmented Information Facility Data Facility.

The US Navy plans to declare Initial Operational Capability with the MQ-4C at IFC-4 standard in the last quarter of

FY2023. The MQ-4C Triton aircraft being acquired for the Royal Australian Air Force under Project Air 7000 Phase 1B will also be delivered in the Multi-INT configuration. – *R. Scott*

## BRIEFLY NOTED

**Kleos Space** (Luxemborg), which provides space-based RF reconnaissance data-as-a-service, has received a data evaluation contract from **Advanced Ground Information Systems, Inc. (AGIS).** AGIS simultaneously processes up to 200,000 real-time sensor reports to provide command and control communication capabilities to US military, government and first responders. Its Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance and Reconnaissance (C5ISR) system enables data interoperability between US and NATO C5ISR systems to provide a common operational picture. Kleos also announced a partnership with geospatial analytics company **Satellogic,** which provides high-resolution satellite imagery to governments and commercial customers globally. It currently has 17 satellites in low earth orbit. Kleos operates eight RF monitoring satellites in orbit and is planning to launch a further eight over the first half of 2022.

The US Air Force's 350th Spectrum Warfare Wing (Eglin AFB, FL) announced plans to award a new $18 million, five-year contract to **Peraton Corp.** (Herndon, VA) for engineering services in support of the B-1 Reprogrammable Electronic Warfare Systems Test (REWST) Lab, the B-52 Electronic Warfare (EW) Mission Data (MD) Test Lab, and the 350th Spectrum Warfare Group/16th EW Squadron Special Test Equipment (STE). Additionally, this SES contract will support the testing of the B-1's AN/ALQ-161 and the B-52's AN/ALQ-172 EW systems. Peraton and its previous corporate entities have served as the primary contractor for sustaining engineering services to the 350th Spectrum Warfare Group (SWG)/16th Electronic Warfare Squadron (EWS) since 1997.

The US Army's **Rapid Capabilities and Critical Technologies Office (RCCTO)** (Redstone Arsenal, AL) has issued a Request for White Papers (RFWP) for Indirect Fire Protection Capability-High Energy Laser (IFPC-HEL) Prototypes. The IFPC-HEL will protect fixed and semi-fixed sites from rockets, artillery and mortars; unmanned aerial systems; and rotary and fixed-wing threats. White papers are sought for a prototype 300kW-class HEL weapon system. This effort will provide up to four (4) complete HEL weapon systems (beam control, beam director, battle management, and power and thermal management), integrated onto an Army vehicle. The HEL weapon systems must be delivered no later than 4QFY24. The contracting point of contact is Joshua Flinn, joshua.e.flinn.civ@army.mil. White papers are due by March 4.

**Narda-MITEQ** (Hauppauge, NY) has acquired SIGINT receiver manufacturer **Intelligent RF Solutions, LLC (iRF)** (Sparks, MD) for an undisclosed sum. iRF, which traces its heritage back through Cobham SIGINT, TYCO SIGINT, M/A-COM SIGINT Products Group, Adams-Russell, and Microtel (founded in 1962), makes SIGINT tuners and collection receivers. Narda-MITEQ itself was recently acquired from **L3Harris** by an affiliate of private equity firm J.F. Lehman. The company said iRF will retain its current operations, facility, processes, identity and leadership team.

The **Air Force Research Lab's Sensors Directorate** (Wright-Patterson AFB, OH) is soliciting proposals for its Proficient Research of Onboard Subsystems Technology (PROST) Program, which calls for development of novel electro-optical (EO), hyperspectral (HSI), radio frequency (RF), and electronic warfare (EW) subsystems, including both analog and digital components. According to the solicitation, "As operating environments become more contested and congested, aircraft survivability and air/space dominance is reliant on the ability to quickly sense the environment, process the data on the edge, and react to the gathered information. Meanwhile, sensor technology has improved to capture more data from the environment. The need to exploit this additional information within congested environments is critical for the future operation of the United States Air Force (USAF), United States Space Force (USSF), sister services, and the nation's security at large. Although processing the data on the edge is critical for an immediate response, data compression is equally important to transmit the data for additional processing and forensic analysis. AFRL/RYDR is developing unique capabilities in the areas of edge processing and data compression and this effort will focus on emerging needs in this research area." The PROST program will focus on development of on-board sensor subsystems that combine heterogeneous devices – including CPUs, GPUs, FPGAs, and AI accelerators – with open system architectures. It will also investigate compression techniques for multiple sensor modalities, including EO, RF, HSI, and EW onboard airborne and space-based platforms. The Sensors Directorate's Aerospace Components & Subsystems Technology Division, Radio Frequency/Electro Optical Subsystems Branch (AFRL/RYDR) is managing the PROST effort, which will focus on several task areas: RF subsystems, EO subsystems, EW subsystems, autonomous subsystems, open architecture research and system engineering, integration and analysis. The five-year program is valued at $8 million. The technical point of contact is David Lucking, Program Manager, AFRL/RYDR, +1 (937) 713-8561, david.lucking.1@us.af.mil.

The US Army's **Program Executive Office – Aviation** and its Unmanned Aircraft Systems (UAS) Project Management Office (PMO) have issued a new Request for Information (RFI) soliciting industry input for its Air Launched Effects (ALE) program. Along with the current ALE technology demonstration and ALE Small (ALE-S) prototyping activities, program officials will use the information gathered through this RFI process to shape its overall ALE acquisition strategy. The UAS PMO has issued three different RFIs simultaneously – each covering a specific part of the ALE strategy and ALE Family of Systems (FoS). The ALE-Architect RFI is being used to define the ALE architecture within the Future Vertical Lift FoS and drive integration across existing platforms and the FVL ecosys-

tem, while ensuring Modular Open System Approach (MOSA) compliance. The ALE-Weapons System (ALE-WS) RFI is being used to integrate the various components within the weapons system to produce a fully functional ALE system. Finally, the ALE-Enablers RFI will focus on providing MOSA-compliant components to the ALE Weapons System. According to the solicitation, the RFIs will inform the initial capabilities for ALE weapons that the Army wants to field in FY2025, with expectation to field an ALE that is capable of all behaviors by FY2030+. Responses to the RFI are due by March 10. The contracting point of contact is Julie Nelson, julie.w.nelson.civ@army.mil.

The **Air Force Research Lab's Materials and Manufacturing Directorate** (AFRL/RX) (Wright-Patterson AFB, OH) has announced an upcoming effort named Low-Cost Optical Systems Technology (Low-COST) that aims to "...apply novel concepts in optical technologies to compact EO/IR systems and sensors engineered for attritable and low-cost, small, unmanned aircraft systems," according to a Jan. 31 Notice of Contracting Action (NOCA). The Low-COST Program aims to mature and demonstrate "...new advances in meta-optics to realize increased system performance through hybrid and planar optic system. Specifically, exploiting the capability of highly configurable meta-optic system to work in concert with computational imaging and subsequent processing to demonstrate increases overall specific system performance outside of imaging applications is a primary goal of the program. This will provide a new capability for active and passive EO/IR sensors, addressing primarily small and attritable UAS platforms and providing autonomous sensing capabilities such as incoming missile warning, laser warning, and infrared search & track (IRST)." Managed by the Directorate's Functional Materials Division, Nanoelectronic Materials Branch (AFRL/RXAN), program officials expect to release a Low-COST Broad Agency Announcement this month. Valued at $2.7 million over four years, the program is expected to award two Cost-Plus Fixed Fee contracts. The technical point of contact is Joseph Burns, Program Manager, AFRL/RXAN, joseph.burns.9@us.af.mil.



The **Air Force Research Lab's Sensors Directorate** (Wright-Patterson AFB, OH) has issued a new call, Mission Systems Open Architecture Prototyping, Experimentation, and Demonstration (MOAPED) (Call 04), under its larger Trusted and Elastic Military Platforms and Electronic Warfare (EW) System Technologies (TEMPEST) program. According to the Combined Synopsis/Solicitation, the aim of MOAPED is to "...develop and demonstrate through collaborative experimentation, technology and advanced component prototype solutions to evolve and expand emerging open architecture (OA) standards and approaches for current and next-generation Air Force and DoD weapon systems...Open Standards of interest include, but are not limited to Big Iron, Scalable Payload for Electronic Attack Development (SPEAD), Common Open Architecture Radar Processing Specification (COARPs), Open Mission Systems/Universal Command and Control Interface (OMS/UCI), and COBRA. The program involves phases of Research, Development, Test, and Evaluation (RDT&E), mission/weapon system development, production, sustainment, operational assessments and deployments through participation in support of Joint All Domain Command Control and Advanced Battle Management System. The MOAPED program also includes advancing other enabling technologies such as Modeling, Simulation, and Analysis (MS&A), Data Lake/Warehouse, Development/Security/Operations (DevSecOps), Digital Engineering, and Cyber Survivability, which must inherently accompany advanced mission capabilities for their verification, validation, maturation, and experimentation." The 48-month program, which is being managed by the Resilient and Agile Avionics Branch (AFRL/RYWA), is valued at $49 million. The Advanced Research Announcement (ARA) number is FA8650-20-S-1958. The technical point of contact is Kenny Littlejohn, AFRL/RYWA, 1 (937) 713-8142, e-mail kenneth.littlejohn@us.af.mil.

The Integrated Battlespace Modeling and Simulation Department at the Naval Air Warfare Center - Aircraft Division (Patuxent River, MD) announced plans to award a sole-source contract to **Northrop Grumman's Amherst Systems** business unit (Buffalo, NY) for procurement, integration, and engineering support of Electro-Optical Infrared Direct Injection (EOIRDI) KEOS/SKIP scene generation systems. The Navy, in collaboration with the US Army's Redstone Test Center, has a requirement for scene generator systems to support test and evaluation of F-35 Distributed Aperture System (DAS) missile warning system (MWS), DAIRCM, LAIRCM, CIRCM, and LIMWS rotary-wing (RW) sensor systems.

# Jamming Efficacy of C

By Tracy-Paul Warrington

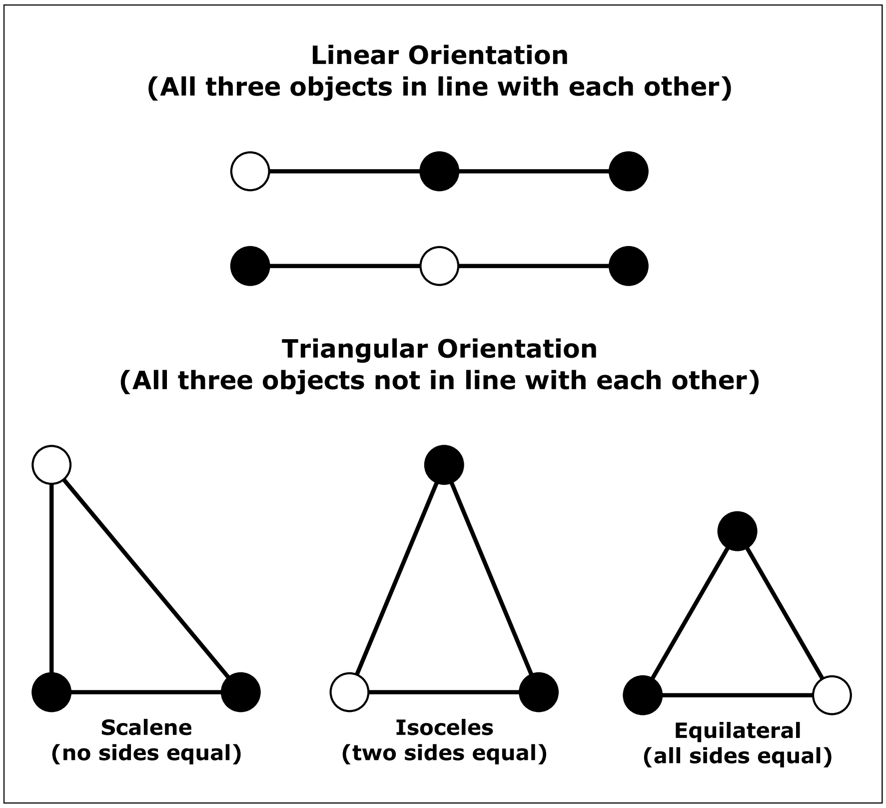
**When jamming communications,** great emphasis is placed on the jammer's signal strength at a victim receiver's location, when in fact there should be an equal emphasis placed on the space, or "link distance," between the transmitter and receiver. The link distance between a victim receiver and transmitter (or transceivers) is crucial because either the receiver or transmitter can move close enough to the other and "burn through" the jamming. The term "burn through" refers to an effect where the transmitted signal strength, at the victim receiver, is greater than or equal to the signal strength from the jammer. For this paper, the term "parity distance" describes the maximum distance a transmitter can be located from a victim receiver and equal the signal strength from the jammer. Any distance less than the parity distance means the transmitter signal is closer and its signal is stronger than the jamming signal, thus rendering the jamming signal less effective or useless. This scenario can create a false-positive condition from an electromagnetic attack perspective; thinking the victim receiver is disrupted and reporting that effect to the tactical commander. This article outlines a technique to estimate parity distance between transceivers, using a well-established algorithm.

## ELECTROMAGNETIC WARFARE AXIOMS

For this article, there are five basic electromagnetic warfare "axioms" (or postulates) which help define the scope of effectiveness for both jamming and communications activities:

1. *Maximum range is a function of antenna heights.* The transmitting and receiving antennas must "see" each other (i.e., have "radio line-of-sight") in the electromagnetic operating environment (EMOE) to communicate and/or effectively jam a victim receiver. Increasing the height of the antennas above ground increases the maximum range. Note: the maximum range is the greatest distance a signal can travel without consideration of diffusion.
2. *Maximum effective range is a function of receiver sensitivity.* As a signal travels farther away from the transmitter, it becomes weaker. For a receiver to detect a signal, it must be as sensitive as the strength of the arriving signal. The weaker the signal, the more sensitive the receiver has to be. Note: the maximum effective range is the maximum distance at which a signal may be expected to be accurate and achieve the desired effect.
3. *Signal strength is a function of transmitter power.* The greater the transmit power, the greater the signal strength. While it is possible to increase the range of transmission by increasing the transmit power; it works only if the antennas "see" each other (first axiom), and the receiver is sensitive enough to detect the signal (second axiom).
4. *Communications and jamming improvement is mostly a result of improving antenna performance.* Using a higher-gain directional antenna helps by both increasing the effective radiated power, as well as improving the signal-to-noise ratio at the receiver (antenna reciprocity). Note: Effective radiated power, or ERP, is equal to the transmit power times the gain.
5. *Jamming effectiveness is a function of the link distance between transceivers.* The greater the distance between transmitters and receivers, the more effective the jamming signal. Conversely, as transmitters and receivers move closer to each other, the less effect the jamming signal has on the link. When the communications signal strength is greater than the jamming signal

**Figure 1: EMS Three-Body Orientations**



# ommunications Links

strength, the transmission signal can "burn through" the jamming signal; rendering the jamming ineffective.

## ELECTROMAGNETIC SPECTRUM THREE-BODY PROBLEM

The simplest example of a communications jamming problem consists of three elements: a jammer (Jx), and two transceivers (TRx). In a geospatial context, their relative orientation to each other is either linear or triangular. There are two linear formations: The first linear formation consists of the jammer at one end of the line, a transceiver occupying the other end, and the remaining transceiver placed in between them (and in-line). The second linear formation is similar; except that the jammer is in between the transceivers (and in-line). Triangular formations occur when the elements are not in line with each other. There are three triangular formations: 1) scalene (unequal lengths amongst the sides), 2) isosceles (two sides with equal lengths), and 3) equilateral (all sides with equal lengths). **Figure 1** illustrates the various formations:

To effectively study the links between the three elements (one Jx, two TRx), the following parameters are needed for each element: frequency (MHz), transmitter power (dBm), receiver sensitivity (dBm), antenna gain (dB), antenna height (m), and distances (km) between the three elements. For reactive and cognitive jamming techniques, receiver sensitivity of the jammer is increasingly important; the basis of which is the jamming platform intercepting victim signals, analyzing the signal, then responding with a jamming signal. Note: A reactive jammer is a type of jammer that can sense a portion of the spectrum and immediately transmit a jamming signal when it senses a signal it wants to jam. A cognitive jammer uses machine learning techniques to improve its reactive jamming capabilities.

## COMMUNICATIONS JAMMING STATES

There are three states of communication link jamming: 1) Neither transceiver can receive a signal from the other; 2) one transceiver can receive a signal from the other, but not vice versa and; 3) both transceivers can receive a signal from the other. These states mirror the standard information "flow" seen in communications models: simplex (information travels in one direction); duplex (information travels in both directions simultaneously); and half-duplex (information travels in both directions alternatively). The ideal jamming state is no information flow in either direction between the transceivers. The next best jamming state is information allowed to flow in one direction only (simplex). The least desirable, and most ineffective, jamming state is information allowed flow in both directions between the transceivers (duplex or half-duplex).

## JAM TO SIGNAL RATIO (J/S)

To assess the disruption of communications, a common measure of effectiveness is the "Jam to Signal Ratio", or "J/S." The J/S ratio is usually expressed in dB notation, of the power of a jamming signal to that of the desired signal at a given point such as the antenna terminals of a receiver. Because both quantities are in decibel notation (decibel milliwatts, or dBm, in this case), instead of dividing "J" by "S" (J/S), one can solve the J/S ratio equation by simply subtracting the transmit signal strength from the jamming signal strength (J - S). For example, if the jamming signal strength at the victim receiver antenna is -100 dBm, and the transmitter signal strength at the same receiver is -110 dBm; the J/S can be expressed as:

$$J - S = \text{Decibel Value} \quad \text{– or –} \quad -100 - (-110) = 10dB$$

If the decibel value is greater than zero, the jamming signal is stronger than the transmit signal at the victim receiver's antenna. Zero means the signal strengths are equal to each other, and a value less than zero means the transmit signal is stronger than the jamming signal. Negative J/S values usually mean the jamming is not effective.

## COMMUNICATIONS LINK CHARACTERIZATION

Characterization of the links between the elements (Jx and both TRx) can be done mathematically. Depending on the degree of detail desired, the number of equations can range from one to more than a dozen formulas. In this article, we will use:

The two-ray path loss formula [1][2];

- A "flat earth" smooth profile for the earth's surface;
- An omnidirectional monopole (whip) antenna;
- A frequency band from 30 MHz to 1,000 MHz;

The noise floor of a clean environment;

- A reactive jammer;
- A noise jamming signal;
- A jamming bandwidth that matches the bandwidth for the transceivers;

The two-ray path loss formula is an estimate, because it does not factor in terrain or land cover. Usually, a modified Fresnel Zone Distance formula determines the change-over range (from the transmitter) for using the free space path loss formula (closer ranges) and the two-ray path loss formula (farther ranges). For the frequency band given (30 to 1,000 MHz), unless the antenna heights go above five meters, the Fresnel threshold distance (change-over range) barely exceeds one kilometer. Therefore, only the two-ray path loss formula will be utilized in this article.

Two-Ray Path Loss Formula:

$$L = 120 + 40log_{10}d - 20log_{10}h_t - 20log10h_r$$

Where:

$L$ = path loss in decibels (dB)

120 = constant used for distance in kilometers and height in meters

$d$ = distance in kilometers (km)

$h_t$ = transmitter antenna height in meters (m)

$h_r$ = receiver antenna height in meters (m)

## SITUATION EXAMPLE

The key metric in communications link analysis is the maximum effective range between transceivers during active jamming. From the jammer's point of origin, the jamming signal becomes weaker as it propagates further from the origin. For example, consider the parametric values shown in **Table 1,** below:

**Table 1: Example Parametric Values**

| Parametric | Jammer | TRx-1 | TRx-2 |
|---|---|---|---|
| Frequency (MHz) | 150 | 150 | 150 |
| Transmit power (W)(dBm) | 8 (39) | 5 (37) | 5 (37) |
| Receiver sensitivity (dBm) | -105 | -100 | -100 |
| Antenna gain (dB) | 0 | 0 | 0 |
| Antenna height (m) | 3 | 1.5 | 1.5 |
| Jammer distance to TRx-1 (km) | — | 4.0 | — |
| Jammer distance to TRx-2 (km) | — | — | 5.0 |
| TRx-1 to TRx-2 distance (km) | — | — | 3.0 |

Using the two-ray propagation formula, the path loss from the jammer to the first transceiver is 131.02 dB. The effective radiated power (effective radiated power, or ERP, is equal to the transmit power plus the gain) of the jammer is 39.03 dBm. By subtracting the path loss (131.02) from the ERP (39.03), the estimated jammer signal strength at the TRx-1 location is -91.99 dBm. Using the same process for the link between the transceivers, the estimated communication signal strength from TRx-2 (to the TRx-1 location) is -95.05 dBm. At the TRx-1 location, the jamming signal (-91.99 dBm) is stronger than the communication signal (-95.05 dBm); meaning the jamming-to-signal (J/S) ratio is a positive value of 3.06 dB; which is considered "effective," depending on the situation.

The unanswered question is how close one of the transceivers has to move towards the other to reach parity with the jammer signal strength (0 dB J/S). Once the "parity distance" is known, then any shorter distance between the transceivers will produce a negative J/S and; the jamming is considered "ineffective." Given the jammer signal strength at a location, the parametric values for the transceivers, and the basic two-ray path loss formula; the parity distance can be estimated.

To determine the signal strength, subtract the path loss from the ERP, as shown below:

$S = P_t - (120 + 40log_{10}d - 20log_{10}h_t - 20log_{10}h_r$

$S$ = signal strength in dBm

$P_t$ = ERP of the transmitter in dBm

120 = constant used for distance in kilometers and height in meters

$d$ = distance in kilometers (km)
$h_t$ = transmitter antenna height in meters (m)
$h_r$ = receiver antenna height in meters (m)

To determine the "parity distance" between transceivers, the formula for signal strength must be algebraically manipulated to solve for the distance. Using the example data from Table 1, the formula below shows the process to solve for parity distance:

$$S_j = P_{t2} - (120 + 40log_{10}d - 20log_{10}h_{t2} - 20log_{10}h_{t1})$$

Where:
$S_j$ = jammer signal strength in dBm;
$Pt_2$ = ERP of transceiver-2 in dBm;
120 = constant used for distance in kilometers and height in meters;
$d$ = distance in kilometers (km);
$h_{t2}$ = transceiver-2 antenna height in meters (m);
$h_{t1}$ = transceiver-1 antenna height in meters (m);

First interim step:
$$S_j = P_{t2} - 120 - 40log_{10}d + 20log_{10}h_{t2} + 20log_{10}h_{t1}$$

Second interim step:
$$S_j - P_{t2} + 120 - 20log_{10}h_{t2} - 20log_{10}h_{t1} = -40log_{10}d$$

Third interim step:
$$(S_j - P_{t2} + 120 - 20log_{10}h_{t2} - 20log_{10}h_{t1}) / (-40) = log_{10}d$$

Fourth interim step: (parity distance is the antilog):
$$D_{km} = 10^{log10d}$$

Using the parametric values derived from Table 1:
$$(-91.99 - 36.99 + 120 - 3.52 - 3.52) / (-40) = 0.40$$

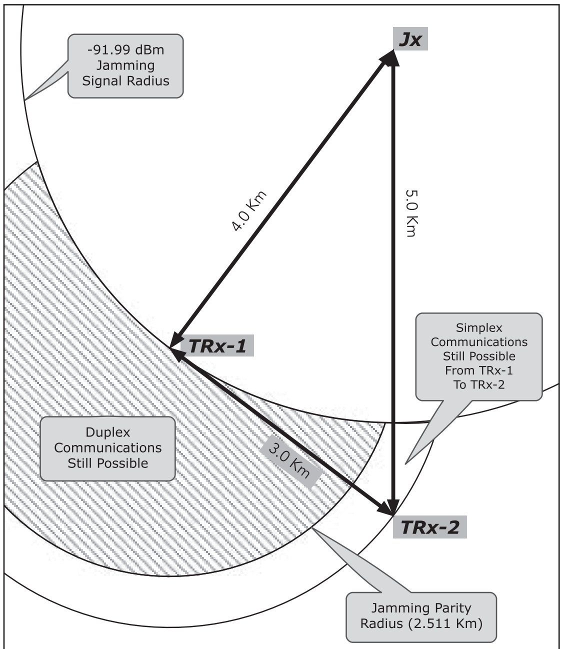
$$10^{0.40} = 2.511 \text{ km}$$

Where:
-91.99 = jammer signal strength, in dBm, at TRXx1;
36.99 = effective radiated power (power + gain) in dBm, from TRx-2;
120 = constant use for height in meters and distance in kilometers;
3.52 = derived values of the antenna heights for TRx-1 and TRx-2;
-40 = coefficient associated with the distance factor;
0.40 = logarithmic value of the distance in kilometers;
2.511 = the parity distance (antilog) in kilometers, the transceivers can be apart.

## RESULTS

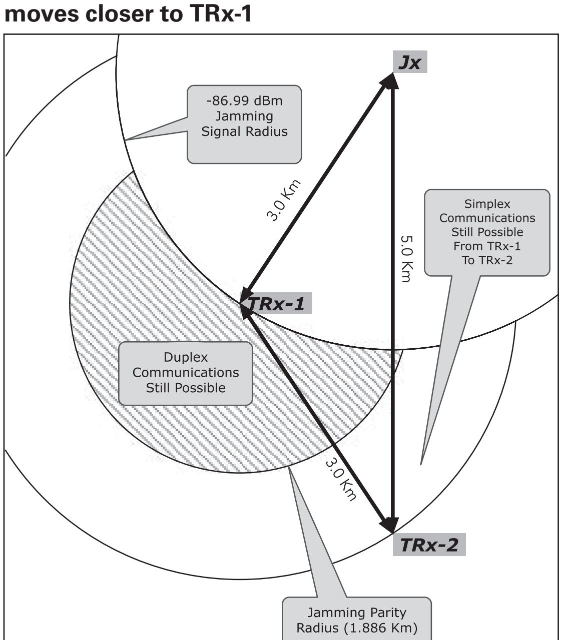
With the modified two-ray path loss formula (parity distance process), we have three key pieces of information regarding the TRx-1 site: 1) jammer signal strength at the site, 2) jam-to-signal ratio (J/S), and 3) the maximum distance from another transceiver to reach parity with the jammer signal. The parity distance is the radius of a circle with the TRx-1 site at its center. To maintain communications, the TRx-2 transceiver must be within 2.511 kilometers of TRX-1, and at least 4.0 kilometers away from the jammer site. Should the TRx-2 transceiver move closer than 4.0 kilometers to the jammer, the jamming effect would be greater than at the TRx-1 site. **Figure 2** shows the geospatial relationship between the elements and affected areas.

**Figure 2: Parity Distance Illustration**




| Name | Jammer | TRx-1 | TRx-2 |
|---|---|---|---|
| Antenna Height (m) | 3 | 1.5 | 1.5 |
| Antenna Gain (dB) | 0 | 0 | 0 |
| Receiver Sensitivity (dBm) | -105 | -100 | -100 |
| Transmit Power (W) | 8 | 5 | 5 |

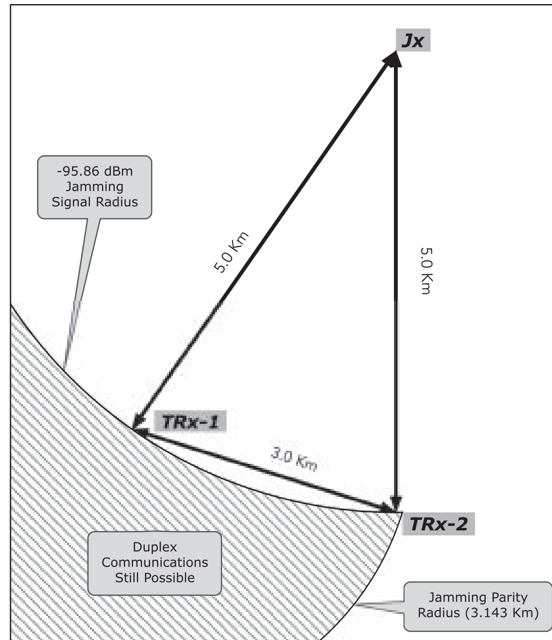
**Figure 3: Parity Distance Illustration – Jammer moves closer to TRx-1**




| Name | Jammer | TRx-1 | TRx-2 |
|---|---|---|---|
| Antenna Height (m) | 3 | 1.5 | 1.5 |
| Antenna Gain (dB) | 0 | 0 | 0 |
| Receiver Sensitivity (dBm) | -105 | -100 | -100 |
| Transmit Power (W) | 8 | 5 | 5 |

***Fig. 3** shows the difference in moving the jammer 1,000 meters closer (moving from 4.0 km to 3.0 km distance) to TRx-1, while maintaining a 3.0 km distance to TRx-2. The parity distance shrinks to 1.886 km, as well as the duplex communications area.*

**Figure 4: Parity Distance Illustration – Jammer moves farther from TRx-1**




| Name | Jammer | TRx-1 | TRx-2 |
|---|---|---|---|
| Antenna Height (m) | 3 | 1.5 | 1.5 |
| Antenna Gain (dB) | 0 | 0 | 0 |
| Receiver Sensitivity (dBm) | -105 | -100 | -100 |
| Transmit Power (W) | 8 | 5 | 5 |

***Fig. 4** highlights the difference in moving the jammer 1,000 meters farther away (moving from 4.0 km to 5.0 km distance) from TRx-1, while maintaining a 3.0 km distance to TRx-2. The parity distance expands to 3.143 km, which is greater than the actual distance between transceivers. The duplex communications area correspondingly increased slightly farther than needed, as well.*

## CONCLUSION

As shown by the previous examples, electromagnetic warfare officers (EWOs) need to carefully examine not only jamming signal strength at a given point, but also the area around the point where duplex communication is still possible. Assuming the enemy's disposition is known, EWOs have no control over the enemy's communications link distances. However, EWO's do have control over setting their jammer's disposition relative to the enemy's communications links. By using maneuver, power and gain, EWOs can affect the enemy's parity distance for each link and better control areas where duplex communication could persist during a jamming operation.

## REFERENCES:


[1] Adamy, David L. Tactical Battlefield Communications Electronic Warfare. 1st ed., Norwood, MA, Artech House, 2009, pp. 129–134. Accessed 19 Sept. 2021.

[2] "Two-Ray Ground-Reflection Model." Wikipedia, 23 Jan. 2021, en.wikipedia.org/wiki/Two-ray_ground-reflection_model. Accessed 27 Jan. 2021.

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# 5G Communication – Part 12)

# Jamming of 5G Signals *cont.*

**By Dave Adamy**

## MORE JAMMING SCENARIOS

Last month, we looked at three jamming situations involving mid-band 5G links. This month, we will consider some situations in which high-band signals are jammed.

The following jamming situations are presented, showing the jamming-to-signal ratios that would be achieved with the parameters entered. Initially, the 5G transmitting antenna is assumed to be accurately aimed at the 5G target receiver. Later, we will consider the impact of link misalignment. The 1-kW (60 dBm) jammer is assumed to be in a 0-dB sidelobe (that is, the side lobe receives like an isotropic antenna – i.e. ,0 dBi).

## HIGH BAND – 5G CELL PHONE NETWORK WITHIN THE ATMOSPHERE

The link and jamming geometry are as shown in **Figure 1.**

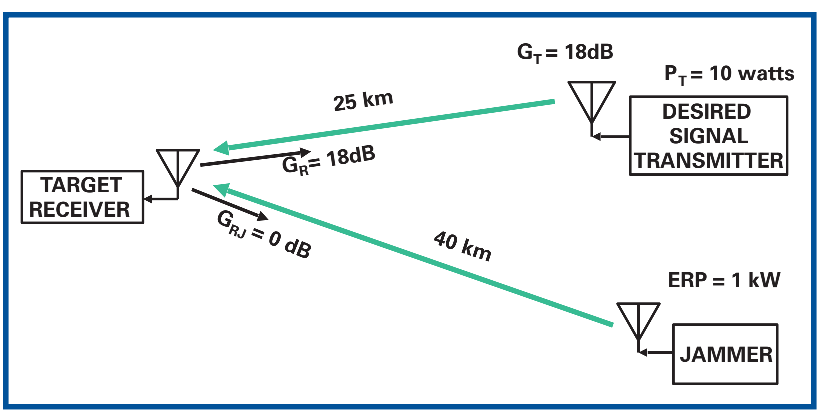


***Fig. 1:*** *Both the desired signal transmitter and receiver are within the atmosphere. This is one link in a cell phone system. All system stations have 64-element phased array antennas with 18 dB gain.*

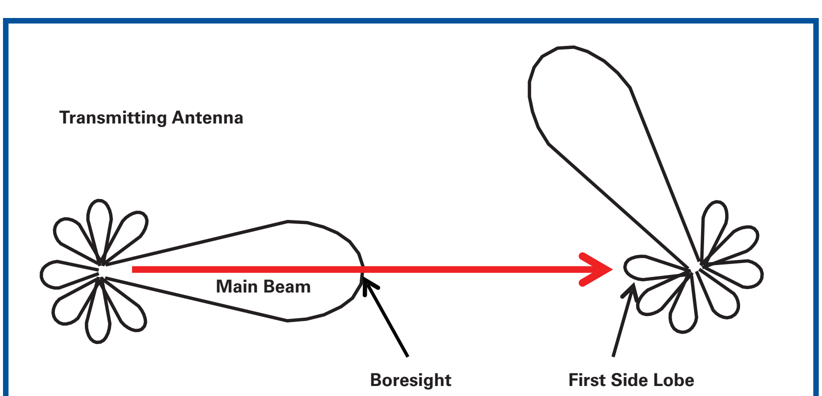


***Fig. 2:*** *The receiving antenna is directed away from the transmitter, so the transmitted signal is received in a side lobe.*

The frequency is 28 GHz (high band). The 5G receiver has a square 64-element phased array antenna with half-wavelength element spacing and array efficiency of 40%. The transmitter power is 10 watts. There is a clear transmission path over both the 5G link and the jamming link, so both links have line-of-sight propagation.

First, consider the link antennas. The transmit and receive antennas in the target link are the same. The gain and beamwidth are derived from the equations presented in the June 2021 "EW 101" column, which also includes antenna misalignment calculations.

At 28 GHz, the wavelength is 0.0107m. The length of a side of the array is 8 half-wavelengths (0.04428 m) and the area of the array is thus .00183 m²

The boresight gain of the link antenna:

**Gain** = $(4\pi An)/\lambda^2$

Where: The gain is not in dB,
*A* is the antenna area in square meters,
The efficiency of the array is *n*, and
The wavelength is $\lambda$ in meters.

Thus, the boresight gain is:
$4\pi(0.00183)(0.4)/0.0001145 = 80.3$. (which is 18 dBi)

The 3-dB beamwidth of the link antenna is:
BW = $(.886\lambda)/(Nd\cos\theta)$

Where:
*BW* is the 3-dB beamwidth in radians
The wavelength is $\lambda$ meters,
*N* is the number of elements on a side of the array,
The separation of the elements is *d* in meters, and
The offset of the beam from the array boresight is $\theta$ in degrees.
We will assume that the target link transmitter is steered 45° away from the boresight of its array, and the elements are spaced at a half wavelength.

Because the antenna spacing is half wavelength, there are 8 elements per side of the square array, and the antenna is steered $45^0$ from the array boresight, the formula simplifies to:

$BW = 2\ (0.886)/(8 \cos \theta) = 0.2215 / \cos 45° = 0.313$
(This is in radians)

There are 57.3 degrees per radian, so the 3-dB beamwidth is 18 degrees

The link transmitter and receiver each have 18 dB gain, and the link stations are 25 km apart.

The 1-kW ERP jammer is 40 km from the target receiver.

Since the target receiver has a directional antenna, the jamming-to-signal ratio formula is:

$$J/S = ERP_J - ERP_S - L_J + L_S + G_{RJ} - G_R$$

Where:
J/S is the jamming-to-signal ratio in dB,
$ERP_J$ is the effective radiated power of the jammer in dBm,
$ERP_S$ is the effective radiated power of the desired signal transmitter in dBm,
$L_J$ is the propagation loss between the jamming antenna and the target receiver antenna in dB,
$L_S$ is the propagation loss between the desired signal transmitter antenna and the target receiver antenna in dB,
$G_{RJ}$ is the gain of the target receiving antenna in the direction of the jammer in dB, and
$G_R$ is the boresight gain of the receiving antenna in dB.

In this example:
$ERP_J = 60$ dBm
$ERP_S = 40$ dBm + 18 dB = 58 dBm
$L_J = 32.4 + 20 \log (40) + 20 \log (28000) = 32.4 + 32 + 88.9$
$= 153.3$dB
$L_S = 32.4 + 20 \log (25) + 20 \log (28000) = 32.4 + 28 + 88.9$
$= 149.3$ dBj
$G_{RJ}$ is 0 dBi
$G_R$ is 18 dBi
$J/S = ERP_J - ERP_S - L_J + L_S + G_{RJ} - G_R = 60 - 58 - 153.3 + 149.3 + 0 - 18 = -20$ dB

With these assumptions, the jamming is not nearly effective. But now, let's change some of the problem levels to make the result more real world:

Place the jammer in the first side lobe of the receiving antenna pattern as shown in **Figure 2. Figure 3** shows that the gain of the first side lobe is 13.5 dB below the bore sight gain. Also, let the steering of the link transmit antenna be accurate to only 10 degrees. This gain reduction is shown in **Figure 4.**

The misalignment of the transmit antenna will reduce the effective ERP of the target link transmitter by a factor of:

$$12(\phi/\alpha)^2$$

Where: the reduction factor is in dB,
$\phi$ is the pointing error in degrees, and
And the 3 dB beamwidth is $\alpha$.

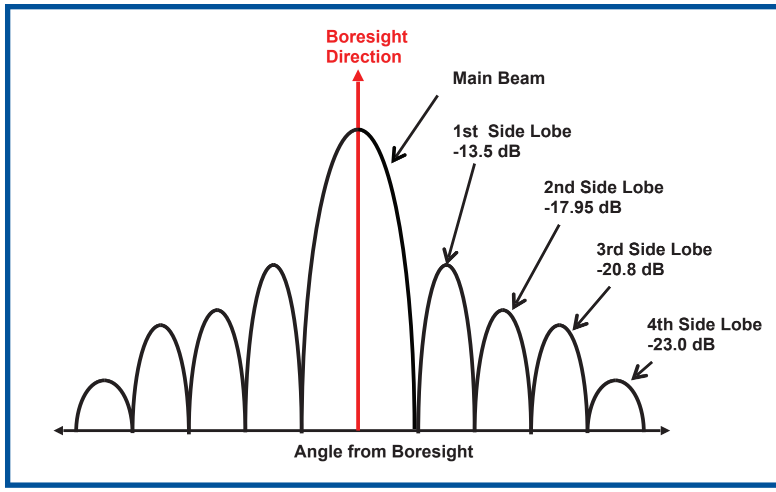


***Fig. 3:*** *The side lobes of an antenna pattern are reduced relative to the boresight gain and are narrower.*

With $10^0$ steering error and an $18^0$ beamwidth, the 5G link ERP is reduced by 3.7 dB. With the jammer in the first side lobe, the jammer ERP is increased by 4.5 dB. Therefore, the J/S is increased by 8.2 dB to -11.8 dB.. This is still not effective jamming.

If the jammer were placed and its transmit antenna oriented so that it transmits to the boresight of the 5G receiving antenna, the J/S would be increased by another 18 dB, so the J/S would be 6.2 dB. In general, anything above 0 dB J/S is extremely effective jamming of a digital link.

Note that in a later EW 101 series, we will be discussing Electronic Protection that involves techniques to reduce the impact of jamming, particularly in military 5G links.

## WHAT'S NEXT

Next month, we will continue our discussion of 5G signal jamming with the analysis of another jamming situation. The target link is from a ground station to a satellite, and the jammer is located on the ground. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

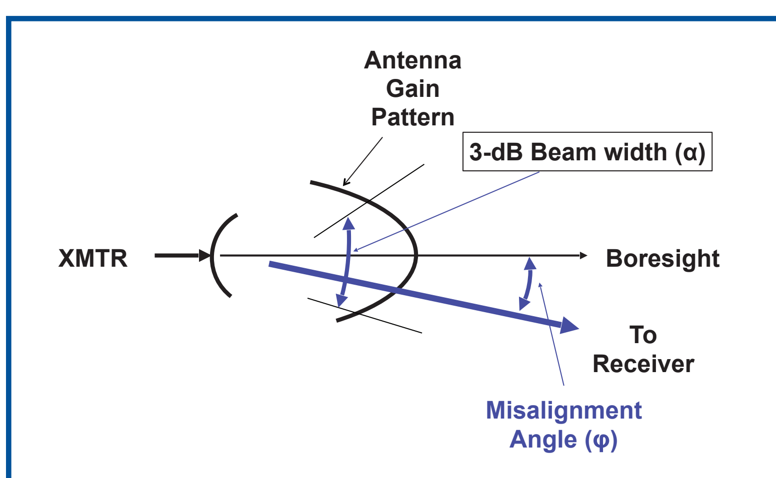


***Fig. 4:*** *The reduction in gain when an antenna is transmitting to a receiving antenna that is away from its boresight is a function of the misalignment angle and the antenna beam width.*

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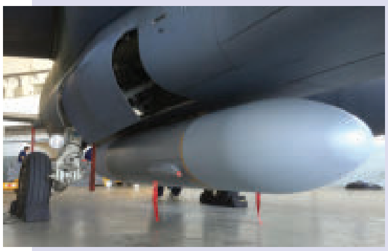


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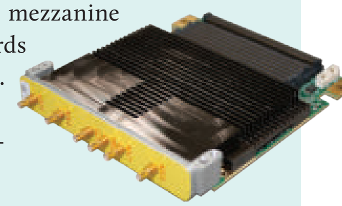
Rheinmetall has introduced the Maske 81-mm smoke/obscurant grenade, the newest member of its Maske family of obscurants designed to protect ground vehicles from visual and electro-optic aiming devices, as well as laser-guided target sensor heads, laser target illuminators and laser rangefinders. The round, which can be fired from any 81-mm launcher, is a bi-modular and bi-spectral obscurant consisting of a fast acting decoy module that generates intense blooming and a long-lasting concealment module whose visible and IR smoke/obscurant material hides the vehicle in both the visual and IR spectrum. The 81-mm form factor makes it compatible with heavy vehicles equipped with smoke grenade launchers designed by Russian and eastern European (former Warsaw Pact) manufacturers. *Rheinmetall Protection Systems GmbH; Bonn, Germany; + 49 228 9750-3; www.rheinmetall-defence.com*

## COTS Mezzanine Card with 64 GSPS ADC/DAC Sample Rates

Annapolis Micro Systems has introduced the WILD FMC+ DME1 ADC & DAC Card for use in demanding EW and SIGINT applications that require direct sampling frequency coverage anywhere from 0.1 to 36 GHz. The card features the Electra-MA chip from Jariet Technologies, which provides 64 giga-samples per second (GSPS), 10-bit ADC and DAC capability. The card offers two ADC channels and two DAC channels, with a usable analog bandwidth of 36 GHz and 6.4 GHz of instantaneous bandwidth on both channels simultaneously. All transceiver channels feature onboard digital downconverters (DDCs) and digital upconverters (DUCs), including sub-band channelizers for dynamic frequency selection. The DME1 is available for use with third-party party FMC+ baseboards or with the company's WILDSTAR 3U OpenVPX Baseboards (one WFMC+ mezzanine site) or 6U OpenVPX Baseboards (two WFMC+ mezzanine sites). *Annapolis Micro Systems; Annapolis, MD, USA; +1 (410) 841-2514; www.annapmicro.com*

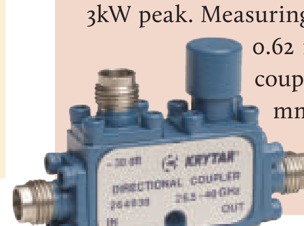


## 1- to 40-GHz GaN Power Amplifier Family

Qorvo has released three new gallium nitride (GaN) power amplifiers – collectively covering 1-40 GHz – designed for EW, radar, communications and test equipment applications. The QPA0106 covers 1-6 GHz and offers 18W (Psat) of output power, 24dB of gain with 40% PAE in a 7 x 7-mm QFN-48 package. The QPA2966D operates over the 2- to 20-GHz range and features 20W (Psat) of output power, 13dB gain with 26% PAE in a 3.6 x 6.9-mm die package. For higher-frequency applications, the QPA2640D operates across the 20- to 40-GHz range and provides 8W (Psat), 12dB gain with 14% PAE. It is offered in a 5.8 x 3.5 mm die package. *Qorvo; Greensboro, NC, USA; +1 (972) 994-8546; www.qorvo.com.*

## 26.5- to 40-GHz Directional Coupler

KRYTAR's new directional coupler, Model 264030, lends itself to many test and measurement applications, as well as military satellite communications (SATCOM). The coupler features nominal coupling (with respect to output) of 30 dB, ±1.0 dB, and frequency sensitivity of ±0.5 dB. It exhibits insertion loss (including coupled power) of 1.3 dB, directivity of greater than 12 dB, maximum VSWR (any port) is 1.7. Input power rating is 20W average and 3kW peak. Measuring 1.12 inches (L) x 0.40 inches (W) x 0.62 inches (H), and weighing 1 oz., the coupler provides industry-standard 2.4-mm SMA female connectors. *KRYTAR Inc.; Sunnyvale, CA, USA; +1 (408) 734-5999, www.krytar.com*



## PASSING OF A CROW: JERRY DUTKA

A native to Chicago, having been raised in the Berwyn area, Jerry Dutka had a sense of service and duty at an early age. He spent his entire adult life in service to his country in one way or another, first serving in the United States Marine Corps. The training and character he developed while in the service continued to serve him well throughout his career.

Dutka joined Northrop Grumman (then Hallicrafters) in 1955 and held a variety of positions in both the engineering and manufacturing organizations, with his 44 years of service culminating with his final position as the Director of Mechanical Engineering.

Dutka's tireless efforts on behalf of the AOC continued beyond his retirement, up until his passing. Through innovative and persistent activity, the AOC scholarship program at the Windy City Roost/Chapter has grown and prospered. Dutka created the Century Club, which supports these yearly scholarships. It is a fitting continuation of engineering development, as he mentored many prominent engineers throughout his career.

Dutka passed away on Feb. 5 and will be greatly missed.

## IMPORTANT DATES FOR AOC MEMBERS

### 2022 AOC AWARDS WILL OPEN MARCH 1 – APRIL 15

A central tenet of the AOC's mission is recognizing individuals, groups and military units for their outstanding performance in furthering the aims of the AOC and the Electromagnetic Warfare enterprise. The AOC has a number of awards that are available each year.

**For more information, visit crows.org/awards.**

### AOC SCHOLARSHIP PROGRAM

#### Undergraduate Scholarship for Sophomores and Juniors Dates: Feb. 15 – April 1

AOC currently provides two scholarships to students currently in their sophomore or junior year of college. Each year one male and one female student studying in engineering or engineering technology and interested in working in the aerospace and defense industry is awarded a scholarship. A generous donation from Raytheon Intelligence & Space funds these scholarships. We are seeking other industry partners to participate as well to grow our program further.

**For more information, go to crows.org/scholarshipprogram.**

#### Cyber Corps Warrant Officer Scholarship – Dates April 1 – May 30

AOC is exceptionally proud of The Cyber Corps Warrant Officer Scholarship established by the Laurie Buckhout Foundation in August 2020 under the Association of Old Crows Education Foundation incorporated and registered as a Non-Profit status under 501(c)(3) of the Internal Revenue Code. The Cyber Corps Warrant Officers Scholarship Foundation is a non-profit organization dedicated to providing support to U.S. Army Cyber Corps (i.e., 170A, 170B, and 170D) warrant officers by allowing them to apply for financial assistance in gaining various levels of formal higher education.

**For more information, go to crows.org/USA_WO_Scholarship.**

### NOMINATIONS FOR THE AOC 2022 ELECTIONS WILL OPEN ON MARCH 1.

**More information can be found at crows.org/elections.**


ASSOCIATION OF OLD CROWS
Cyber Electromagnetic Activity (CEMA) 2022
MAY 3-4
Belcamp, MD
The Invisible Battlefield: Deterrence During Competition, Dominance Throughout Conflict
Register now!
In-person spots are limited.
VISIT CROWS.ORG/CEMA2022 FOR MORE INFORMATION
Sponsorship opportunities available.
Contact Sean Fitzgerald, fitzgerald@crows.org, to learn more.


ASSOCIATION OF OLD CROWS
EW Capability Gaps & Enabling Tech 2022
MAY 10-11
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VADM Sean Buck
Superintendent,
U.S. Naval Academy
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Theme: Force Level Electromagnetic Warfare
Classification: US Secret
There will be three sessions focused on Joint Long Range Fires,
Joint All-Domain Command and Control, and Information Advantage.
VISIT CROWS.ORG/Crane2022 FOR MORE INFORMATION
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