July/August 2020 Vol. 43, No. 7

ASSOCIATION OF OLD CROWS

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JED

Journal of Electromagnetic Dominance

Upgrading Eurofighter EW

- EMSO CFT Workforce Study
- Technology Survey: Radar Jammers
- US Army Discusses Multi-Domain Ops

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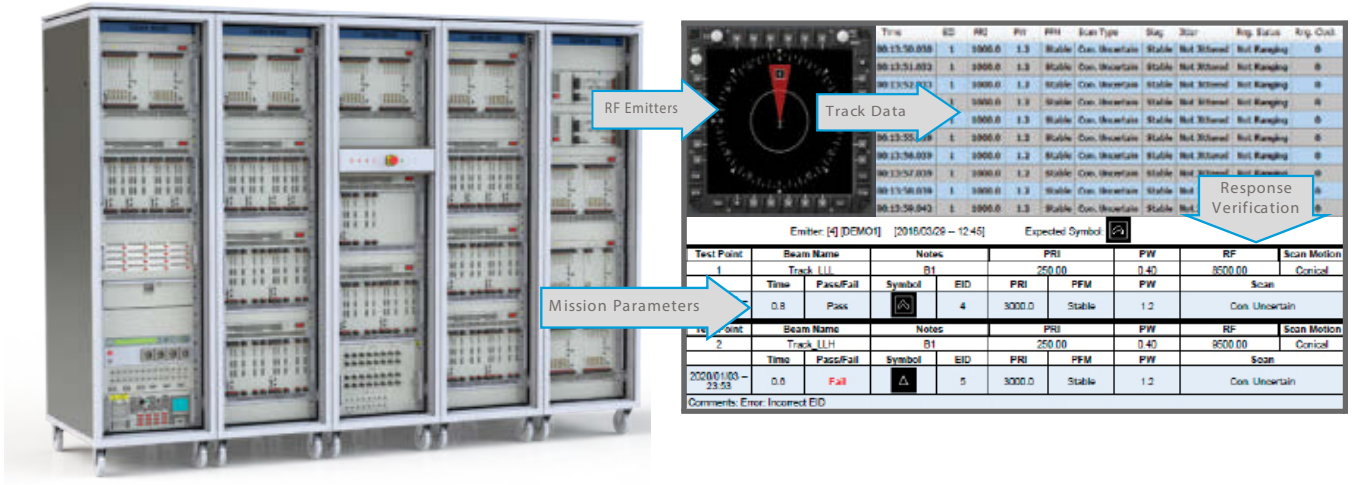

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Journal of Electromagnetic Dominance

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European countries are contemplating an upgrade path for the Eurofighter, including the EW suite.

COPYRIGHT EUROFIGHTER-DR. STEFAN PETERSEN, LUFTWAFFE

US Marines with Alpha Company, 1st Radio Battalion, I Marine Expeditionary Force Information Group (MIG), hike during a field exercise (FEX) at Marine Corps Base Camp Pendleton, CA. The FEX, conducted in May, was the culminating event of a three-week long course which involved several static team sites that provided specific military occupational specialty training, reinforcing the Marines' deployment capabilities and unit readiness within I MIG.

US MARINE CORPS PHOTO BY CPL DALTON S. SWANBECK

COVER PHOTO COURTESY OF ANDY SHAWYER

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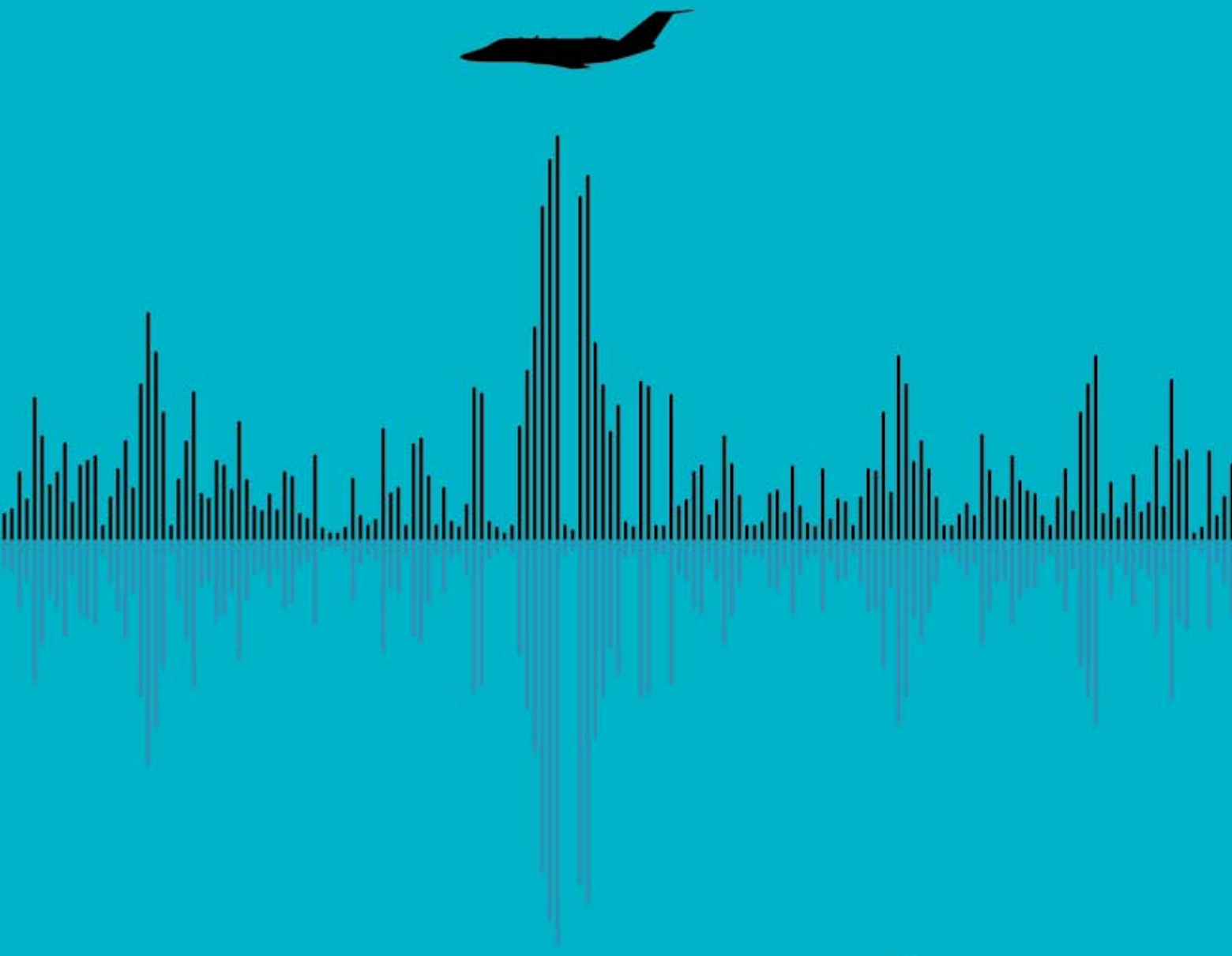

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EW RED TEAMS

You may have noticed that this issue of *JED* covers two months (July and August) instead of one. COVID-19 has affected *JED* just as it has negatively impacted many other magazines. As a result, we needed to adapt to this situation. We work very hard to make sure we bring you the best possible magazine we can deliver, and we expect to resume our monthly schedule again with the September *JED.* Thank you for taking your valuable time to read our magazine.

In June, the Senate Armed Services Committee (SASC) passed its version of the FY2021 National Defense Authorization Act (NDAA). The bill and its accompanying committee report highlighted several issues regarding EMS Operations (EMSO). (See news article on page 16 of this issue.)

In the committee report, several "Items of Interest" focused on electronic warfare (EW). In one of these, the SASC called for the Secretary of Defense to deliver a report about EW Red Teams to the congressional defense committees by March 21, 2021. EW Red Teams play the role of adversary EW and SIGINT units during regular training exercises. They attempt to intercept, geolocate and identify Blue Force signals and then jam them or exploit them for intelligence and/or initiate cyber attacks, just as a real adversary would.

Within the DOD, US Special Operations Command's Joint Electromagnetic Warfare Center (JEWC) had for decades featured an Electromagnetic Red Team, which travelled to ground exercises and played the role of adversary EW and SIGINT units. It's not clear how robust that activity is today, however. In addition, the US Air Force operates aggressor aircraft, some of which are fitted with foreign-made self-protection jammers to jam Blue Force radars. The US Navy also contracts with industry to provide airborne EW aggressor aircraft that can simulate an attack (including jamming) as carrier strike groups depart from naval bases on the east and west coasts. But these deploying strike groups quickly travel beyond the range of the aggressor aircraft, and they will spend months in the Indian Ocean or the Persian Gulf or the Barents Sea without any EW aggressors to hone the skills of their crews. In recent years, the Army has started to address Cyber Red Teams. But it has not invested heavily in CEMA Red Teams that would create what a near-peer adversary could do in the EM Environment.

To put it mildly, these few EW Red Team resources are nowhere near adequate – in terms of numbers or capability – for preparing US forces to operate against EM-savvy competitors, such as China, Russia and Iran. Congress is absolutely right in asking the DOD for more information about what it is doing to invest in EW Red Teams. Ten years ago, no one could have imagined the DOD and Congress having a conversation about EW Red Teams. Today, they cannot afford to ignore it. – *J. Knowles*

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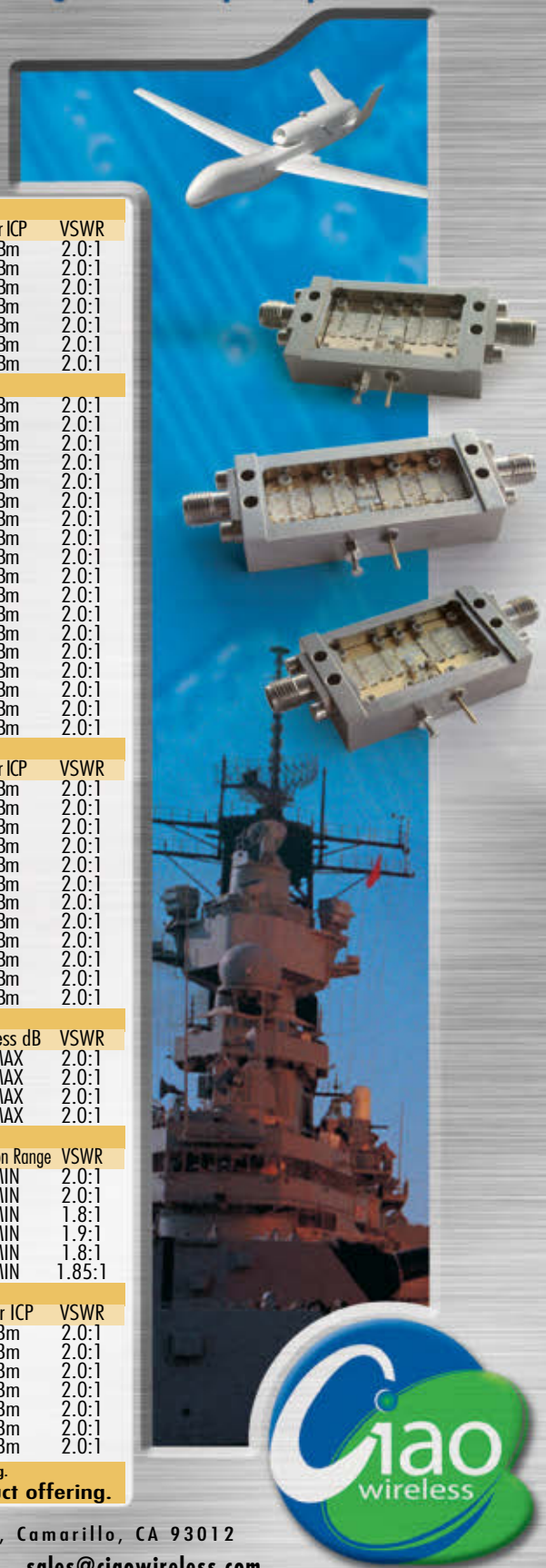

OCTAVE BAND LOW NOISE AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2110	0.5-1.0	28	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA12-2110	1.0-2.0	30	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA24-2111	2.0-4.0	29	1.1 MAX, 0.95 TYP	+10 MIN	+20 dBm	2.0:1
CA48-2111	4.0-8.0	29	1.3 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA812-3111	8.0-12.0	27	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA1218-4111	12.0-18.0	25	1.9 MAX, 1.7 TYP	+10 MIN	+20 dBm	2.0:1
CA1826-2110	18.0-26.5	32	3.0 MAX, 2.5 TYP	+10 MIN	+20 dBm	2.0:1

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

CA01-2111	0.4 - 0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8 - 1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2 - 1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2 - 2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7 - 2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7 - 4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4 - 5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25 - 7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0 - 10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75 - 15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35 - 1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1 - 3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9 - 6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0 - 12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0 - 12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2 - 13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0 - 15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0 - 22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA0102-3111	0.1-2.0	28	1.6 Max, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA0106-3111	0.1-6.0	28	1.9 Max, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-3110	0.1-8.0	26	2.2 Max, 1.8 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-4112	0.1-8.0	32	3.0 MAX, 1.8 TYP	+22 MIN	+32 dBm	2.0:1
CA02-3112	0.5-2.0	36	4.5 MAX, 2.5 TYP	+30 MIN	+40 dBm	2.0:1
CA26-3110	2.0-6.0	26	2.0 MAX, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA26-4114	2.0-6.0	22	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA618-4112	6.0-18.0	25	5.0 MAX, 3.5 TYP	+23 MIN	+33 dBm	2.0:1
CA618-6114	6.0-18.0	35	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA218-4116	2.0-18.0	30	3.5 MAX, 2.8 TYP	+10 MIN	+20 dBm	2.0:1
CA218-4110	2.0-18.0	30	5.0 MAX, 3.5 TYP	+20 MIN	+30 dBm	2.0:1
CA218-4112	2.0-18.0	29	5.0 MAX, 3.5 TYP	+24 MIN	+34 dBm	2.0:1

LIMITING AMPLIFIERS

Model No.	Freq (GHz)	Input Dynamic Range	Output Power Range Psat	Power Flatness dB	VSWR
CLA24-4001	2.0 - 4.0	-28 to +10 dBm	+7 to +11 dBm	+/- 1.5 MAX	2.0:1
CLA26-8001	2.0 - 6.0	-50 to +20 dBm	+14 to +18 dBm	+/- 1.5 MAX	2.0:1
CLA712-5001	7.0 - 12.4	-21 to +10 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1
CLA618-1201	6.0 - 18.0	-50 to +20 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	Gain Attenuation Range	VSWR
CA001-2511A	0.025-0.150	21	5.0 MAX, 3.5 TYP	+12 MIN	30 dB MIN	2.0:1
CA05-3110A	0.5-5.5	23	2.5 MAX, 1.5 TYP	+18 MIN	20 dB MIN	2.0:1
CA56-3110A	5.85-6.425	28	2.5 MAX, 1.5 TYP	+16 MIN	22 dB MIN	1.8:1
CA612-4110A	6.0-12.0	24	2.5 MAX, 1.5 TYP	+12 MIN	15 dB MIN	1.9:1
CA1315-4110A	13.75-15.4	25	2.2 MAX, 1.6 TYP	+16 MIN	20 dB MIN	1.8:1
CA1518-4110A	15.0-18.0	30	3.0 MAX, 2.0 TYP	+18 MIN	20 dB MIN	1.85:1

LOW FREQUENCY AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure dB	Power-out @ P1-dB	3rd Order ICP	VSWR
CA001-2110	0.01-0.10	18	4.0 MAX, 2.2 TYP	+10 MIN	+20 dBm	2.0:1
CA001-2211	0.04-0.15	24	3.5 MAX, 2.2 TYP	+13 MIN	+23 dBm	2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 MAX, 2.8 TYP	+17 MIN	+27 dBm	2.0:1
CA002-3114	0.01-2.0	27	4.0 MAX, 2.8 TYP	+20 MIN	+30 dBm	2.0:1
CA003-3116	0.01-3.0	18	4.0 MAX, 2.8 TYP	+25 MIN	+35 dBm	2.0:1
CA004-3112	0.01-4.0	32	4.0 MAX, 2.8 TYP	+15 MIN	+25 dBm	2.0:1

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Calendar *Conferences & Trade Shows*

SEPTEMBER

AFA 2020 Air, Space and Cyberspace Conference
September 14-16
National Harbor, MD
www.afa.org

Africa Aerospace and Defense
September 16-20
Centurion, Gauteng, South Africa
www.aadexpo.co.za

Directed Energy to DC (DE2DC)
September 23-24
Washington, D.C.
www.deps.org

2020 DE Systems Symposium
September 28 – October 2
Washington, D.C.
www.deps.org

Due to the disruptions caused by COVID-19, some event organizers have chosen to change the dates and/or venues of their event. Please contact the event provider to receive the latest details.

OCTOBER

Seoul ADEX 2020
October 9-22
Seoul, ROK
www.seouladex.com

AUSA Annual Meeting
October 12-14
Washington, DC
www.ausa.org

Electronic Warfare Gulf Cooperation Council (EWGCC) 2020
October 20-21
Abu Dhabi, UAE
www.electronic-warfare-gcc.com

9th Annual AOC Pacific Conference
October 20-22
Honolulu, HI
Arthur.N.Tulak.ctr@pacom.mil

Precision Strike Symposium
October 20-22
Laurel, MD
www.precisionstrike.org

EURONAVAL
October 20-23
Paris, France
www.euronaval.fr

MILIPOL Qatar 2020
October 26-28
Doha, Qatar
https://en.milipolqatar.com

NOVEMBER

EW Europe
November 16-18
Liverpool, UK
www.crows.org

Bahrain International Airshow 2020
November 18-20
Sakhir Air Base, Bahrain
www.bahraininternationalairshow.com

I/ITSEC
November 30 – December 4
Orlando, FL
www.iitsec.org

DECEMBER

Electronic Warfare Symposium
December 1-2
Shrivenham, Oxfordshire, UK
www.cranfield.ac.uk

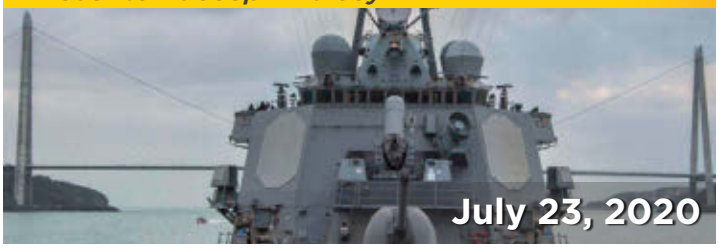
57th Annual AOC International Symposium and Convention
December 8-10
Washington, DC
www.crows.org

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

AOC Virtual Series Webinars

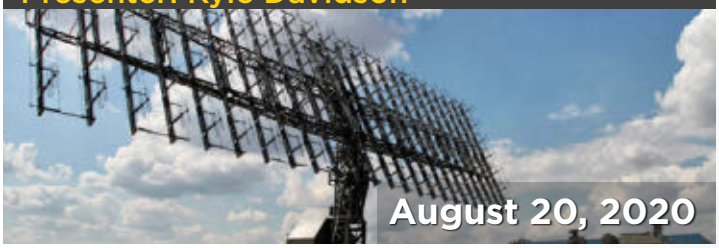
AOC Virtual Series has been a tremendous asset providing the AOC's audience with learning, advocacy, and the exchange of information. Register today to hear from subject-matter experts on all things EW!

EW System Development: Critical Thinking in Design Tradeoffs
Presenter: *Joseph Hulsey*



The Lost Art of HF: The Rebirth of Shortwave in a Digital World
Presenter: Paul Denisowski

High Resolution Direction Finding
Presenter: Kyle Davidson



Understanding Quantum Computing & Communications
Presenter: Mark Elo

Convergence of TDOA/AOA in Operational Environments
Presenter: *Luc Dondainas*

Specific Emitter Identification (SEI)
Presenter: Dr. Warren du Plessis

Introduction to Radar Pulse Deinterleaving
Presenter: Antonio Dias de Macedo Filho

High Power Radio Frequency/Microwave DE Weapons
Presenter: John T. Tatum

For more upcoming AOC Virtual Series Webinars, visit crows.org

ASSOCIATION OF OLD CROWS

Calendar *Courses & Seminars*

AUGUST

Infrared Countermeasures
August 4-7
Shalimar, FL
www.pe.gatech.edu

AOC Virtual Series Webinar: The Lost Art of HF: The Rebirth of Shortwave in a Digital World
August 6
1400-1500 EST
www.crows.org

Radar Cross Section Reduction
August 10-12
Atlanta, GA
www.pe.gatech.edu

Due to the disruptions caused by COVID-19, some course organizers have been forced to change the dates and/or venues of their event. Please contact the course provider to receive the latest details.

Test and Evaluation of RF Systems
August 11-13
Las Vegas, NV
www.pe.gatech.edu

Directed Infrared Countermeasures: Technology, Modeling, and Testing
August 18-20
Atlanta, GA
www.pe.gatech.edu

AOC Virtual Series Webinar: High Resolution Direction Finding
August 20
1400-1500 EST
www.crows.org

SEPTEMBER

AOC Virtual Series Webinar: Understanding Quantum Computing & Communications
September 3
1400-1500 EST
www.crows.org

Fundamentals of Radar Signal Processing
September 14-17
Lake Buena Vista, FL
www.pe.gatech.edu

AOC Live Professional Development Web Course: Introduction to Machine Learning for Electronic Warfare
September 14-28
7 sessions, 1300-1600 EST
www.crows.org

SIGINT Fundamentals
September 15-16
Lake Buena Vista, FL
www.pe.gatech.edu

Basic RF Electronic Warfare Concepts
September 15-17
Lake Buena Vista, FL
www.pe.gatech.edu

Adaptive Arrays: Algorithms, Architectures and Applications
September 21-24
Atlanta, GA
www.pe.gatech.edu

Advanced Radar Signals Collection and Analysis (ARSCA)
September 22-24
Atlanta, GA
www.pe.gatech.edu

Radar Warning Receiver System Design and Analysis
September 22-24
Shalimar, FL
www.pe.gatech.edu

Digital Radio Frequency Memory (DRFM) Technology
September 22-25
Atlanta, GA
www.pe.gatech.edu

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

FEATURED LIVE COURSES

Machine Learning for EW

Kyle Davidson

Mondays, Wednesdays, & Fridays

13:00 – 16:00 EDT | September 14 – 30, 2020

This course introduces students to the fundamentals of machine learning and its application to modern Electronic Warfare (EW) and cyber solutions.

Electro-Optical/Infrared Sensor Engineering

Dr. Phillip Pace

Mondays & Wednesdays

13:00 – 16:00 EDT | October 5 – 28, 2020

This course presents the fundamentals of electro-optical (EO) & infrared (IR) sensor technology, its analysis and its application to military search, track and imaging systems.

Intermediate Electronic Warfare
EW EUROPE 2020

Dr. Clayton Stewart

Thursday & Friday | 08:00 – 17:00 BST

November 19 – 20, 2020 | Liverpool, UK

We will begin with a historical perspective and introduce use of radar, integrated air defense system, early EA functions and conclude with an overview of modern EA, ES, and EP.

Fundamental Principles of Electronic Warfare

Dave Adamy

Mondays & Wednesdays

13:00 – 16:00 EDT | April 5 – 28, 2021

This is an introductory Electronic Warfare course in eight three hour sessions. It provides insight into the whole electronic warfare field at the systems and operational level.

Advanced Principles of Electronic Warfare

Dave Adamy

Mondays & Wednesdays

13:00 – 16:00 EDT | May 3 – 26, 2021

This Advanced Electronic Warfare course has eight three hour sessions. It is designed for individuals who have completed a fundamental EW course or have significant experience in the field.

= Web Course, no travel required!

57 AOC INTERNATIONAL SYMPOSIUM & CONVENTION

RF Theory for ES Operations

Dr. Patrick Ford

Sunday & Monday

09:00 – 17:00 EST | December 6 – 7, 2020

Advanced EW – Concepts and Developments

Kyle Davidson

Friday & Saturday

09:00 – 17:00 EST | Dec 11 – 12, 2020

Hands-on Introduction to Radar and EW

Dr. Warren Du Plessis

Sunday & Monday

09:00 – 17:00 EST | December 6 – 7, 2020

Tactical Battlefield Communications

Dave Adamy

Friday & Saturday

09:00 – 17:00 EST | Dec 11 - 12, 2020

FOR COURSE LISTINGS AND MORE VISIT **CROWS.ORG**

BECOMING AN EMS PROFESSIONAL

This month's *JED* includes an interesting article from the Electromagnetic Spectrum Operations Cross Functional Team (EMSO CFT) about its ongoing EMS Workforce Study (see page 40). For the first time, the DOD is trying to build a Department-wide understanding of what it needs in terms of EMS professional expertise.

Our community's unique professional expertise is something Western governments have counted on since World War II. But it has typically evolved in pockets – technological, operational and bureaucratic – on an as-needed basis rather than on a broader strategic level. As we move forward, development of our EMS workforce – not only in the US, but across its allies and security partners – needs to be more holistic and more intentional.

Let's take a moment to step back and think about what our governments need. We continually strive to gain superiority in the Electromagnetic Environment (EME). We design and engineer innovative evolutionary and revolutionary technologies. We prototype, we integrate, we test, we manufacture, we deploy, we train, we fight. This is a continuous and never-ending cycle. How do we stay on top of the technology? We discuss strategy, policy, doctrine, prioritization, acquisition, organization manning equipping and training for this fight – all good and all necessary. However, all of this is based on one thing: developing professionals in all our lanes of influence, including government, industry and in our fighting forces – we need professionals in every aspect of what we do.

The mission of the AOC has three primary thrusts: Advocate, Educate, and Support. Right now, I'm focusing on education. How do you become a professional or maintain your status as a professional? In today's environment, you need continuous education. The AOC educates and trains the EMS workforce through world-class Professional Development courses. Our mission is to provide a series of relevant courses that cover technologies and operations for military use in the electromagnetic domain and to establish a window through the *JED* for relevant EW and Domain Dominance research papers. The AOC currently has 13 on-demand courses that cover Fundamentals of Electronic Warfare, Radar, Communications, Space, Expendables, New Generation Threats, DRFM and 21st Century EW systems technology, just to name a few. We have nine live courses remaining in 2020 that include EW Modeling & Simulation, Missile Design and Development, Intro to Machine Learning, EW Critical Thinking and Problem Solving, Intermediate and Advanced EW, and Electro-Optical/Infrared Sensor Engineering. Our free 2020 Virtual Series Webinars are open to everyone, and this year includes 22 topics spanning the depth and breadth of what we do and the technologies and focus areas that are emerging. We are currently developing an EW Professional Certification program. In the current COVID-19 work from home/self-quarantine environment, we are providing the resources you need to dedicate the time and effort to learn, think and grow – we need professionals to guarantee our collective security into the future.

As always, I hope you will enjoy this month's *JED.* It is essential reading for an essential "Professional" community. – *Muddy Watters*

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UH-OH!

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  >35% efficiency vs. <10%
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- **Greater Reliability** :
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- **No Additional Cooling Required** :
  Integrated cooling within the MPM unit

Learn more about our various MPMs and TWTs by visiting our website **www.photonisdefense.com/MPM**.

[1] - *Nicol, E. F., Mangus, B. J., Grebliunas, J. R., Woolrich, K., & Schirmer, J. R. (2013). TWTA versus SSPA: A Comparison Update of the Boeing Satellite Fleet On-Orbit Reliability (pp. 1-2, Tech.). Los Angeles, CA: Space & Intelligence Systems, Boeing Corporation.*

9TH ANNUAL INFORMATION OPERATIONS & ELECTRONIC WARFARE SYMPOSIUM

All Domain Operations from Competition into Conflict

The theme for the 2020 IO/EW Symposium, "All Domain Operations from Competition into Conflict," will focus on how IO and EW contribute to Joint all-domain warfighting challenges, as well as their contributions to achieving a Free and Open Indo-Pacific during competition. This year's theme builds on the work of the 6th Annual Symposium in 2017, which focused on the Army's Multi-Domain Operations (MDO) Concept. The Army's now well-established MDO Concept focuses on optimizing the land force contribution to a Joint fight in multiple domains, and provides a strong foundation for the development of a Joint All-Domain Operations Concept, both of which are intended to be employed across the spectrum of operations, from competition to conflict. The 2020 theme also benefits from the presentations and work accomplished at the 7th Annual Symposium in 2018, focused on the roles of IO and EW in overcoming A2/AD challenges, which are a driver for the development of the Joint All-Domain Operations (JADO) concept.

Presentations and Papers Due August 21, 2020

INDOPACOM J39 and the AOC are soliciting original unclassified English language presentations and/or papers for the 9th Pacific IO & EW Symposium from subject matter experts in the U.S. and Allied militaries/government, as well as from academia and industry on the conference theme. Presentations for the full plenary session in the first two days of symposium must be UNCLASSIFIED. Presentations for the classified session on 22 October for cleared personnel at Camp H. M. Smith should be at the SECRET REL/FVEY, FRA, JPN level (or at higher classification for smaller US-only break-out sessions held in smaller conference rooms at the HQs).

Please contact the Symposium Chair, Arthur Tulak, COL USA, Ret., via e-mail at Arthur.N.Tulak.ctr@pacom.mil if you are interested in speaking or want more information. Proposed presentations should be provided in the form of a brief synopsis, with the proposed title, and biographical information on the speaker.

KEYNOTE SPEAKERS

ADM Philip Davidson
Commander U.S. Indo-Pacific Command (Invited)

LtGen Loretta E. Reynolds
Deputy Marine Corps Commandant for Information, and Commander of Marine Corps Forces Strategic Command (Invited)

FEATURED SPEAKERS

Ms. Libby Liu
Former President, Radio Free Asia and Former CEO, Open Technology Fund

Ms. Bay Fang
Executive Editor, Radio Free Asia

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AIR FORCE RESEARCH LAB TO ISSUE SIGINT/EW/CYBER SOLICITATION

The Air Force Research Lab's Information Directorate (AFRL/RI) (Rome, NY) has issued two draft task orders under its Unicorn Blue program. Unicorn Blue is a five-year, $49 million effort to "…develop digital signal processing capabilities that will scan through the Radio Frequency (RF) spectrum to detect high priority emissions, as well as research, develop and integrate technologies that will provide collection, detection, exploitation and geo-location capabilities of emerging signals of interest to various collection platforms" according to a program description. Furthermore, "The work will include providing real-time processing solutions and expanding the unique knowledge and experience base to automatically extract the contents of the transmissions and provide time-critical alerts and information on the signals collected. Additionally, this effort will develop prototypes that can be rapidly fielded, upgraded and transitioned to address current and emerging requirements."

In May, the Information Directorate's Information Exploitation and Operations Division, Sensor Exploitation Branch (AFRL/RIGC) issued two draft task orders. Task Order #1, titled, Network Operations Identification and Sensing Environment (NOISE), calls for developing "real-time signal processing solutions for Command and Control (C2) and Size Weight and Power (SWAP) constrained platforms that break down complex defense system communication links to isolate specific data of interest and then stream results in real-time to national level consumers. The solutions must show effectiveness in both Radio Frequency (RF) and Cyber domains and be capable of accessing, creating and observing adverse effects within critical communications paths for defense systems. Demonstrated effects cannot simply be the result of electromagnetic interference, jamming, or denial of service and must demonstrate a detailed knowledge of RF and Cyber signal characteristics, external and internal structures, and data fields." In addition, this effort entails development of "capable solutions to perform high quality waveform captures of known and unknown wireless communication systems which are subject to degrading or degraded environmental effects to include co-channel, narrow and wideband interference or multipath fading while still ensuring maximum dynamic range of targeted emissions in order to consistently recover the original transmission content and data," as well as developing data analysis tools and incorporating "advanced machine learning and artificial intelligence methodologies to allow for autonomy to remote sensor operations."

Task Order #2 covers an effort dubbed "Lemon Crabcakes" and calls for developing real-time signal processing solutions for SWAP-constrained platforms to exploit next-generation 5G communications waveforms and associated technologies. According to the task order, "The solutions must be effective to address the appropriate aspects and maximize the return on investment of the following concepts: Increased Data Volume (1000x over 4G), Decreased Network Latency (approx. 1 ms), Faster data-transfer speeds (1-10Gbps), and More Devices (up to 1000 per square km)." This effort also will address "appropriate exploits" for the novel communications strategies with respect to SIGINT and Cyber algorithm development. These strategies include interception and interference mitigation of Millimeter wave frequencies (30GHz – 300GHz); developing geolocation algorithms (TOA/TDOA, FOA/FDOA) for Millimeter wave frequencies, interception of Small Cell and 5G transmissions; developing hardware and/or software technologies to intercept beamformed transmissions; developing synchronized intercept algorithms for interception and reconstruction of full duplex communications technologies; and researching SIGINT and Cyber aspects of Software Defined Networking (SDN) and Network Functions Virtualization (NFV) algorithms and their applications to 5G communications.

As this issue of *JED* went to press, program officials were expected to issue final versions of task orders #1 and #2 in late June. Additional task orders are also anticipated. The solicitation number is FA8750-20-F-1004. The point of contact is Shelley Dormio, e-mail shelley.dormio@us.af.mil. *– J. Knowles*

LEONARDO DAS SELECTED FOR UK WEDGETAIL FLEET

Boeing has selected Leonardo to deliver an integrated Defensive Aids System (DAS) for the UK Royal Air Force's (RAF's) new fleet of E-7 Wedgetail airborne early warning and control (AEW&C) aircraft.

The UK Ministry of Defence in March 2019 signed a US$1.98 billion contract with Boeing to purchase five E-7 aircraft (to be designated Wedgetail AEW Mk 1 in RAF service). The Wedgetail fleet, due to achieve initial operational capability in 2023, will replace the current E-3D Sentry aircraft and ensure the continued delivery of the UK's AEW&C capability.

Leonardo will deliver the DAS fit from its site in Luton, using its Modular Advanced Platform Protection System (MAPPS) architecture as the basis, with the MAPPS Controller at the heart. This is the latest iteration of Leonardo's Electronic Warfare Suite Controller, a variant of which is used by the Royal Australian Air Force on its Wedgetail fleet.

As part of the selection, Thales UK, under a subcontract from Leonardo, will provide its Elix-IR infrared threat warning system and Vicon XF countermeasures dispensing system. While not included in the MAPPS baseline for Wedgetail, the MAPPS architecture can be easily extended to accommodate a directed infrared countermeasures (DIRCM) system: Leonardo is promoting

its Miysis DIRCM as a potential future option for the E-7 platform.

The contract for Wedgetail marks the second success for Leonardo's MAPPS architecture. Last year, a MAPPS variant was selected to meet the DAS requirement for the RAF's fleet of eight Shadow R1 intelligence gathering aircraft: this instantiation includes the Thales Elix-IR threat warner, the Thales Vicon XF countermeasures dispensing system and a dual-head Miysis DIRCM fit. – *R. Scott*

US ARMY DISCUSSES MULTI-DOMAIN OPS

Senior US Army officials provided a high-level look at the US Army's activities regarding "Multi-Domain Operations in the Electromagnetic Spectrum" during the AOC's Virtual EMS Summit in May. Beginning with GEN John Murray, Commander, Army Futures Command, it was made very clear that the Army is giving a whole new level of attention to dramatically expanding and improving its capabilities in all things EMS, including all new force structure to better operate and fight in the future operational EMS environment. "It's not just being able to operate in the EMS," he said. "The first step has got to be understanding not only your opponent's signature but your signature as well. And really understand how to take advantage of protecting yourself while exploiting your opponent's actions."

General Murray explained, "Multi-Domain Operations (MDO) are absolutely critical to the Joint Staff's joint,

SASC PASSES FY2021 DEFENSE BILL

The Senate Armed Services Committee (SASC) passed its version of the FY2021 National Defense Authorization Act (NDAA) and sent it to the full Senate for consideration as this issue of *JED* went to press. The committee report (116-236) accompanying the bill (S. 4049) includes several budget items to support electromagnetic spectrum operations (EMSO).

EMS Operations and Superiority

In an effort to promote EMSO modernization efforts, the committee report recommends that all EMSO responsibilities currently under the purview of the Commander of United States Strategic Command (USSTRATCOM) be transferred to the Chairman of the Joint Chiefs of Staff (CJCS). This recommendation would place additional responsibilities with the Vice Chairman of the Joint Chiefs of Staff (VCJCS), designating the VCJCS "as the senior designated official for EW and EMSO" to provide "oversight and advocacy," in particular, to "lead the development of EMSO concepts of operations and oversee their integration into the joint warfighting concept, the warfighting plans of the combatant commands, and the programs of the military services."

The SASC also requested reports on two separate EW programs as they relate to ensuring EMS superiority, including a report from the Navy on the use of the ALQ-249 Next Generation Jammer, as well as a report from the Air Force on intelligence, surveillance and reconnaissance (ISR) shortfalls, and more specifically, limitations of the RC-135 Rivet Joint ISR aircraft fleet.

Concerned that the ALQ-249 is the only Joint Force standoff jammer of its kind capable of supporting joint EW, the SASC has asked the Secretary of the Navy, along with the Vice Chairman of the Joint Chiefs, to "provide a report detailing: 1) The current procurement strategy of the ALQ-249 and an analysis of its capability to meet the radio frequency ranges required in a NDS [National Defense Strategy] conflict; (2) Its compatibility and ability to synchronize non-kinetic fires with other joint electronic warfare platforms; (3) A future model of an interlinked/interdependent electronic warfare menu of options for commanders at the tactical, operational, and strategic levels." The report is due to the committee no later than July 30, 2021.

From the Secretary of Defense and the Secretary of the Air Force, the SASC has requested a report addressing unmet ISR requirements and the efficacy of converting retiring KC-135 aircraft into RC-135 ISR aircraft, as was previously achieved in the conversion of KC-135 aircraft to RC-135W Airseekers for the UK's Royal Air Force (RAF). The report must include "an assessment of the overall ISR shortfall based on combatant commander demand, to include analysis of specific shortfalls and limitations imposed by the size of the current RC-135 fleet."

To that end, the report must address the benefits of increasing the RC-135 inventory, as well as plans for integrating the RC-135 into next generation networks; the number of KC-135 to be retired and therefore available for alternate uses in the coming years, including in conversion to other C-135 aircraft beyond the RC-135; cost and time estimates for the KC-135 conversion process, per aircraft; and lessons learned during previous KC-135 conversions. The report must be submitted to the committee by February 1, 2021.

EW Training

Recognizing the need for improved EW training capabilities, the SASC has requested a briefing from the Secretary of Defense establishing "progress made and gaps remaining in training [EW] red forces" to promote the "realistic training of blue forces in [EW]." Such training "requires a red force that is trained in the tactics, techniques, and procedures of potential opponents." The committee has requested the briefing take place no later than March 31, 2021.

The committee has also requested a plan from the Secretary of Defense for the establishment of a Joint Electronic Warfare Training Range, conscious that "development of capabilities needed to control the EW battlespace requires well-developed training ranges." The training range must "(1) [Offer] sufficient space for spectrum isolation; (2) [Provide] for the ability to protect sensitive technologies from detection by offering access to large, inland space; and (3) ... be specifically dedicated to EW activities to avoid overcrowding." The congressional defense committees must be briefed on this plan by December 1, 2020. – *H. Swedeen*

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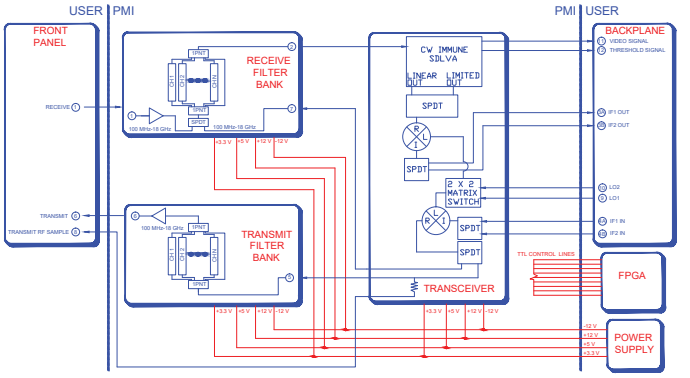

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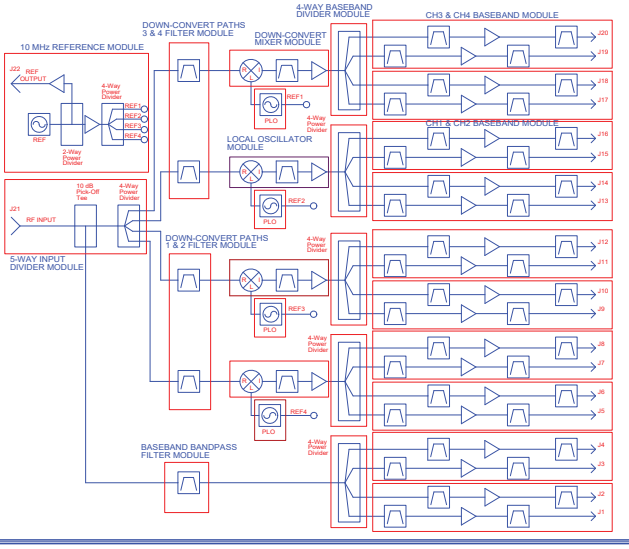

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all-domain operations concept." With a target operational capability of 2028, Murray described the Army's main tenets of MDO, including calibrated force posture, "which means being in the right places, at the right time, with the right force and with the right authorities. One key element of this new formation will be the Multi-Domain Task Force, which will be critical to realizing the full potential of MDO."

Murray emphasized that another important concept that he is pushing across the enterprise is that of 'soldier touch points,' "which is getting soldiers involved early in the developmental process so that we can deliver them a capability they want and provide important feedback loops that inform the next round of soldier test."

Murray pointed out that capability gaps can only be solved by technology, which is the focus of the Army's modernization efforts across the cross functional teams (CFTs), as well as the development and acquisition priorities of the Army's Rapid Capabilities and Critical Technologies Office (RCCTO). As he put it, "We will never be done modernizing, but we have got to take this opportunity to modernize now."

Following General Murray's presentation, LTG Neil Thurgood, Director for Hypersonics, Directed Energy, Space and Rapid Acquisition within RCCTO said, "This organization exists for one single outcome, and that is to produce prototype weapons for combat units that we call 'Units of Action.'" Thurgood notes, however, that it's important to clearly define what is meant by the term "prototype weapons." "If you're in the Science and Technology (S&T) world, prototyping would mean something like, 'we tried a thing and we demonstrated a thing worked.' They do this very well, but where we struggle is moving things from the S&T community that produced this demonstration of a thing into the hands of soldiers. Under General Murray, we're working to overcome this by aligning the S&T community with the modernization community." Said Thurgood, "Our objective of 'acquisition-at the-speed-of-relevance' is always paced by the resources allocated at the time for that outcome, but this is a unique time in our history when we do have the opportunity to change the future – where we have an opportunity to set conditions."

According to Thurgood, hypersonics is his top priority. The Army is teamed with the Navy on this effort and completed a very successful flight test in March. Specifically, in terms of EMS technology and capabilities, Thurgood notes what he describes as a "relatively simultaneously developing and maturing industrial base, with great ideas and combining of ideas together." For example, he points to current thinking regarding multi-function systems – "treating a radar like a radio, or as a high-power microwave weapon, or one that does all three things. We have to be agile enough with our equipment that we can use it to accomplish multiple outcomes."

Responding to a question regarding the relationship of employment of hypersonic weapons in today's EM environment, Thurgood said, "Today, you cannot develop a weapon system of any type that does not account for the electromagnetic environment, either on the defensive side or the offensive side. This is why these cross-functional teams are so important, because various domain expertise doesn't necessarily exist in the missile world."

LTG Scott Berrier, Army Deputy Chief of Staff of the Army G-2, followed General Thurgood with an excellent discussion and assessment of the threat universe at the unclassified level. In regard to this, he then spoke to his role as the lead integrator of the Intelligence, Surveillance, Reconnaissance (ISR) Task Force. "I feel like I am a CFT [cross functional team] just because of the amount of time I spend with the other CFTs, as well as Futures Command."

Berrier says the ISR Task Force has EW as a critical component of its capability. "Whether terrestrial or aerial, I'm an advocate of EW assets on the ground and in the air. We're working very hard to bring together specialties like SIGINT, EW and cyber that are currently trained at different locations, and looking very closely at what the manning and training component will look like. We have to be very deliberate on how we go about constructing the DOTMLPF architecture for this and there will be some cross-over."

When asked if the EMS should be recognized as a warfighting domain, Berrier said that, from his perspective, he doesn't know why the Joint Force hasn't declared the EMS a separate domain. "A major competition is going to take place in the EMS. It's a place that we're operating in every single day, and I myself think of it as a domain. I just don't think the Joint Force has come around to designating it yet." – *J. Haystead*

IN BRIEF

The Air Force Life Cycle Management Center (Wright-Patterson AFB, OH) has awarded 28 five-year Indefinite Delivery / Indefinite Quantity (IDIQ) contracts worth up to $950 million each to further develop the Advanced Battle Management System (ABMS) under the Joint All Domain Command and Control (JADC2) architecture. Awardees include a mix of traditional defense electronics companies, such as **BAE Systems, Boeing, General Dynamics, L3Harris, Lockheed Martin, Northrop Grumman** and **Raytheon,** as well as many companies that have historically served commercial technology markets. The JADC2 concept calls for connecting any sensor to any shooter in the battlespace. According to the contract announcement, "These contracts provide for the development and operation of systems as a unified force across all domains (air, land, sea, space, cyber and electromagnetic spectrum) in an open architecture family of systems that enables capabilities via multiple integrated platforms." While the Air Force does not envision awarding the maximum $950 million ceiling on each of the contracts, it has set a $3.2 billion ABMS development budget in the FY2021-2025 Future Years Defense Program.

The **Defense Logistics Agency (DLA)** issued a Sources Sought Statement (SSS) for an upcoming C5ISR Gateway to Sustainment (G2S) effort for the US Army's Communications-Electronics Command. The C5ISR G2S effort will cover hardware and software sustainment of more than 200 legacy EW, sensor, communications and other defense electron-

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ic systems in service with the US Army. The work also includes test and evaluation repair, upgrades and design changes, engineering studies and hardware obsolescence monitoring. The C5ISR G2S program budget is estimated at $2-$5 billion over a 10-year ordering period. Multiple contracts are anticipated. Responses to the SSS are due by July 17. The point of contact is Megan Luber, e-mail megan.luber@dla.mil.

Naval Air Systems Command (Patuxent River, MD) has announced plans to award a sole source contract to **Boeing** (St. Louis, MO) for six depot-level modifications to Navy's EA-18G Growler fleet. These include aircraft modifications to integrate Tactical Targeting Network Technology (TTNT), Next Generation Jammer Mid-Band Pods, Distributed Targeting Processor-Networked and Growler Satellite Communications. The schedule covers 12 aircraft modifications in FY2021 and 32 per year from FY2022 through FY2024. The modifications would be performed at Boeing's Oak Harbor, WA, facility.

US Special Operations Command (MacDill AFB, FL) has announced plans to host a demonstration in September to evaluate candidate signals intelligence (SIGINT) solutions under its Joint Threat Warning System (JTWS) program. In June, Program Executive Officer for Special Reconnaissance, Surveillance and Exploitation (PEO - SRSE), Program Manager for Joint Threat Warning Systems (PM-JTWS) issued a Request for Information (RFI) to obtain input about 1) UAS RF SIGINT sensors (preference for modular payload); 2) small-form-factor antennas that can be mounted on UAS platforms; 3) signal processing at the Tactical Edge for SIGINT applications; 4) Artificial Intelligence/Machine Learning capability at the Tactical Edge for SIGINT; and 5) capability to detect and locate frequency-agile radio transmitters and other signals of interest. PM-JTWS has scheduled demonstrations during the week of September 21 at the Muscatatuck Urban Training Center (MUTC), (Butlerville, IN). The point of contact is Mark Spadaro, Program Manager, (813) 826-7263, e-mail mark.spadaro@socom.mil.

Northrop Grumman (Herndon, VA) received a $29.9 million firm-fixed-price contract option from Naval Sea Systems Command for mounted systems, dismounted systems and auxiliary kits for the Joint Counter Radio-Controlled Improvised Explosive Device Electronic Warfare (JCREW) Increment One Block One (I1B1) systems full rate production in support of the Expeditionary Warfare Program Office. This option exercise is in support of a Foreign Military Sale to the Australian Army. Work also includes diminishing material and depot repairs to keep FMS and I1B1 viable for future production and to maintain operational readiness for the field. Work is expected to be complete by April 2022.

Naval Sea Systems Command (Washington, DC) announced plans to issue a sole-source Request for Proposals to **L3Harris** (Clifton, NJ) for procurement of Nulka Mk234 RF decoy payloads. The company will supply payloads developed under the Advanced Decoy Architecture Program (ADAP) and provide engineering services. The RFP will cover one base year and two option years.

DRS Systems (Dallas, TX) received a $120 million contract from Naval Air Systems Command to design, develop, integrate and test engineering development models and production representative models of weapons replaceable assemblies for the AN/AAQ-45 Distributed Aperture Infrared Countermeasures (DAIRCM) system. The AAQ-45 is a lightweight directed IR countermeasures (DIRCM) system developed under a Joint Urgent Operational Needs Statement (JUONS) effort to equip AH-1Z, UH-1Y, and MH-60S helicopters. Although the system has been fielded on a limited number of helicopters under the JUONS, the recent contract marks the beginning of a formal Engineering and Manufacturing Development (EMD) program for Navy platforms. The Navy plans to buy 253 DAIRCM A-kits and B-kits for UH-1Y helos and another 500 A-kits and B-kits for its MH-60R/S helos.

The US Navy has completed its first captive carry test of **Northrop Grumman's** AGM-88G Advanced Antiradiation Guided Missile -Extended Range (AARGM-ER) on June 1 at its NAS Patuxent River Test Range in Patuxent River, MD. The flight test, which was carried out from an F/A-18E Super Hornet, represents a major step in the AARGM-ER EMD program, according to CAPT Mitch Commerford, program manager, Direct and Time Sensitive Strike program office (PMA-242). The Navy plans to integrate the AARGM-ER, which will significantly extend the original AARGM's 60-mile range, onto the F/A-18E/F Super Hornet, the EA-18G Growler and F-35 A/B/C aircraft.

Mercury Defense Systems Inc., (Cypress, CA) has received an $11.7 million follow-on order for hardware and software design and development of the Type II Advanced Digital Radio Frequency Memories (DRFMs), as well as the production and delivery of 22 DRFMs for the Navy and the Air Force under Small Business Innovation Research Topic N06-036 titled, "Advanced Techniques for Digital Radio Frequency Memories (DRFM)." Deliveries are scheduled through November 2021.

Dynetics Inc. (Huntsville, AL) has won a $10.5 million indefinite-delivery/indefinite-quantity (IDIQ) contract from the US Air Force for the Laboratory Intelligence Validated Emulator (LIVE) Virtual Constructive (LVC) production and sustainment. The company will deliver and sustain LIVE LVC test systems for the Air Force's Electronic Warfare and Avionics Integration Support Facility at Robins Air Force Base, GA, and for other Department of Defense agencies. Work is expected to be completed by May 2030.

Applied Research Associates Inc. (Dayton, OH) has been awarded a $24.7 million cost-plus-fixed-fee contract for the research and development of algorithms and tools to produce high-quality radio frequency modeling data. Work will be performed at Wright-Patterson Air Force Base, OH, and is expected to be completed by September 2025.

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Keeping Praeto

By Richard Scott

Originally conceived as a Cold War air defender, the four-nation Eurofighter Typhoon fighter has over time evolved into an advanced swing-role combat aircraft providing simultaneously deployable air-to-air and air-to-surface capabilities. In addition to its "parent" customers – Germany, Italy, Spain and the UK – variants of Typhoon also serve with the air forces of Austria, Oman and Saudi Arabia, and are on order for Kuwait and Qatar.

The aircraft has won its spurs in combat missions over Libya, Iraq and Syria, and has also regularly contributed to NATO's Baltic Air Policing mission. Furthermore, Eurofighter Jagdflugzeug GmbH – the industrial consortium of Airbus, BAE Systems and Leonardo responsible for the design, production and sustainment of Typhoon – is continuing to pursue new business: for example, Typhoon is one of a number of candidates for Finland's HX fighter acquisition program, while Germany has signaled its intention to order up to 93 more aircraft to meet its respective Project Quadriga and Tornado replacement requirements.

With the expectation that Typhoons will remain flying out beyond 2050, the Eurofighter industry partners and the NATO Eurofighter & Tornado Management Agency (NETMA) have now begun to explore options for enhancement and sustainment the under the umbrella of a multi-strand Long Term Evolution (LTE) activity. One of those strands is specifically examining the way forward for the aircraft's Praetorian Defensive Aids Sub System (DASS).

At the same time, the Euro-DASS consortium – made up by Leonardo, Elettronica, Indra and Hensoldt – is self-investing in the definition and maturation of an evolved DASS architecture known as Praetorian eVolution (eVo) that seeks to assure the electronic warfare (EW) and platform self-protection capability of Typhoon against an evolving threat out to the type's Out of Service Date (OSD).

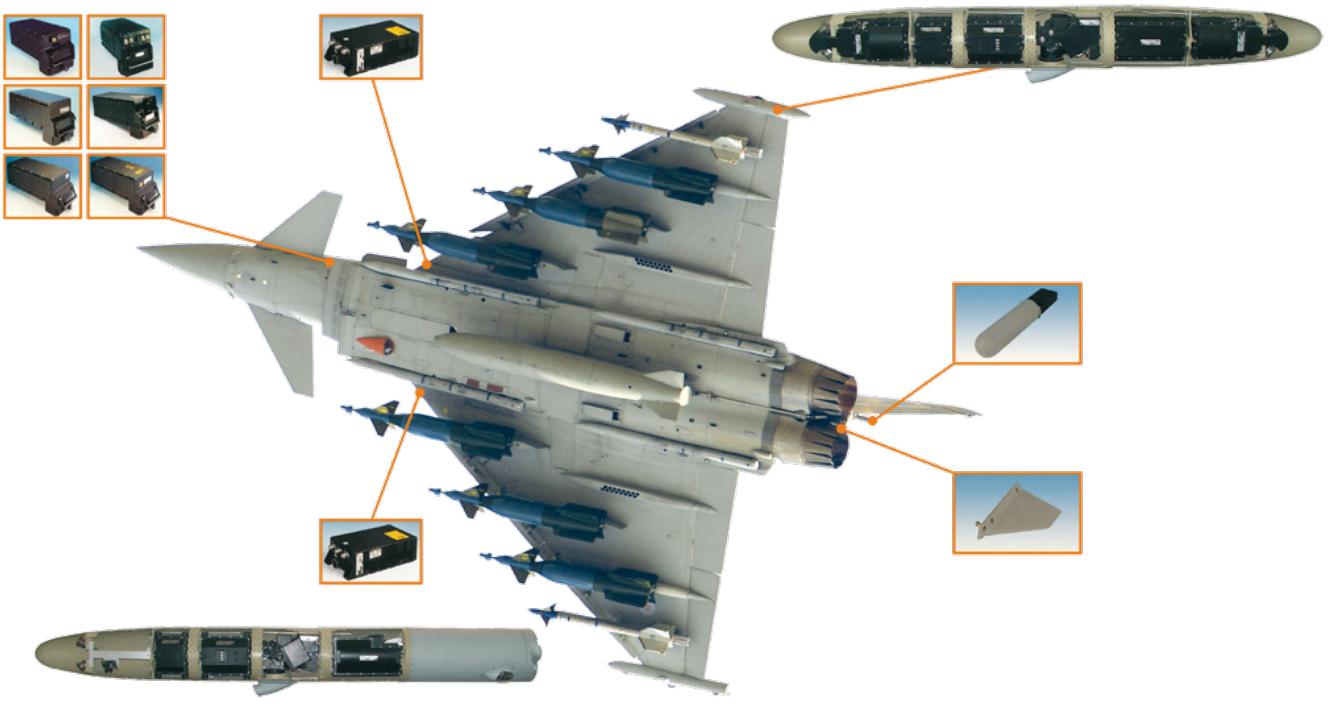
DASS ORIGINS

The mission programmable Praetorian DASS suite fitted to the Typhoon is an intrinsic part of the aircraft's advanced multi-role capability, providing the aircraft with self-protection against air-to-air and surface-to-air threats. BAE Systems, on behalf of the four-nation Eurofighter consortium, has taken the role of Equipment Design Responsible for the provision and installed performance of the full DASS fit. This embraces the totality of Praetorian (based on integrated electronic support measures and electronic countermeasures [ESM/ECM] equipment against RF emitters and an active missile warner system to provide alert of missile threats), two underwing Saab BOL-510 integrated chaff dispensers (housed in the weapon pylons), and Cobham-supplied integrated flare dispensers housed in the actuator fairings beneath the wings.

As the central component of the DASS, Praetorian itself comprises approximately 20 Line Replaceable Items (LRIs) and Shop Replaceable Items (SRIs). The power supply, ESM/ECM processor, techniques generator and RF source are all located in the

Two RAF Typhoon FGR4 aircraft prepare to take off from RAF Akrotiri in Cyprus to fly a sortie in support of Operation SHADER. Operation SHADER is the codename given to the UK's contribution to the military intervention against ISIS in Iraq/Syria. ROYAL AIR FORCE/CROWN COPYRIGHT

rian on Guard



Praetorian DASS LRU locations. LEONARDO

Typhoon's internal avionics bay, as are the processor and transmitter boxes associated with the missile warner.

Each wingtip pod hosts eight ESM receive antennas, plus associated preselector and downconverter LRIs. The port wingtip pod also contains solid-state ECM phased array transmitters fore and aft, together with a monopulse steering unit.

The aft section of the starboard wingtip pod houses two Towed Radar Decoy (TRD) dispensers, each containing a flight body, tow cable, and deployment and braking mechanism. A TRD is deployed using a 100-meter Kevlar cable containing a fiber-optic link and a separate Extra High Tension power distribution line.

Space and weight provisions remain in the forward section of the pod for an additional ECM phased array transmitter. Also housed in the starboard wingtip pod is the power supply unit for the TRD installation.

Heat management in the wingtip pods – essential to allow the equipment LRIs to be shrunk down – presented a significant development engineering challenge. Engineering studies showed that none of Polyalphaolefin, Coolanol, R25, water or water glycol could cool below the cold wall temperature limit of 70°C. The answer, neatly embodied in each pod, is an elegant yet robust liquid-to-vapor phase compression system using R245fa liquid refrigerant.

The missile warner features an aft-facing antenna for rearward coverage, and two forward-facing antennas in the wing roots to cover frontal aspects port and starboard. Given the very high closing speeds on the frontal aspect, low-noise amplifiers are matched to the two wing root antennas so as to offer enhanced sensitivity.

Overall DASS system control is exercised through the dedicated and fully reprogrammable Defensive Aids Computer (DAC). The DAC interfaces, via the defensive aids bus, with all DASS subsystems and, through a STANAG 3910 fiber-optic databus, into the Typhoon avionics system. The functionality residing in the DAC provides a fully automated capability to analyze and respond to multiple threats, ensuring sensor interoperability at platform level, prioritizing and coordinating the appropriate countermeasures response, and authorizing specific jamming techniques.

Typhoon pilots can access DASS information by means of a specific "page" shown on any one of three heads-down Multifunction Head Down Display units. Cues can also be shown on the pilot's wide-angle Head Up Display.

As well as providing self-protection by means of automatic threat alert and responsive countermeasures, the Praetorian DASS is an important contributor to Typhoon's fused sensor picture. That reflects both the sensitivity and measurement accuracy of the ESM subsystem, and commensurate investment in programmable mission data to maximize the efficacy of the DASS in specific theatres and scenarios.

The UK is unique among the four Eurofighter partners in that it also procured a laser warner system for its Typhoons as a national fit (hence outside the boundary of the Praetorian DASS). Developed by Leonardo in Edinburgh, this instantiation of the company's Type 491 laser warner features six passive sensor heads, distributed around the airframe, connected via fiber-optic cables to a central processor unit.

Praetorian has already been upgraded during Typhoon's lifetime. Tranche 1 aircraft gestated in an era when highly proscriptive Mil-Spec standards were the norm, which conditioned the use of highly bespoke processors and interfaces.

However, pricing development for Tranche 2 aircraft highlighted the fact that the Praetorian DASS electronics architecture would require significant re-engineering in order to resolve hardware obsolescence and ensure sustainability. Furthermore, the insertion of new software-based functionality would require new high-speed processors able to execute more complex algorithmic functions.

As a consequence, the aircraft in Tranche 2 and after have seen a widespread transition to commercial-off-the-shelf (COTS) hardware, with software re-hosted on a new processing architecture based on PowerPC processor cards. Harnessing COTS innovation has also enabled reductions in size, weight and power requirements, while at the same time providing a platform for expanded functionality. A Common Obsolescence Removal Program was established in parallel to ensure that the Praetorian baseline remains in step with the accelerated cycle time of the COTS component market.

Praetorian at Tranche 2 build standard has also introduced new functionality. For example, dual-circular polarized ESM antennas and improved Digital Radio Frequency Memory (DRFM) and TRD equipment have all been embodied.

However, there is no escaping the fact that the existing Praetorian DASS was defined in the late 1980s/early 1990s. As a consequence, its architecture now imposes constraints on further development with regard to further expansion, capability insertion, and long-term sustainability.

One strand of Eurofighter's Long Term Evolution activity is exploring future options for the Typhoon's Praetorian Defensive Aids Sub System. EUROFIGHTER GMBH

LTE STUDY

There is a consensus across both the Eurofighter industry team and the Typhoon customer community that now is the time to look at options to further evolve the aircraft and its weapons system so as to ensure continued relevance out to 2050. To address this need, Eurofighter Jagdflugzeug GmbH, EUROJET Turbo GmbH and NETMA in May last year signed initial contracts worth an aggregate €53.7 million to support a series of LTE studies aimed at identifying technology enhancements in areas of mission system architecture, human-machine interface, DASS, power and cooling, and engine performance.

These study contracts are designed to provide a clear road map for the long-term development of the aircraft against a backdrop of accelerating technology advancement and growing threat proliferation. From the standpoint of the DASS, the objective of the LTE is to explore potential future requirements out to 2060 in order to enable Typhoon to maintain an edge against these new threats.

Under an 18-month contract awarded by BAE Systems (on behalf of Eurofighter Jagdflugzeug GmbH), the EuroDASS consortium has been tasked to characterize the future threat environment, evaluate potential future DASS requirements, identify technologies and techniques to enhance the survivability of Typhoon, and deliver options for long-term technical solutions and enablers which will sustain the growth path of the platform in the future. "Each of the four industry partners is addressing specific topics within the study," Phil Liddiard, Leonardo's vice president combat air, explained. "We started with an analysis of where we thought the threat would be [going] over the next 30 years, identified the capability gaps, and then came up with options to fill those gaps. The work has looked at how we keep the current [Praetorian DASS] system flying and manage obsolescence removal. At the same time, we have looked at future technology options in light of likely threat trends."

Among the options are a more flexible software-driven architecture, allowing for the introduction of new capabilities in a more agile and low-cost manner. Improvements to the exploitation and fusion of onboard sensors are also being investigated, and work is additionally considering both onboard and offboard countermeasures.

EuroDASS in February 2020 submitted its interim report, including a range of options, to BAE Systems, which has in turn passed the conclusions to NETMA. The plan as it stands – pending the full impact of COVID-19 – is that NETMA will downselect specific options and issue a Request for Quotations (RFQ), with EuroDASS to respond with a bid by the end of 2020.

"We have a baseline option, which is basically taking the current system forward," said Liddiard. "Then we have two additional options, based on a new architecture, one left of arc and one right of arc. So as you go left to right so we cover more and more of the gaps.

"Obviously, from an affordability view, the cost increases the further you go to the right. That is also true on the impact to the airframe and the aircraft. We can't do these modifications without BAE and the other EPCs [Eurofighter Partner Companies]. At the end of the day this will be a joint activity."

Option 1 seeks to maximize the capability of the existing fleet, proposing modifications that would keep a limited level of growth going forward. For future aircraft, EuroDASS has, in options 2 and 3, proposed a new architecture to enable continued growth out to OSD. "If you're building a new aircraft you have more scope for changing some of the pods, and the wiring and cooling situation," explained Liddiard. "And if you want to exploit the improved reliability, then we need to start removing some of the microwave analog circuitry that's [currently] in there.

"We are not saying that options 2 and 3 are unsuitable for retrofit to existing aircraft," he added. "But they would be quite disruptive retrofits that would likely require a return-to-works program, because the implications for the airframe are more significant."

Liddiard continued: "Option 1 is basically replacing current units with new hardware that would fit in the same spaces with minor wiring changes, some of which have already been proposed and incorporated into later Tranche 2 and Tranche 3 aircraft. So, it can be performed by updates to the current architecture and is less invasive to the aircraft, and builds on existing national programs."

However, it is acknowledged that Option 1 will not offer the same capability "headroom" for growth as the new architecture. One of the key limiters, for example, would be the number of digital channels. "Yes, it will have digital channels, but they won't necessarily be able to be used all over the bandwidth at the same time," explained Liddiard. "With options 2 and 3, then that would be a full digital architecture with modular software supporting algorithmic mission data applications that we've been developing, software-configurable common hardware modules, and multi-platform cooperative techniques.

"For the end user, it brings benefits in terms of improved situational awareness against modern and complex threats, improved threat ID, a greater contribution to the overall weapon system, and the ability to have agile updates – even on the fly potentially, if the comms are in place on the aircraft. It will also give improved reliability, so less spares leading to lower costs of ownership and increased availability."

The intention is, Liddiard added, that baselining the Option 2 configuration would still enable phased growth to the full Option 3 standard in due course. "So, for instance, you could plug in additional digital modules for more channels over time. That could be a way that the nations end up with slightly different systems, but it will all be within the same architecture concept."

EVOLUTION THEORY

This "optioneering" work has been based on internal activity started by EuroDASS prior to the start of the LTE study activity. "This is what we're calling Praetorian eVolution, or Praetorian eVo for short," said Liddiard. "As a consortium, we've been looking at various solutions over the last three years or so [because] we recognized the need some time ago to get a head-start on working up what we thought was the best option. We're covering all the elements of the current system, so that's the ESM, the ECM – onboard and offboard – and the missile warner."

Investment to date – measured in several millions of Euros – has been funded by the EuroDASS board and the partner companies. The teams involved with Praetorian eVo and LTE are essentially the same personnel to maximize the transfer of eVo thinking into the LTE contract.

"We started out examining what we thought the partner nations would want going forward, and how the future threat was evolving," said Liddiard. "We then looked at the technology available, and have developed an architecture to keep the Typhoon DASS/EW system relevant through to out-of-service-date in the middle of the century."

At an operational level, work to evolve a future DASS architecture is addressing the fast evolving and ever more complex threat environment. In turn, this is driving expansion beyond the classic self-protection role such that EW can make a greater contribution to Typhoon situational awareness, and combat ISR functions such as high-precision targeting and advanced combat identification. Multi-platform EW is also on the agenda.

Praetorian eVo was first briefed to NETMA at a conference in October 2019. The roadmap laid down by EuroDASS envisages the move to an all-dig-

Typhoon is expected to remain in service beyond 2050. EUROFIGHTER GMBH

ital architecture so as to simplify future upgrades, optimize lifecycle costs, and make the best use of mission data. "This will improve adaptability, and improve the speed of updates by enabling software-based spiral development to keep ahead of the threat," Liddiard said. "It also provides an opportunity to take advantage of the latest hardware advances to increase the reliability and reduced integrated logistics support requirements."

He continued: "The baseline architecture will be common across the nations, so that each partner has a minimum standard and can then develop additional national capabilities as required. That's why we've gone for the algorithmic software concept so you can 'bolt on' software modules.

"What we are very keen to avoid is any substantial deviation in the baseline. Keeping multiple configurations of build standards is already hard."

Praetorian Evolution is architected around common modules. "We would move away from specific, dedicated analog circuits, and move to an architecture based on common digitized modules with firmware and software dictating the function," Liddiard said. "That gives you much more flexibility in how you use resources across the entire system."

This approach also supports a DASS solution that is supportable, sustainable and cost-efficient. "Improved availability, reliability and maintainability is another key driver for the new architecture," Liddiard observed. "In the past, [we had] dedicated microwave functions where each one was a completely independent module that had to be tested right across the temperature band. That incurs significant costs in terms of making sure that it all works. The idea with the new system is that an awful lot of that functionality will be digitized immediately, and that work will now be performed on what are effectively common hardware modules using software functions."

Much of the thinking around mission data and apps has been based on trials work already performed by Leonardo in the UK to evaluate the way that adversaries are changing the nature of the threat. For example, introducing modern processing to older generation radars to enable them to produce new waveforms

"We've been developing mission data for many years," Liddiard pointed out. "Previously, it was sufficient to identify emitters on the basis of descriptors, such as frequency and PRF. But as things get more and more complex, we actually need algorithms to recognize the waveforms, and you can then try and determine the mode of the threat. Knowing what mode the threat is in means you can decide whether it is necessary to alert the pilot. Previously, you had to identify the threat as soon as you saw it. Now we want to bring more intelligence into the system to support the pilot."

DASS integration within the Typhoon airframe and wider weapons system is an important consideration. "BAE is looking at new displays and buses, and EuroDASS wants to maximize their potential in the new architecture," said Liddiard. "So, the DASS solution must fit within the constraints of space, weight power and cooling."

One item outside of the Praetorian eVo scope is the application of Typhoon's new Captor-E active-electronically scanned array (AESA) multi-mode radar to the electronic attack mission. The UK's Bright Adder technology demonstrator program has sought to demonstrate "jamming through the radar," and the Royal Air Force has ambitions to incorporate this functionality in its so-called Radar 2 build standard. In this case, it would be necessary to engineer a high level of functional interoperability between the DASS and the AESA radar."

TECHNOLOGY HORIZONS

Some technology developments – partly customer-funded – are already underway to mature certain key technologies. For example, EuroDASS recently demonstrated digital receiver algorithms installed in the current processor standard. There is also an expectation that Leonardo's BriteCloud expendable active decoy technology – development of which has been supported by the UK customer – will be exploited.

Another proposal within Praetorian eVo is the introduction of a hybrid active/passive [radar/IR) missile warner. "The real estate currently occupied by the laser warners [on UK aircraft] is something we're coveting for the hybrid warner, as we would need a few extra sites for sensor heads," Liddiard said. "That would build on the real estate that the current active missile warner occupies. Subject to the customer requirement, we believe the hybrid missile warner would have benefits and should significantly reduce false alarms."

This view of a Royal Air Force Typhoon provides a clear view of the two Towed Radar Decoy dispensers housed in the starboard wingtip pod. ROYAL AIR FORCE/CROWN COPYRIGHT

The application of cognitive EW techniques – using Machine Learning to aid detection, characterization and jamming against previously unknown threat waveforms – is also being explored. "What we're conscious of is that we can't have a full software clearance process every time that we change a bit of that sort of software because, by definition, it's going to be pretty rapid development," explained Liddiard. "Part of the reason for having the apps and the algorithmic mission data is having the ability to be able to put that sort of [functionality] in [the DASS] – making sure it doesn't degrade the baseline system – and then enable it as additional advice [to the pilot]."

Going forward, EuroDASS currently expects some "order cover" in the first or second quarter of 2021, although whether that is a full-scale development program or a more modest level of start-up/long lead activity has yet to be determined. "This [program] clearly represents a significant investment, and there will almost certainly be some trade-offs," said Liddiard. "So, it could be that there will be some further work to do before the final configuration is settled on."

The timescale for implementation of a modernized DASS remains dependent upon the LTE contract, and how the Eurofighter partner nations decide to progress: at this stage, initial indications are for the realization of the LTE around the mid-2020s, leading to aircraft deliveries in the late 2020s/early 2030s. What is already clear is that the modernization of the Praetorian DASS will be a critically important program for both Typhoon operators, and a number of the main industry players in the European EW sector.

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TECHNOLOGY SURVEY
A SAMPLING OF RADAR JAMMERS

By John Knowles and Hope Swedeen

This month, our technology survey is taking a look at radar jammers. Ever since their introduction during World War II, radars have had a profound impact on modern warfare. It is no coincidence that radar jammers were immediately introduced in response to radars, and the two have evolved in a leapfrogging technology competition in the ensuing decades.

Today, radar developers are leveraging many types of new technologies – especially from the commercial sector – to improve radar performance. These include active electronically scanned arrays (AESAs), gallium nitride (GaN) transistors and ICs, low-probability of detection waveforms, Machine Learning, and many others. While these improvements are defining a new era of radar performance, they are also posing challenges that make radars harder to detect and more difficult to jam. Yet EW developers are leveraging many of these same commercial technologies and further developing them for new-generation radar jammers, as well as legacy systems.

Over the past few years alone, EW companies have introduced many new radar jammer models and active expendable decoys. In the table on the following pages, companies responded with more than a dozen new jamming systems or decoys since our airborne radar jammer survey two years ago. One of the most active categories within the airborne EW market, for example, is for support jammers. Not only are new airborne radar jammers being introduced, there are also new naval and ground-based radar jammers coming onto the market.

In addition to these performance trends, the size, weight and power footprint of radar jammers continues to shrink. Radar jammers are finding their way onto new types of host weapons platforms, including small, expendable unmanned aerial systems (UASs), unmanned ground vehicles (UGVs) and unmanned surface vessels (USVs). At an even smaller scale, these new technologies are enabling a new generation of active expendable decoys, which you will also notice in the table.

THE SURVEY

This month's survey includes 50 jamming systems from 15 companies. In the survey table, the first column lists the jammer model. As mentioned, the survey also includes active expendable decoys – both airborne and naval. The second column describes the host weapons platform, either by model (i.e., F-35, F-15, etc.) or by type (airborne, naval, etc.).

The next two columns cover the jammer's configuration (internal or podded) and the role of the jammer – self-protection jammer or support jammer. As you'll notice from the responses, the jammer's role is not as clear cut as it once was. In the past, support jammers (which protected multiple aircraft in a group) tended to cover lower radar frequencies associated with detection, acquisition and target tracking functions. Self-protection systems (which primarily protected the host platform) typically focused on higher radar frequencies associated with target tracking and fire-control radars. Today's radars operate in multiple modes and across wider frequency ranges than older systems. There are also 3D radars and passive coherent radars to deal with. The responses in this survey tend to reflect this more complex radar environment, and a jammer's role depends to some degree on frequency coverage, ERP and other factors. In the case of airborne jammers, you will see some responses delineate between support jamming and self-protection. Others will describe stand-off vs. stand-in, escort, modified escort, and mutual protection.

The next column lists the jammer's operational frequency range. Some surveillance radars, for instance operate in the lower portions of VHF band, while others can go up to approximately 6 GHz. This is a wide frequency range for just one type of radar. As radar technology evolves, the frequency for each type of radar is expanding and jammers must follow suit.

The next column describes installed receiver sensitivity, which defines the ability of the radar jammer's receiver to detect the radar signal and provide necessary jamming techniques. Lower installed sensitivity generally translates into greater detection range. Because a support jammer usually operates outside of a threat's lethal range, the ESM receiver typically requires more sensitivity to detect the radar signals. Note that sensitivity has to be balanced with the jammer ERP to prevent interference between the jammer's receive and transmit paths.

ERP, or effective radiated power, defines the jammer's maximum output power. The ERP of a self-protection jammer is usually lower than the ERP of a support jammer. With the advent of GaN-powered ASEAs, which can generate more power in multiple tighter beams that can be quickly steered toward multiple radars, the distinction between support jammers and self-protection jammers is beginning to blur. The last few columns describe the size, weight, and additional features of each radar jammer.

Our next survey in the September *JED* will cover RF tuners for EW and SIGINT applications.

NEXT GENERATION JAMMER TESTING

Ultra-wideband signal analysis and systems performance evaluation.

Test challenges for advanced and integrated jammer designs

The design of advanced jammers plays a central role in providing vital protection for modern military system platforms, as they face a multitude of radar threats spreading over a wide frequency range and are, nowadays, agile in most of their operational parameters. In order to check the correct parameters of the used jamming and deception techniques, interoperability with other subsystems like radar warning receiver systems (RWR) or tactical air navigation systems (TACAN) has to be ensured. In addition, since an imminent threat is often a combination of different emitters (e.g. early warn, target acquisition, target track/illumination and missile guidance radars), different parts of the electromagnetic spectrum have to be tested at the same time.

The art of radar simulation and signal generation

To verify the parameter set of an electronic countermeasure (ECM) technique, multiple-domain analysis is crucial. The threat radar or the full scenario can be simulated with vector signal generators, the R&S®SMW200A. An example for an ECM may be a sophisticated coherent range gate pull-off (RGPO) with range-Doppler matching, which emulates one or more moving false targets and aims at achieving a break lock of the threat radar. The original radar pulse is used as reference for the ECM. To measure the position of the cover pulse, the hook and the dynamic behavior of the RGPO pulse, time domain analysis is necessary. In parallel, in the frequency domain, it needs to be evaluated whether movement of the false target also inherits the corresponding Doppler behavior. Majority of modern radar systems use matched filtering and pulse compression, so the retransmitted false targets have to maintain coherence with the original signal. Otherwise, they will lose in processing gain compared to the original signal and will be ineffective. For frequency agile radars (pulse-to-pulse or burst-to-burst), the DRFM should follow that agility, so an RF hopper analysis over a relatively wide bandwidth may be necessary. It may be noteworthy that lab testing only verifies the correct settings of an ECM technique, not its effect on a radar system. For that, it is necessary to do an evaluation of a live threat system.

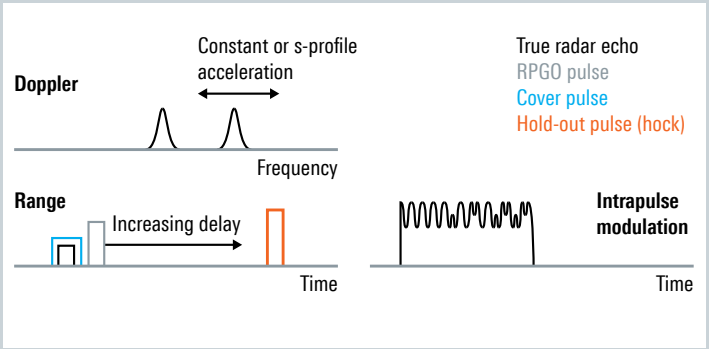

Figure 1 Domains tested for a coherent RGPO deception technique

Webinar: Deceptive jammer/DRFM testing

Rohde&Schwarz offers cutting edge test and measurement solutions for verifying proper operation and timing of the deception techniques on the system level, qualifying individual components, submodules and modules at the RF/IF level, as well as addressing clock jitter and power integrity early, at the design stage.

Watch our webinar at: **www.rohde-schwarz.com/DRFMJammerTesting/webinar**

Ultra-wideband signal analysis. Needed today, more than ever.

In order to analyze these scenarios in the lab, a wide frequency band has to be captured and saved covering different radar emitters at the same time. A multistandard radio analyzer mode enables users to have a detailed look at different frequencies by resampling the whole capture buffer and to analyze how all these systems interfere with each other or what frequencies are covered by frequency agile systems. The R&S®FSW signal and spectrum analyzer is able to capture a wide signal from the RF frequency of 8.3 GHz up to 90 GHz in just one box.

The data can be saved and analyzed by software tools running on an external computer or by internal tools like the multistandard radio analyzer in combination with different application software. The analyzer offers the tools needed to analyze hopping sequences of frequency agile radar systems or to characterize pulses or pulse compression techniques as well as tools for analysis of digitally modulated signals.

All models of the R&S®FSW from 26 GHz and above support up to 2 GHz internal analysis bandwidth, models from 43 GHz and higher frequencies offer the 8.3 GHz internal bandwidth for this application. Internal memory options up to 24 Gsamples/s make a capture time of several seconds possible at a bandwidth of 1 GHz. If longer sequences are needed, signals with bandwidths up to 512 MHz can be streamed over the I/Q interface and sequences up to 40 minutes can be recorded, for example by the R&S®IQW wideband I/Q data recorder. With smaller bandwidths, the sequences can be significantly longer. For example, users can measure real-world scenarios in the field and use a signal generator to feed in a realistic environment in a lab scenario.

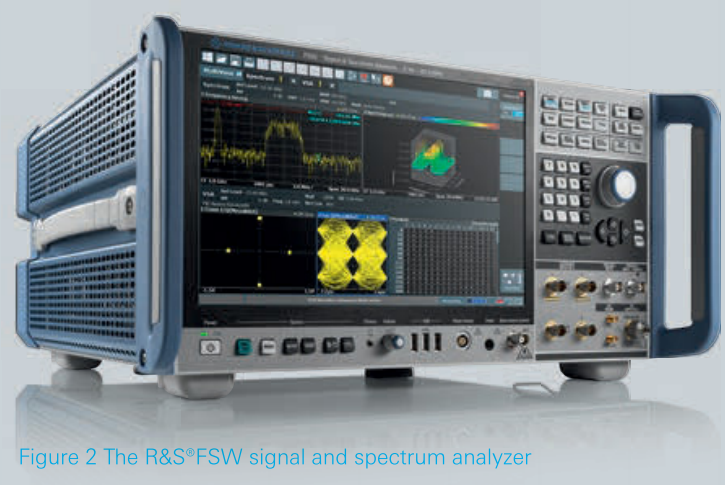

Figure 2 The R&S®FSW signal and spectrum analyzer

In addition, for the development and characterization of frequency agile radar systems and communication solutions, it is essential to acquire and process signals seamlessly, detect extremely short signals with a frequency mask trigger without interruptions. This is only possible with a real-time signal analyzer calculating up to 2 million spectra per second. The R&S®FSW signal and spectrum analyzer offers a real-time analysis with a bandwidth 800 MHz. The fast Fourier transform (FFT) length is adjustable between 32 and 16,384 to achieve different resolution bandwidths. Signals as short as 0.46 µs are detected with correct signal level with a probability of intercept (POI) of 100 %, and signals lasting only a few nanoseconds are still reliably detected but not necessarily with correct signal level.

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- 500 MHz I/Q data streaming interface to capture real-world scenarios
- Low phase noise of –140 dBc (1 Hz) at 10 kHz offset, –143 dBc at 100 kHz offset (1 GHz carrier)
- SCPI recorder simplifies code generation
- Multiple measurement applications like pulse and hopping analysis can be run and displayed in parallel

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For more information, visit:
www.rohde-schwarz.com/DRFMJammerTesting

RADAR JAMMERS

MODEL	HOST WEAPONS PLATFORM	CONFIGURATION	JAMMER ROLE/ FUNCTION	FREQ RANGE	SENSITIVITY
BAE Systems; Nashua, NH, USA; +1 603-885-6065; www.baesystems.com					
AN/ASQ-239 Electronic Warfare/ Countermeasure System	F-35 A/B/C Lightning II	Internal	Offensive and self-protection	*	*
AN/ALQ-250 Eagle Passive Active Warning Survivability System (EPAWSS)	F-15E Strike Eagle	Internal	Self-protection	*	*
AN/ALQ-239 Digital Electronic Warfare System (DEWS)	F-15 platforms	Internal	Self-protection	*	*
AN/ALQ-251 Radio Frequency Cpuntermeasures (RFCM)	AC/MC-130J	Internal	Self-protection	*	*
Elbit Systems EW and SIGINT - Elisra; Bene Beraq, Israel; +972-3-6175411; www.elbitsystems.com/elisra					
Light SPEAR™	*	Internal	Self-protection, support jammer, stand off, stand in	*	*
SPJ-20V5	*	Internal	Self-protection	*	*
ALQ-903	*	Pod	Self-protection, support jammer, stand-in	*	*
SPJ-20G	*	Internal	Self-protection	*	*
Advanced Tactical Air-Launched Decoy (ATALD)	Aircraft	Expendable active decoy	Stand-in decoy	*	*
Elettronica S.p.A; Rome, Italy; +39 06 41541 ; www.elt-roma.com					
IEWS (v)12	Combat SAR Helicopter	Internal RWR/ESM/ ECM integrated system	Self-protection	C-J bands (RWR/ ESM); H-J bands for jamming	High
IEWS(v)8	Ground application	Internal RWR/ESM/ ECM integrated system	Mutual protection	D-J bands (RWR/ ESM/ECM)	Very High
JNU	Naval application	Internal ECM system	Self-protection	H-J bands	Very High
EDGE	Fighter aircraft	Podded RWR/ESM/ ECM integrated system	Escort/modified escort	C-J bands (RWR/ ESM); H-J bands (self-protection and/or mutual protection); C-G bands for jamming (mutual protection)	Very High
SPARK	Airborne applications	Expendable active decoy	Self-protection	X, Ka	*

ERP	SIZE (HxWxL inches/mm/cm)	WEIGHT	FEATURES
*	*	*	Its advanced technology optimizes situational awareness while helping to identify, monitor, analyze and respond to threats. Advanced avionics and sensors provide a real-time, 360° view of the battlespace, maximizing detection ranges and giving pilots evasion, engagement, countermeasure and jamming options.
*	*	*	Fully integrated with radar warning, geo-location and increased chaff and flare capability, EPAWSS detects and defeats surface and airborne threats in signal-dense and highly contested environments.
*	*	*	The AN/ALQ-239 DEWS integrates its receiver, digital radio-frequency memory jamming, and countermeasures dispenser with the aircraft central computer and radar.
*	*	*	The AN/ALQ-251 helps detect, identify, locate, deny, degrade, disrupt, and defeat threats in the battlespace and beyond a pilot's line of sight.
Transmitter dep. (selectable)	195 x 127 x 345 mm	11 kg	Unified ESM & ECM solution, embedded into a single compact LRU; advanched technology of Digital receivers and RF Memory (DRFM).
Transmitter dep. (selectable)	175 x 164 x 300 mm	12 kg	*
Transmitter dep. (selectable)	590 x 864 x 3628 mm	180 kg	*
Transmitter dep. (selectable)	175 x 164 x 300 mm	12 kg	*
*	*	170 lb	Generates multiple false targets; 18 min. low altitude endurance; 35-min. igh-altitude endurance; max. cruise altitude 20k ft.
*	*	120 kg	High-accuracy direction finding in order to improve the DOA accuracy; high sensitivy search with the aim to improve the sensitivy of the system in order to detect LPI threats.
*	*	1000 kg	Functionalities and jamming under operator control; integration with ground-based command and control.
*	*	750 kg	Countermeasure for self-protection purposes; scalable configuration for several types of naval platforms.
*	*	400 kg	Multi-platform coordination based on mission preparation and planning; ELINT functions and emitter geolocation. High-sensitivy earch with the aim to improve the sensitivy of the system in order to detect LPI threats.
*	2x1x8 in.	250 g	DRFM-based architecture, programmable techniques in time and frequency, compatible with on board countermeasure dispensing system.

RADAR JAMMERS

MODEL	HOST WEAPONS PLATFORM	CONFIGURATION	JAMMER ROLE/ FUNCTION	FREQ RANGE	SENSITIVITY
HENSOLDT Sensors GmbH; Woerthstraße, Ulm, Germany; +49 731 392-0; spectrumdominance@hensoldt.net					
Kalaetron Attack (in development)	Business jet, figther, large body A/C	Pod or internal	Stand-off jammer; escort jammer; self-protection jammer	*	*
MFJS – Multi-Frequency Jammer System	Business jet	Pod or internal	Airborne training and target simulation; testing of radar system vulnerability to ECM	*	*
JamGen	Fixed and mobile ground plattforms	19-in. rack for integration into platform or labratory use	Ground-based training and target simulation	*	*
IAI Elta Systems Ltd; Ashdod, Israel; +972-8-857-2415; www.iai.co.il					
ELL-8212 ELL-8222	Fighter aircraft	Pod	Self-protection jammer	*	High
ELL-8222SB	Fighter aircraft	Pod	Self-protection jammer	*	High
ELL-8251SB	Fighter aircraft	Pod or internal	Support jammer	*	High
ELL-8256SB-Ground	Mobile platform	Ground Installation	Land based jamming system	*	High
Indra; Madrid, Spain; +34-91-480-50-01; www.indra.es					
ALQ-500P	*	Pod	Self-protection, support jammer	2-18 GHz	*
Rigel EA System	Ship	Internal	Point defense; area protection	6-18 GHz	*
L3Harris Technologies; Melbourne, FL, USA; www.L3Harris.com/ew					
ALQ-254 Viper Shield	Aircraft	Pod or internal	Self-protection, support jammer	*	*
ALQ-214 IDECM	Aircraft	Internal	Self-protection, support jammer	*	*
ALQ-211	Aircraft	Pod or internal	Self-protection, support jammer	*	*
Disruptor SRx	Aircraft, Unmanned, Munitions	Internal	Electronic attack / electronic support for small platforms	*	*
Naval Decoy Jammer	Maritime	Expendable	Self-protection	*	*

ERP	SIZE (HxWxL inches/mm/cm)	WEIGHT	FEATURES
*	Platform dependent	Platform dependent	GaN AESA technology; Artificial Intelligence technology.
*	270 (L) x 60 (W) x 40 (H) cm	280 kg	The level can be adapted to the skills of the radar operator and modified during the training mission.
*	19-in. industry standard rack	Config. dep.	A multi-bit DRFM forms the core of the system providing a broad ECM techniques toolbox including coherent and non-coherent ECM techniques.
*	24.38 x 19.30 x 243 cm	~100 kg	Small, lightweight, low-drag pod conformed to the shape of an A/A missile; automatically scans, detects, identifies and jams enemy radars in both forward and aft directions.
*	24.38 x 19.30 x 243 cm	~100 kg	Includes an autonomous receiver to perform threat detection and identification; ECM techniques are dynamically allocated, based on detected threats; uses high-ERP Active Phase Array directional GaN transceivers equipped with high gain narrow beam antennas employing fast beam-steering.
*	Pod - 300 gallon	~600 kg; based on configuration	An advanced Active Electronically Scanned Array (AESA) transceiver directs high ERP beams towards the targets; system engages numerous targets simultaneously through multi-beam and fast time-sharing capabilities.
*	Config. dep.	~300 Kg; based on configuration	A land-based jamming system that provides advanced wideband RF ECM detection and jamming capabilities against modern radars; uses an advanced Active Electronically Scanned Array (AESA) to detect, direction find, and point the high-ERP jamming beams toward the targets; the system achieves high-power directional multi-jamming beams to achieve multi-target jamming.
*	330 x 34 x 48 cm	284 kg	Multiple techniques (SJAM, BJAM, NCP, HDT, RGPO, RGPI, RANRAP, VGPO, VGPI, SVGPO, VN, VFT); multi-threat (up to 8 simultaneous threats) capability.
Up to 500W	*	1,356 kg (incl. 2 ant.)	Integrated with Rigel ES system; multiple noise and deception jamming techniques; opt. frequency extension 0.4-2 GHz or 2-18 GHz.
*	*	*	Next-generation digital EW system for advanced F-16 Block 70/ Block 72.
*	*	*	Naval carrier-proven EW system protects F/A-18 Hornet and Super Hornet (F/A-18C/D/E/F variants).
*	*	*	Multiple versions within ALQ-211 family of systems, protecting F-16 fighters, CV-22 tilt-rotors, and MH-47 / MH-60 helicopters.
*	23 x 51 x 102 mm	0.45 kg	Small form factor EW for various platforms, including unmanned aircraft and munitions; also used for augmenting existing EW systems.
*	*	*	Naval decoy EW payload technology, protecting various maritime platforms.

RADAR JAMMERS

MODEL	HOST WEAPONS PLATFORM	CONFIGURATION	JAMMER ROLE/ FUNCTION	FREQ RANGE	SENSITIVITY
Leonardo; Luton, Bedfordshire, UK; +44 1582 886000; www.leonardocompany.com					
BriteCloud 55	All military platforms	Expendable	Self-protection	H-J	high
BriteCloud 218	All military platforms	Expendable	Self-protection	H-J	high
BriteCloud 55T	All military platforms	Expendable	Self-protection	H-J	high
Compact Jamming system	All military platforms	Internal, podded or pylon	Self-protection	E-J	high
My-konsult System AB; Stockholm, Sweden; +46 703 44 03 50; www.Mykonsult.com					
Astor IV	Aircraft	2 cooperating pods	Electrotic attack and training	C - J/Ka band	65-70 dBm
Astor III (V)	Aircraft, ship, ground platforms	Internal	Self-protection, support jamming, training	C - J/Ka band	65-70 dBm
Northrop Grumman; Linthicum, MD, USA; +1-847-259-9600; www.northropgrumman.com					
SEWIP Block 3 AN/ SLQ-32(V)7	Ship	Internal	Self-protection	*	*
ALQ-131(V)	Aircraft	Pod	Self-protection	*	*
Rafael; Haifa, Israel; +972-4-879-4444; www.rafael.co.il					
Sky Shield	Aircraft	Pod	Support jammer	1-18 GHz	-70 dBm
Lite Shield	Aircraft	Pod	Self-protection / escort jamming	2-18 GHz	-65 dBm
Green Shield	Aircraft	Pod	Self-protection	D to G bands	*
C-GEM	Ship	Active Decoy	Self-protection	*	*
Raytheon; El Segundo, CA; +1 805-967-5511; www.raytheon.com					
Miniature Air Launched Decoy-Jammer Payload	Aircraft	Expendable decoy	Stand-in	*	*
Next Generation Jammer - Mid Band	Aircraft	Pod	Stand-off	*	*
Rodale Electronics, Inc.; Hauppauge, NY; +1 631-231-0044; www.rodaleelectronics.com					
AN/ALQ-167 Jammer	*	Pod	Training	Selected bands w/in .05-10.5 GHz	*
Saab; Linköping, Sweden; +46 13 18 00 00; www.saab.com					
Arexis Fighter Integrated ECM	Aircraft	Internal	Self-protection	1-18 GHz	*
Arexis SPJ Pod	Aircraft	Pod	Self-protection	1-18 GHz	*

ERP	SIZE (HxWxL inches/mm/cm)	WEIGHT	FEATURES
Low	55 (dia) x 200 (length) mm	1.1 kg	DRFM; rapid response; mission reprogrammable.
Low	2 x 1 x 8 in.	0.52 kg	DRFM; rapid response; mission reprogrammable.
Med	55 (dia) x 200 (length) mm	1.1 kg	DRFM; rapid response; mission reprogrammable.
Med	200 x 125 x 400 mm + MPM and antennas	from 15 kg	Compact and advanced DRFM; offered as F-16 ECIPS pylon fit; configurable ERP and Field of View.
Min 200W / band	3245 x 426 cm; 14- and 30-in. lugs per pod	Max 195 kg /pod	ITAR free, Dual DRFM/band, ES, Treath Emitter Simulation.
200W + +/ band	Rack mounted	150 - 250 kg	ITAR free, dual DRFM/band, ES, threat emitter simulation.
*	*	*	Upgrade to SLQ-32; entered LRIP in 2019
*	*	*	Flown on F-16s and A-10s; recent digital upgrade
High ERP	380 x 56 x 86 cm	650 kg	Solid state steered array; fully autnomous and accurate jamming against several targets, includes accurate direction finding; one certified pod contains entire system.
High ERP	200 x 40 (dia) cm	200 kg	Solid state steered array; fully autnomous and accurate jamming against several targets, includes accurate direction finding; one certified pod contains entire system.
High ERP	200 x 40 (dia) cm	220 kg	Provides self-protection against search and acquisition radars; based on digital and solid-state technologies; DRFM TG.
*	*	*	Wideband frequency coverage; fits all 110- and 150 mm decoy launching systems; 360 deg spatial coverage; solid-state electronic beam steering array
*	*	*	Maneuvering active decoy
*	*	*	Support jamming pod for EA-18G Growler
4-8 kW	350 x 26 cm	175 kg	Noise, deception, coherent techniques.
*	*	*	GaN AESAs; wideband DRFM; ultrawideband digital receivers; extensive recording capabilities; central processing unit with Ethernet interface.
*	0.38/0.46 x 4 m	Version dependent, ~ 300 kg	GaN AESAs; wideband DRFM; ultrawideband digital receivers; extensive recording capabilities; possible to operate in autonomous mode.

RADAR JAMMERS

MODEL	HOST WEAPONS PLATFORM	CONFIGURATION	JAMMER ROLE/ FUNCTION	FREQ RANGE	SENSITIVITY
Saab; Linköping, Sweden; +46 13 18 00 00; www.saab.com *cont'd.*					
Arexis EA Pod	Aircraft	Pod	Electronic attack / escort jammer	0.15-4 GHz	*
Systems & Processes Engineering Corporation (SPEC); Austin, TX, USA; +1 512-479-7732; www.spec.com					
ADEP™ Active Expendable	Aircraft	Expendable cartridge	Self-protection, support jamming	Fixed frequency in the range 2-18 GHz	40 dBm
ADEP™ Blade	Aircraft, ground mobile, manpack	Pod, Internal	Self-protection, support jamming	Tunable 20-3600 MHz	40 dBm
ADEP™ T4000	Aircraft, ground mobile	Pod, Internal	Self-protection, support jamming	Fixed 2.3 GHz, 5.7 GHz, Tunable 8-18 GHz	30 dBm
ADEP™ T4000 Ultra	Aircraft, shipboard, ground mobile	Pod, Internal	Self-protection, support jamming	Tunable 100 MHz – 18 GHz	60 dBm
Thales Airborne Systems; Elancourt CEDEX, France; +33 (0) 1 34 81 60 00; www.thalesgroup.com					
PAJ-FA (Podded Airborne Jammer)	Aircraft	Pod	Self-protection	H to J bands	*
HBJ (High Band Jammer)	Aircraft	Internal	Self-protection	H to J bands	*
SPECTRA	Rafale	Internal	Self-protection	G to J bands	*
Scorpion 2	Ship	Internal	Point defense; area protection	7.5-18 GHz	*

SURVEY KEY – RADAR JAMMERS

MODEL
Product name or model number

HOST WEAPONS PLATFORM
Indicates which types of aircraft, ships, etc. carry the jammer

CONFIGURATION
Jammer configuration (Internal, pod or both)

JAMMER ROLE/FUNCTION
Type of radar jammer (self protect, support jammer, etc.)

FREQ RANGE
Operating frequency range (in GHz)

SENSITIVITY
Typical receiver installed sensitivity

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

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

WEIGHT
Weight in kg

FEATURES
Additional features

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

SEPTEMBER 2020 PRODUCT SURVEY: SIGINT TUNERS

This survey will cover standalone RF and microwave tuners for COMINT and/or ELINT applications. Please e-mail the editorial team, JEDEditor@naylor.com, to request a survey questionnaire.

ERP	SIZE (HxWxL inches/mm/cm)	WEIGHT	FEATURES
*	0.36/0.46 x 4 m	350 kg	Fwd and aft coverage with GaN AESAs; wideband DRFM; ultrawideband digital receivers; VHF/UHF capabilities; side coverage optional.
Config. dep.	1 x 2 x 8 in.	< 1 lb	Expendable Target Generator/Active Emitter; 500 MHz IBW, 12-bit ADC/14-bit DAC; ultra-low latency.
Config. dep.	7.9 x 0.89 x 5 in.	< 2 lb	Tactical Complex Target Generator; 1-128 MHz adj IBW; 16-bit ADC/16-bit DAC; ultra low latency.
Config. dep.	3 x 5.5 x 11.9 in.	7.5 lb	Tactical Complex Target Generator, 1400 MHz IBW, 12-bit ADC/12-bit DAC, Ultra low latency.
Config. dep.	3U VPX, 3 slots per channel	4 lb	Tactical/Simulator Complex Target Generator; 100 MHz -1000 MHz IBW; up to 14-bit ADC/14-bit DAC.
*	135 x 6.3 (dia) in.	85 kg	In service on Mirage-F1 and Super Etendard.
*	*	62 kg	In service on Mirage 2000.
*	*	*	In service on Rafale.
100W typ.	*	*	In service with 20 navies; DRFM-based techniques generator; various noise and deception techniques.

Many EW companies are offering support jamming pods for integration onto multi-role fighter platforms. Above, a US Navy EA-18G Growler aircraft assigned to Electronic Attack Squadron (VAQ) 131 takes off during Red Flag 20-1 at Nellis Air Force Base, NV. It carries three ALQ-99 jamming pods.

US AIR FORCE PHOTO BY AIRMAN 1ST CLASS DWANE R. YOUNG

EMSO CFT Workforce Study Underway to Grow EMS Capabilities Department-Wide

By CDR Shelly Frank

As Electromagnetic Spectrum technologies have proliferated globally, the operational-technological dominance once enjoyed by the US military has waned, forcing greater emphasis on how the users of EMS technologies – the people of the EMS workforce – employ, design and integrate their skills to achieve EMS Superiority. The 2017 National Security Strategy states, "Our task is to ensure that American military superiority endures, and in combination with other elements of national power, is ready to protect Americans against sophisticated challenges to national security." To accomplish this requires the Department of Defense (DOD) and the Joint Force to maintain a skilled, comprehensive and enduring EMS Professional cadre that can adapt to meet the challenges of a contested and congested operating environment, as well as adjust resources to meet dynamic mission requirements. Yet, this area represents a significant weakness for the Department. While the traditional Electromagnetic Warfare and Spectrum Management communities possess the core expertise for achieving EMS control, the current disaggregated composition of the force prevents the Department and the Joint Force from integrating joint EMS functions necessary to achieve and maintain EMS control.

The DOD has recognized the need to integrate core EMS disciplines across the Department to fix the lack of operational synergy. To tackle this task, the Secretary of Defense-empowered Electromagnetic Spectrum Operations Cross Functional Team (EMSO CFT) is conducting a year-long workforce study to understand, optimize and maintain competent EMS professionals. In a world marked by peer and near-peer competitors seeking control of the Spectrum, these EMS professionals are critical to achieving and sustaining EMS superiority against US adversaries.

IDENTIFYING A DISTRIBUTED WORKFORCE

The greatest challenge facing the EMS workforce is its distributed nature. The current organization of the DOD's EMS enterprise does not permit the United States to effectively compete in the Electromagnetic Operational Environment (EMOE). According to a March 2019 Institute for Defense Analysis (IDA) study, "EMS responsibilities are spread across the OSD, the Joint Staff, the COCOMs, the military services and the defense agencies. The multiplicity of accountable officials and organizations mean that, in practice, nobody is accountable for addressing the EMS as whole."

Another critical challenge is the Department's EMS complement is not well-defined. At present, there is no consistent definition of what an EMS professional is or how the proficiencies at the community level are maintained; for example, job classifications across components are inconsistent, training varies widely, and there is no shared model of expectations, interests, processes or objectives. This lack of a well-defined EMS complement, coupled with the lack of understanding on how to leverage proficiencies from complementary EMS functions, exacerbates the fragmented nature of the force.

In many respects, this inconsistency is understandable given the role of each Service to man, train and equip its forces. There are skilled practitioners across the Department in traditional Service-specific Electromagnetic Warfare and Spectrum Management roles who possess deep core expertise for EMS control. However, it is also critical to integrate EMS-related functions within the Intelligence, Space, Cyber, Communications, and Science and Technology communities to adequately scope the EMS professional workforce. Because the EMS is the one entity shared across all domains, the EMS workforce requires greater integration of effort and coordination of purpose. As the IDA study identified, "the lack of a cohort of operators and planners skilled in all aspects of EMS operations" creates unsustainable risks to missions, materiel and personnel.

REBUILDING THE EMS WORKFORCE

Driven by the demand for greater visibility into the full range of skills and talents of each individual EMS professional, the EMSO CFT workforce team launched a year-long, in-depth workforce study of the EMS enterprise. The study will:

Analyze workforce data from across the DOD and build a detailed assessment of the current EMS Workforce across all Services and Agencies, providing the first holistic understanding of EMS professionals for the Department;

Deliver a competency model that identifies the skills EMS professionals will need for the future of warfighting and identify the largest skill gaps across the Department;

Create an education framework for EMS professionals to target the expected skill gaps in the future and standardize EMS training across the Department; and

Establish a living five-year implementation work plan including considerations for how to integrate EMS professionals across the Department.

The results of this study will establish a way-ahead for EMS professionals within the workforce, helping DOD to organize, develop and implement essential reforms to the EMS enterprise. The results of this study will also contribute to ensuring continuity in the workforce by establishing a Department-wide EMS certification program that lays the foundation for service-specific EMS qualification standards.

ALL HANDS ON DECK

An essential element of the EMS workforce study is the engagement with EMS stakeholders to understand the ground truth on the shape, scope and complexity of the broader EMS enterprise. To do this, the EMS workforce study includes a series of EMS summits to engage leaders, gain perspective and align efforts across the Department. These summits bring together key personnel and stakeholders across the Department and provide a platform for input to shape the composition of the future EMS workforce.

The first summit, conducted in Washington, DC, in November 2019, identified the functions that differentiate EMS professionals from the broader community of the EMS workforce or EMS users and began an initial review of the skills needed to differentiate the EMS professional. Input from this event formed the foundation of the EMS workforce study.

From November 2019 through June 2020, the study evolved as EMS stakeholders were further interviewed and Service-specific manpower data was reviewed to identify the billets with EMS professional responsibilities. This in-depth analysis – the first of its kind within the EMS community – identified a substantial body of EMS professionals across the department, including officers, enlisted personnel and civilians.

Despite COVID-19 pandemic restrictions, the second series of virtual summits occurred in June 2020 to validate the manpower findings, confirm the definition of an EMS professional, and align billets to seven EMS communities to better understand how these individuals contribute to EMS superiority.

These first two virtual summits have established the conditions for three additional summits throughout the next nine months to further refine and develop the EMS complement across the Department.

A FOUNDATION FOR THE FUTURE

The EMS workforce study is the first step to assess, engage and build the professional workforce needed to sustain EMS superiority in the "Future of Warfare." Adversaries view EMS Operations as a force-equalizer that can provide opportunities to cripple US operational superiority with a fraction of the military spending. Through the EMS workforce study, the Department will build a more professional, effective and lethal fighting force – one that is properly organized and resourced. This skilled cadre of professionals – influenced by a common set of capabilities, education and culture – will better leverage technological innovation; work with Joint, interagency, multinational and private sector partners; and generate decisive and sustained US military superiority in the EMS. In short, the establishment of an EMS professional workforce is critical to the Department's ability to respond to a complex and uncertain future, to ensure American military superiority and to protect Americans against sophisticated challenges to national security.

CDR Shelly Frank is the US Navy representative to the Electromagnetic Spectrum Operations Cross Functional Team (EMSO CFT). She leads the workforce study initiative.

EMS WORKFORCE STUDY: APPROACH & METHODOLOGY

EMS Professional Organizing Framework

This assessment focuses on EMS Professionals across seven core communities that are associated with the EMS related functions required to obtain EMS superiority.

EMS PROFESSIONAL:

- ✓ Select personnel that have EMS certifications and accreditations
- ✓ Achieved and maintained a demonstrated standard of expertise in EMS-related core skill(s)
- ✓ Personnel with positions and skills that rely on EMS as a means and an ends
- ✓ Sustained by the EMS enterprise throughout their career (not any other enterprise)
- ✓ Responsible for planning, design, and coordination of maneuverability in the EMS

SEVEN CORE COMMUNITIES:

1.0 Electromagnetic Warfare	The planning and coordination of military actions involving the use of electromagnetic and directed energy to control the EMS or to attack the enemy. (i.e. EWO)
2.0 Electromagnetic Spectrum Management	The planning and coordination of the joint use of operations within the electromagnetic operational environment through operational, engineering, and administrative procedures. (i.e. Spectrum Manager)
3.0 Science & Technology	The operating, testing, and engineering required to explore, develop, and manage current and future EMS technologies, assess their military utility, and develop the most promising ones into key acquisition programs. (i.e. Radio Frequency Engineers, Capability Designers)
4.0 Intelligence	The collection, assessment, and planning of the battlespace with EMS tools and space systems dynamics and capabilities and the intel workforces that rely on the EMS for their job performance. (i.e., SIGINT, S&T All-Source Analysts, and Op Planners)
5.0 Space	The planning and coordination of the means for reliable and survivable sensing and communications in the Space domain. (i.e. all workforce, except those in orbital mechanics and IT)
6.0 Communications	The planning and coordination of radio designs, frequency planning, and signal propagation. (i.e. Radio Frequency Data Analyst, Radar Operator). Does not include IT or communications functions.
7.0 Cyber	The planning and coordination of systems that operationally use energy and data packets for effect.(i.e. Cyber-EW Officer). Does not include IT or communications functions.

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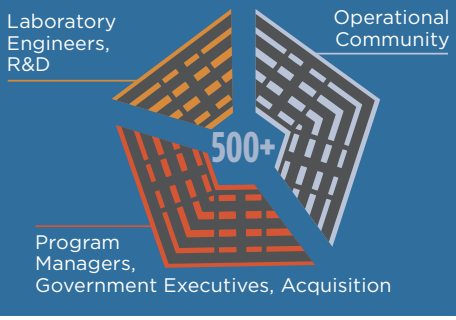

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July 31: Deadline for Abstract Submission

All-Domain Operations—Integrating Across the Spectrum

The importance of the electromagnetic spectrum cannot be over emphasized; it is the bedrock that supports the emerging concepts of all-domain operations, an integrated and synchronized application across all domains. Awareness of the spectrum, understanding its properties, its role in modern day operations, and the ability to command and control effects and operations within the spectrum are necessary to fully strategize, plan, and execute all-domain operations.

The dominance of the electromagnetic spectrum is foundational to successful all-domain operations.

ters for Disease Control and Prevention (CDC) and the World Health Organization (WHO). We are actively working precautionary measures to further reduce health risks at our events. The health and safety of our attendees,

Space EW (Part 21)

Down-Link Intercept

By Dave Adamy

This month, we will discuss the vulnerability of space links to intercepts by hostile ground-based receivers.

For this discussion, we will assume that the vulnerable satellite is in a circular orbit 300 km above the Earth. Its sub-vehicle point is at 100° East longitude and its latitude is 40° North. The intercepting site is on the Earth at 102°East longitude, 42° North latitude.

The satellite down link has a 100-Watt transmitter at 2 GHz. Note that this is just a calculation number; we don't care if any satellite has ever operated with this transmitter.

We will start by assuming that both the satellite down link and the intercepting station have isotropic antennas with 0 dB gain. Later, we will change these to directional antennas.

- There are several important values we need to calculate:
- What is the range from the satellite to the intercept site?
- What is the elevation of the intercept site from the satellite?
- What is the elevation of the satellite from the intercept site?

In an earlier EW 101 column (June 2016), we discussed spherical trigonometry. The following includes a few points from that detailed discussion. As before in this series, both spherical and plane triangles use capital letters for angles and lower-case letters for sides.

Figure 1 shows a spherical triangle on the Earth's surface formed by the North Pole, the satellite sub-vehicle point and the hostile receiving site. All three sides are pieces of great circle paths on the Earth's surface. In a spherical triangle on the Earth, the length of a side is stated as the geocentric angle between its end points. The dimension of an angle is the geocentric angle between the two planes on which the two adjacent sides are defined. Therefore, both the sides and the angles are expressed as angles.

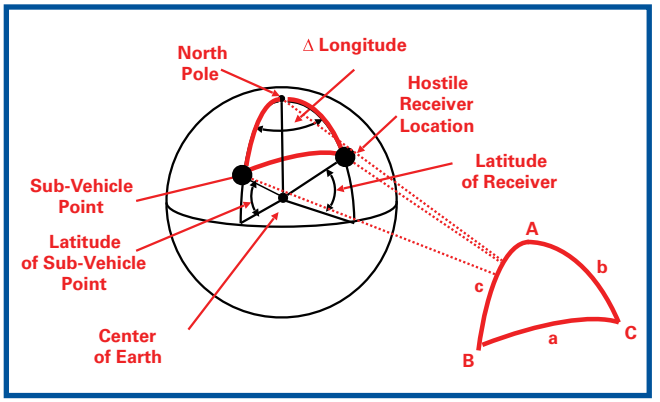

Fig. 1: *A spherical triangle is formed between the North Pole, the sub-vehicle point and the receiver location.*

Side a is the geocentric angle between the satellite sub-vehicle point and the intercept site. *Side b* is 90° – the latitude of the sub-vehicle point. *Side c* is 90°– the latitude of the intercept site. *Angle A* is the difference in longitude between the sub-vehicle location and the intercept site.

In **Figure 1**:

Side a = 90° - 40° = 50°
Side b = 90° - 42° = 48°
Angle A = 2°

The spherical law of cosines for sides is:

Cos a = (cos b)(cos c) + (sin b)(sin c)(cos A)
= (cos 50°)(cos 48°) + (sin 50°)(sin 48°)(cos 2°)
= (0.643)(0.669) + (0.766)(0.743)(0.999)
= 0.430 + 0.569 = 0.999

So *side a* = 2.828°

Now consider **Figure 2**. This is a plane triangle formed by the satellite, the center of the Earth and the intercept site. *Side d* is the range from the satellite to the intercept site. *Side e* is the radius of the Earth (R_E) plus the elevation of the satellite (H). *Side f* is the radius of the Earth. *Angle D* is the same angle we calculated as *Side a* in the spherical triangle of **Figure 1.**

Angle D is 2.828° (This is the same as *Side a* in the spherical triangle of Figure 1.)
Side e is 6,671 k

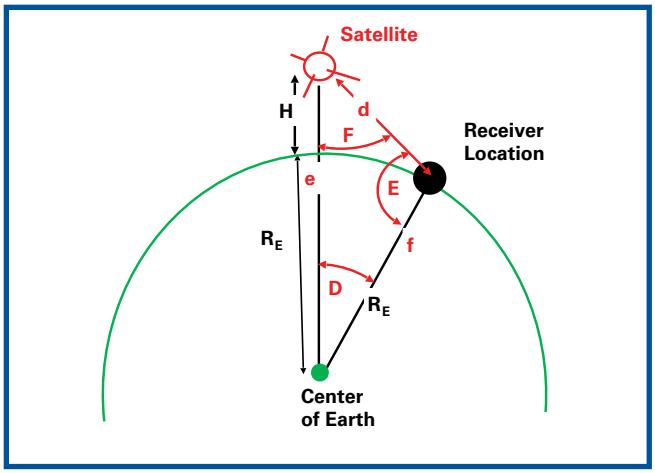

Fig. 2: *The propagation distance between a transmitting satellite and an intercept receiver on the Earth's surface can be calculated from the plane triangle formed by the satellite location, the receiver location, and the center of the Earth.*

Side f is 6,371 km

The law of cosines for sides in plane triangles is:

$d^2 = e^2 + f^2 - 2ef \cos D$

$= (6{,}671 \text{ km})2 + (6{,}371 \text{ km})2 - 2(6{,}671)(6371) \cos 2.828°$

$= 44{,}502{,}241 + 40{,}589{,}641 - 84{,}916{,}880$ km2

$= 175{,}002$ km2

$d = \text{sqrt}(175{,}002 \text{ km2})$

$= 418$ km

Continuing with Figure 2, we want to calculate the elevation from the satellite to the intercept site and the elevation angle from the intercept site to the satellite. We know *Side d* and *Angle D,* so we can use the law of sines for plane triangles.

$\text{Sin D} / d = \text{sin E} / e = \text{sin F} / f$

$\text{Sin E} / 6{,}671 = \text{sin } 2.828° / 418 = 0.04933/418 = 0.000118$

$\text{Sin E} = 0.000118 \times 6{,}671 = .7873$

but *Angle E* is greater than 90°, so Angle E (the elevation of the satellite above the center of the Earth) = 180° - 59.1° = 128.1°

The elevation of the satellite above the horizon viewed from the intercept site is 51.9°

$\text{Sin F} / 6{,}371 = \text{sin } 2.828° / 418 = 0.04933/418 = 0.000{,}118$

$\text{Sin F} = (0.000{,}118)(6{,}371) = .7518$

Angle F (the elevation of the intercept site above the center of the Earth) = 48.7°

Since this is a plane triangle, the three internal angles add to 180 degrees. However, we did some rounding of very large numbers, so these three angles add to 179.6 degrees. Be not afraid, the laws of physics prevail; without the rounding they would add to 180°

The Earth surface distance from the sub-vehicle point to the intercept site is given by the formula:

(Angle D/ 360°) (2π x radius of the Earth)

= (2,828°/360°) (2π x 6371 km) = 314.4 km

In next month's column, we will use two of these three numbers (link distance and elevation of the satellite above the horizon from the intercept site) in determining the intercept link performance.

IS THE SATELLITE ABOVE THE HORIZON FROM THE INTERCEPT SITE?

Now, consider **Figure 3**. It shows a plane right triangle made by the satellite, the horizon point and the center of the Earth.

Angle J is 90 degrees, it is the angle from the center of the Earth to the satellite as seen from the horizon point,

Angle K is the geocentric angle from the satellite to the horizon,

Angle M is the angle from the center of the Earth to the horizon as seen from the satellite,

Side j is the distance from the center of the Earth to the satellite (R_E+ H),

Side k is the direct distance from the satellite to the horizon, and

Side m is the distance from the center of the Earth to the horizon point (R_E)

Since this is a plane right triangle, side j^2 = side k^2 + side m^2

Side k = sqrt(side j^2 - side m^2)

= sqrt($6671^2 - 6371^2$) = sqrt(44,502,241 – 40,589, 641)

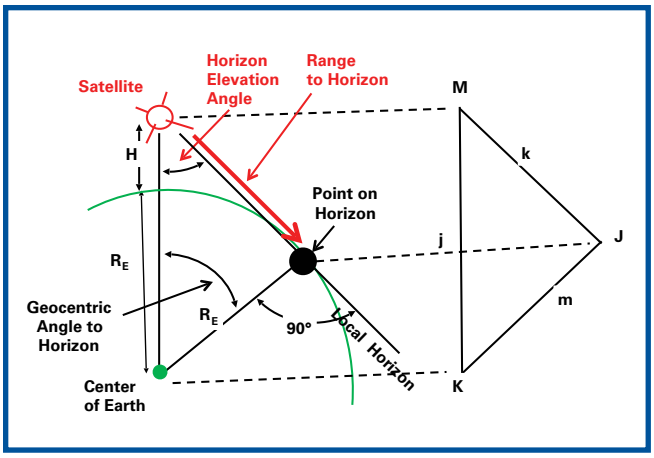

Fig. 3: *The range to the horizon from a satellite can be determined from the plane triangle defined by the satellite, a point on the horizon, and the center of the Earth.*

= sqrt(3,912,600)

= 1978 km

This is the signal path to the horizon, so the intercept site is well within the distance to the horizon.

Angle K can be found from the formula (based on the law of cosines for sides for plane triangles):

$\text{Cos K} = (j^2 + m^2 - k^2)/2jm$

$= (6671^2 + 6371^2 - 1978^2) / 2 \times 6671 \times 6371$

$= (44{,}502{,}241 + 40{,}589{,}641 - 3{,}912{,}484) / 85{,}001{,}882$

$= 81{,}179{,}398 / 85{,}001{,}882$

$= 0.955$

Angle K = acos(0.955) = 17.2°

The Earth surface distance from the sub-vehicle point to the horizon is given by the formula:

(Angle K / 360°) (2π x radius of the Earth)

= (17.2°/360°) (2π x 6371 km) = 1913 km

The intercept site is well within the horizon distance from the sub-vehicle point

HOW STRONG IS THE DOWN-LINK SIGNAL AT THE INTERCEPT SITE?

The Received signal, ignoring atmospheric, rain and polarization losses and several more important considerations, is given by the formula:

$P_R = \text{ERP} - (32.4 + 20 \log F + 20 \log d)$

Where: *PR* is the received signal power at the intercept site in dBm,

ERP = the effective radiated power from the satellite in dBm,

F = the link transmission frequency in MHz, and

d = the link distance in km

$P_R = 50 - 32.4 - 20 \log(2000) - 20 \log(418) = 100 - 32.4 - 66 - 52.4$

= -100.8 dBm

WHAT'S NEXT

Next month, we will significantly complicate this intercept problem by adding directional antennas, several more loss elements, signal modulation and receiver sensitivity. For your comments and suggestions, Dave Adamy can be reached at dave@lynxpub.com.

FAILURE IS NOT AN OPTION

Tektronix co-founder Howard Vollum, along with British and American engineers, developed a revolutionary, high-resolution radar system during WWII. Since then, Tektronix has been innovating in both the time and frequency domains. We've created advanced acquisition and simulation technology with bandwidths up to 70 GHz, utilizing the industry's most advanced measurement trigger systems.

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ASSOCIATION OF OLD CROWS

2020 AOC BOD Election Guide

Election runs October 1-31, 2020

Your participation is critical. Please exercise your right to vote for your AOC Board of Directors representatives.

You can familiarize yourself with the candidates with this election guide. This information describes the candidates' backgrounds, leadership styles and contributions to the AOC. The 2020 Nominating Committee carefully considered the impressive nominations it received before recommending this year's candidates. The slate of candidates was subsequently approved by the AOC Board of Directors. We are grateful to all of those who participated in this process and applaud those willing to submit their names for consideration.

Thank you for your continued support of AOC. Let your voice be heard by casting your vote for the new leaders of your association!

AT-LARGE

Vince Battaglia

Vince is a military design survivability expert with a long history of aerospace industry leadership and active AOC participation. With a 30-plus year track record of successfully leading military development programs and fielding operational systems, he has led several industrial defense organizations in the design, development and fielding of military technologies and systems. Vince is a long-time, dedicated supporter of the AOC with a proven work history of leading large and small, domestic and international companies, providing defense platform and space applicable Survivability technologies. He currently provides strategic growth guidance and education to organizations dedicated to engineering development and delivery of military defense operational capabilities. He provides participative direction for new business initiatives, product development, production and product support functions. Vince is currently President of the Greater Los Angeles AOC Chapter. Vince's professional experience is complemented by a bachelor's degree in electrical engineering, a master's degree in physics and business management.

Joe Koesters

Joe Koesters has been a manager and engineer for the Air Force Research Laboratory, Sensors Directorate, for more than 33 years. He has served in a variety of assignments, including branch chief, tech advisor and program manager. He is currently the Deputy Division Chief for the Spectrum Warfare Division.

Joe previously served on the AOC BOD from 2012-2018 and would like the opportunity to serve on the Board again. His previous experience as Treasurer (4 yrs) and Governance Chair (1 yr), combined with his experience as an Air Force civil servant, give him a unique blend of AOC corporate knowledge, experience and collaboration partnerships that will serve the AOC well moving forward.

As a director, Joe would advocate three focus areas for the AOC. The first is to maintain a strong financial posture for the organization, including positive budget margins and long-term infrastructure (people and facilities) financial planning. The second is to re-energize senior level EW advocacy in the US Government given recent position changes. The final focus area would be to reinstate a spirit of camaraderie and community within the AOC – a balance between electronic communications and face-to-face interactions.

LTC Gary M. Lyke

LTC Gary M. Lyke, USA, currently serves as the Operations Branch Chief at the Joint Electromagnetic Preparedness for Advanced Combat (JEPAC) at Nellis AFB, NV. Prior to his Joint assignment, he served as the Military Deputy and Chief of Operations, TCM-EW, Cyber Center of Excellence; the Chief of Cyberspace Electromagnetic Activities for the US Army Pacific (USARPAC); and as the Division Electronic Warfare Officer for the 25th Infantry Division at Schofield Barracks and 1st Armored Division in Iraq.

Lieutenant Colonel Lyke was commissioned as a Field Artillery officer upon graduation from the University of South Alabama in 1997. He holds a master's degree in civil engineering from the University of Missouri – Science and Technology.

Lieutenant Colonel Lyke became an AOC member shortly after joining the Electronic Warfare (EW) community in 2009. Since joining, he has served as an appointed director on the Board; assisted in establishing two AOC chapters, as well as a scholarship program; assisted in the coordination of the annual AOC STEM exhibit; and participated on various AOC committees. As a former president of the Diamond Head Roost, he assisted in the development and sponsoring of four AOC PACOM conferences. Gary currently serves on the AOC Board of Governors.

His goals as an At-Large Director include partner programs with industry and academic institutions; outreach to middle and high schools to encourage STEM; and support to partner associations, such as AFCEA.

Jeffrey Malone

Jeff is an experienced national security professional, having worked in the Australian Army, private, public and academia sectors. Currently, he is a Senior Analyst in the Defence Science and Technology Group, the science and technology agency of the Australian Department of Defence.

During his military service, he was intimately involved in the adoption of Information Operations (IO) as an operational concept by the Australian Defence Force (ADF). This included drafting the ADF's first joint IO doctrine, redesign of the ADF's joint IO staff course and designing the ADF's architecture for strategic IO. Currently, he teaches a Masters-level IO unit in the School of Engineering and Information Technology at the University of New South Wales (Canberra), and has published extensively on IO and related topics. He is Vice President of the Australian Chapter and was the Director for the Chapter's 2016 and 2018 conventions and 2019 symposium.

Jeff is standing for election to enhance the AOC's engagement in the IO field. IO is becoming an increasingly important element of warfighting, and it is critical that the AOC position itself to contribute to developments in this field. He believes that the highly successful Hawaii IO conference series – which entails collaboration between the local Chapter and a geographic combatant command – is a model that might be applied elsewhere within the US and internationally. Jeff believes it is vital that the AOC increase the effort it devotes to the IO field. Given his experience, expertise and achievements he believes that he is ideally situated to support the AOC in achieving this outcome.

COL (Ret.) Steven Oatman

Steve is running for the AOC Board of Directors following a 31-year career in the US Army, in which he served as an Enlisted Military Police Officer and as an officer in the Field Artillery, and as an Electronic Warfare Officer, and where he began his career as a Private/E-1 and retired as a Colonel/O-6. His extensive experience and background during peacetime and combat will enable him to assist the AOC with its efforts to expand the membership and the focus of efforts across all of the services. Having been one of the senior Electronic Warfare Officers in the US Army, Steve is continuously focused on increasing the personnel, readiness, and material capability within the US Army Operational and Tactical formations.

As a member of the AOC Board of Directors, Steve will bring that same determination, and focus on increasing the visibility and importance of EW across the services drawing on real world combat and peacetime experience to assist in achieving the AOC's overarching goals regarding all of the services' EW capabilities. Simultaneously, based on his background and experience, he believes he would add a crucial element to the AOC Board overall with regards to the US Army and ground EW that, while not missing on the board, is clearly underrepresented.

Col (Ret.) Greg Patschke

Col Greg "Patch" Patschke, USAF (Ret.), has 30 years of experience in the EW field. He brings a unique perspective, having worked on EW efforts for all of the military services, as well as in industry. During his 25 years in the Air Force as a career electronic warfare officer (EWO), he contributed to EW in multiple capacities: operations as B-52 EWO; test and evaluation of EW systems; Commander of the 36th Electronic Warfare Squadron; Combatant Command EW planner; USAF EW Requirements on the Air Staff; and lastly, a Brigade EWO for the Army during Operation ENDURING FREEDOM. Before he retired, Greg held the position of the Director for the Joint Electromagnetic Preparedness for Advanced Combat (JEPAC), USSTRATCOM. This joint EW unit was responsible for the advancement of EW by conducting operational assessments to determine vulnerabilities/capability gaps,

develop mitigation strategies, validate the solution and then migrate the solution to a service or Combatant Command. In this capacity, he engaged EW experts within government, academia and industry to solve the tough EW issues. After retiring from the Air Force, Greg worked multiple EW programs for Lockheed Martin and L3/Harris. He is currently the General Manager for Keysight Technologies, where he leads all of the company's radar, EW and space programs. Greg was on the AOC BOD from 2017 to 2019 and served on the EXCOM as the treasurer. Greg is an active AOC symposium presenter and received AOC Leadership Awards in 2014 and 2015.

Charles Quintero

Chuck feels fortunate to have had the opportunity in his 40-year career to have attended great schools like MIT and UPenn. He has had tremendous opportunity to continue his education from premier contractors like Lockheed Martin (legacy RCA), Harris (legacy ITT), Northrop Grumman (legacy Westinghouse), SRI International, and now the Johns Hopkins Applied Physics Lab, where he is starting his PhD work.

JHU-APL has really kindled his desire to do more to educate young engineers in signal processing aspects of EW and ELINT, and to expand the representation of Hispanics in AOC leadership. He wants to help provide outreach to under-represented groups and help guide people into the great engineering field of EW. Chuck loves the work AOC does in providing webinars, and he wants to help expand that into adjacent areas that help young engineers understand the fundamentals that lead into these technology areas.

Mike Ryan

Mike has been an EW professional for most of his Government/Industry career. He worked on electro-optic countermeasure programs in the '90's, and stood up PM CREW during OIF/OEF in the 2000's fielding tens of thousands of life-saving RCIED jammers that still operate effectively today. After Senior Service College, Mike led PM Electronic Warfare and Cyber as its senior civilian and architected the rebuilding of Army CEMA capabilities, which had severely declined since the end of the Cold War. He held several key leadership positions in PEO Intelligence, Electronic Warfare & Sensors (PEO IEW&S) throughout his career and understands the value of Electromagnetic Spectrum Operations and its game-changing effects. Today, he continues to work through those challenges as an EW professional in the Defense Industry. Mike's AOC experience makes him the ideal candidate, having served as the APG Susquehanna Chapter President, AOC At-Large Board of Director, AOC Northeastern Regional Director and is currently on the AOC EXCOM as the Director of Strategy. He stood up the popular CEMA Conference in 2015, which continues today as an AOC staple event. If elected, his focus will be on AOC's three primary tenets: Advocacy, Education and Support. Advocacy is critical in helping to influence policy, laws and budgets with respect to electromagnetic spectrum superiority. For Education, he plans to push for EW certified professionals and a sustainable global STEM program. For Support, he will focus on membership needs, increase outreach and support to our chapters, and focus on attracting young professionals who will be our future.

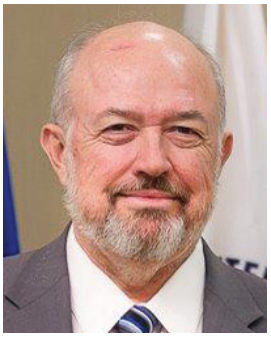
Air Marshal Daljit Singh, IAF (Retd)

Air Marshal Daljit Singh was commissioned in the Fighter stream of the Indian Air Force (IAF), in June 1976. During his 38-year career in the Air Force, he flew more than 3,400 hours on fighters, including the Gnat, Hunter, MiG 21, Jaguar, Su 30 and the Mirage 2000. He commanded a Mirage 2000 squadron and a major fighter base. During his career, he formulated EW operational doctrine, tactics and training curriculum for the IAF, and operationalized the modern EW suite of the Mirage Fleet. As Director of the IAF's EW Range, he organized an International EW Seminar, attended by renowned international EW Manufacturers, and he operationally evaluated EW systems of diverse fleets for integrated operations. At Air Headquarters, the Air Marshal Singh has held key staff appointments of Director EW Operations, Assistant Chief of Air Staff (Air Defence) and Director General (Air Operations). He retired in October 2014 as Air Officer Commanding-in-Chief of an Operational Command. He has been awarded with Presidential Awards for devotion to duty and professionalism of the exceptional order. The Air Marshal has been regularly participating in International EW and AD Seminars. He delivered the Keynote Address during the AOC-sponsored EW Asia 2019 Seminar and was the Guest Speaker during the Opening session of the EW Asia 2020. As an AOC member, the Air Marshal visualizes synergy in AOC International Regions to share experiences and expertise by cross participation. With more emphasis on Electromagnetic Spectrum Operations in the Indo-Pacific Oceanic Region, greater interaction would benefit the members in understanding the operational art and technological advances of the EW systems.

Col (Ret.) Steve Tourangeau

Col Steve "Tango" Tourangeau, USAF (Ret.), serves as president of the Granite State Roost. His AOC membership spans over 30 years, spawned by his assignment as an F-4 EWO. He graduated top in his class and earned the DO Trophy at EWO School. Tango's recognized EW expertise led to his selection as wing project officer and test navigator/EWO for Airlift Defensive Systems and Special Operations EW modifications to the C-141 fleet. Tango later transitioned to the 33rd Flight Test Squadron as Air Mobility Command's EW flight test director. Tango's passion for and commitment to the EW mission dramatically improved effectiveness and survivability of AMC aircraft and crews. Upon retirement in 2004, Tango took a position with MacAulay Brown (MacB), serving nine years as Director of EW Programs. He influenced and shaped compelling EW/EMS trends for HQ USAF, MAJCOMs and Air Force Materiel Command. Tango then took a position at BAE Systems managing business development with the research, development and acquisition communities at Wright Patterson AFB. Drawing from his experience, Tango and his wife Melinda founded Warrior Support Solutions, a woman-owned, veteran-owned, small consulting business providing EW/EMS Subject Matter Expertise. Tango has a unique perspective on providing EMS capabilities necessary to support the warfighter. As an AOC International Board member, Tango will continue to champion the criticality of EMS Operations in current and future conflicts and advocate for necessary capabilities for our warfighters. By improving communication, collaboration and coordination with chapters and general membership, the AOC will have tremendous influence on our future warfighters' ability to dominate the EMS.

NORTHEAST REGION



Nino Amoroso

In his over 36 years of involvement with the AOC, Nino has chaired various activities and committees, including symposia at the chapter, national and international levels. Nino has over 44 years of both operational and procurement, government and industry experience within the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), information operations and EW communities, where he has spearheaded new initiatives and directed the procurement of Air Force, Joint systems, special operations capabilities, counter-narcotics centers, coalition, command and control networks, aerial ground surveillance systems and the rapid acquisition of critical technologies. He has had government and corporate responsibility for the planning, identification and execution of programs within the C4ISR area, and has held government leadership positions up to the System Program Office and Division level. Nino has also represented corporate organizations to senior government and industry across many focus areas, including the US Air Force, the US Intelligence Community, Battle Management, Aerial Ground Surveillance Systems, Battle Control Systems, International C4ISR programs and Homeland Security (HLS). Nino holds a Bachelor of Arts degree from the Catholic University of America and a Master of Science degree from the University of Southern California. He is also a graduate of the Air War College, Federal Executive Institute, and programs within the Defense Intelligence College and Defense Acquisition University. In addition to military and civil service awards, he has received several AOC awards, including the Hal Gershanoff Silver Medal, Anton D "Tony" Brees Lifetime Service Award, and the Clark G. Fiester Command and Control Warfare Award.

Tuhin Das

Tuhin wants to serve the Northeastern chapters by enhancing communications, advocating for EW/EMSO and creating realistic goals for regional success. His vision is to inspire Young Crows and work with EW veterans to create innovative learning/networking opportunities. Tuhin has been a proud Young Crow for seven years and works for one of the most disruptive EW companies as the head of Global Business Development and Marketing. He is responsible for the EW Emulation and ELINT marketing campaigns that have gained worldwide attention.

In 2014, he was elected as the youngest president of an AOC chapter. He also served 10 nonprofits, and on November 25, 2019, he was presented the prestigious Good Business Award by the Sprott School of Business, Carleton University for his professional and philanthropic endeavors. By 2016, he revitalized the AOC Maple Leaf chapter and created programs that generated new revenues of $100,000. This was a result of a new partnership with the local university and bringing in Dave Adamy to teach his courses to the Canadian military. Tuhin led a series of well-attended AOC "lunch 'n' learns" and socials, and chairs the annual gala.

Tuhin plans to build a multi-chapter/regional group that brings value by launching high-profile networking and joint virtual sessions. For example, he helped the Maple Leaf chapter sign a charter with the Capitol Club in 2015. As a result, he co-

hosts the annual EW Industry Day at the Canadian Embassy in Washington, D.C., after the Annual Symposium. This attracts over 100 attendees from DOD, DND, Industry and Academia.

Col (Ret.) Myles Murphy

Myles has been a member of the AOC since 1989, during which time he has worked in the EW industry and served in the US Air Force. He had the honor to serve with the 913th AW at Willow Grove Air Reserve Station, PA, and the 512th AW at Dover Air Force Base, DE. He retired at the rank of Colonel. He was Vice President of the AOC Garden State Chapter for two years, then President for five years, and learned from other board members how to run an outstanding chapter. The Garden State Chapter did great things for the local community by teaching EW seminars, promoting STEM activities, funding a scholarship for local ROTC students, while also helping the Fisher House Foundation and disabled veterans in need. When he was President, the chapter was selected as Medium Chapter of Year in 2018 and 2019.

If elected Northeast Director, Myles would like to "pay forward" what he has learned in industry, as a military officer and as AOC chapter President, to help other chapters succeed. As a past chapter president, he has the experience to understand chapter challenges. He also has an excellent relationship with the staff at AOC Headquarters. He desires to work with local chapters and AOC Headquarters to develop a winning vision and strategy for the AOC for the future. He would love the opportunity to carry the mission and goals of AOC National to all the Northeast chapters while communicating the goals and needs of individual chapters back to AOC Headquarters.

Melinda Tourangeau

Melinda, a USAF ROTC graduate of Georgia Tech, served as a Program Manager and Research Engineer at AFRL for the nation's Strategic Defense Initiative's laser programs. She completed her master's in electrical engineering at AFIT, majoring in electro-optics and semiconductor physics. After active duty, she transferred to the USAF Reserves at Hanscom AFB and went to work for Raytheon, developing the terminal track algorithm for an infrared seeker head on the BAT munition.

Melinda worked as a program manager at BAE Systems, where she led multiple electro-optic and signals intelligence programs. She worked on three EW programs that are flying in theater today: USQ-113 Communications Jammer, ICAP III - Radar Receiver Upgrade (both on the EA-6B), and antenna pods for the EA-18G. She also managed a critical Rapid Deployment System program that developed the life-saving D-CREW systems deployed in theater to mitigate the threat of IEDs.

Melinda currently serves as President of Warrior Support Solutions, LLC. She maintains distinctive expertise in EW, authoring critical reports for the DOD. As an AOC board member, Melinda will contribute her time and talent to help strategize and facilitate the AOC's key initiatives in STEM, Education, Career and Professional Development, the *JED*, webinars, chapters and membership. She will devote her passion and advanced knowledge of EW systems to achieve goals set by the board and the AOC executive staff. Melinda is a team player and works in concert with all board and executive members to collaborate, mediate and find solutions that will work for everyone.

INTERNATIONAL REGION 2

LEE Kar Heng

Kar Heng is the Founding President of the AOC Singapore Chapter. He is an Engineerpreneur, which means he practices Engineering and runs his own business. He travels widely to present and publish close to 50 papers worldwide, and he is aware of the lack of AOC outreach in many Asian countries. He hopes to induce the local experts to start up local chapters of their own, for sharing, for better friendship and extended peace. Kar Heng's region is currently seeing strong disruption due to the raise of China and the drift of Taiwan. Being a Regional Director as a Singaporean, he is able to use his strategic position to breach the East and West. As an Asian, it is easy for him to outreach to the countries that still do not have an AOC local chapter.

From 2017 to 2020, the Asia version of Electronic Warfare Europe was run in Singapore with very positive feedback from the participants. The Singapore Chapter has also been engaged actively in STEM programs; for 3 years since 2017, the chapter has conducted the AOC supported complimentary STEM program to more than 100 students. Kar Heng would like to rotate the Electronic Warfare Asia Conference among the Region 2 countries and engage the local chapters to practice STEM.

Kar Heng wants to take up the challenge to increase the number of AOC Chapters in this Region to 50% more than the current figure.

Jurgen Opfer

Jurgen works for Fujitsu as the Chief Engineer and Design Authority in a C4ISR modernization program for Australia's Military and National Security organizations. He joined the Association of Old Crows in 1986, was elected to the Australian Chapter board of directors in 2006 and elected as the Vice President in 2013, serving through to 2016. In 2017, he was elected as President and again in 2018. He has continued his participation in AOC events and advocates for the AOC. He is also a member of the Australian Institute of Professional Intelligence Officers and a member of the IEEE, a member of the International Cyber Threat Task Force (ICTTF) and a participating member of the Standards Australia Committee IT-012-04 Data Security Techniques.

Jurgen is an accomplished author and presenter, having written numerous training manuals, course materials and three technical books. In 2011, Jurgen authored a feature article on terrorism for the 10th Anniversary of 9/11 Edition of Security Solutions Magazine. He then wrote on corruption and arms trafficking in their 75th issue. He later wrote a feature article on the "Security implications of Social Networking." He also wrote the lead article on Cyber warfare for the Cyber special edition for Australian Defence Magazine and presented a paper on "The Overlap between Electronic Warfare and Information Warfare" at the ADM Cyber Security Summit.

Jurgen has presented papers on Cyber Warfare at several AOC conventions and a modified version at the inaugural Cyber security seminar for the Institute of Engineers Australia.

SOUTHERN REGION

Karen Brigance

Ms. Karen Brigance is currently the Chief Engineer for Electronic Warfare and Software at Mercer Engineering Research Center (MERC). MERC provides critical engineering support to both Air Force and Navy weapon systems spanning the entire spectrum of EW, to include Radio Frequency (RF), Electro-Optical (EO) and Infrared (IR). Ms. Brigance retired from civilian service January 2019 as the Chief Engineer for the Electronic Warfare and Common Avionics Systems Program Office at Robins Air Force Base. She was responsible for providing comprehensive, full life-cycle system engineering support consisting of development, test, production, fielding, sustainment, reprogramming, mission data and consultation to ensure war-fighting MAJCOMS have the capabilities they require.

Ms. Brigance began her career in the Electronic Warfare Directorate in 1982. In January 1990, she began work in Detachment 8, 2762 Logistics Squadron, as the program manager for a $500 million SIGINT program. In February 1999, she became the Exploitation Division Chief in the U-2 Management Directorate, providing worldwide support to the U-2 Dragon Lady's associated ground processing stations, airborne sensors and data links. In December 2003, she was promoted as Avionics/Electronics Engineering Division Chief for the Engineering Directorate, providing functional management and advocacy for over 750 electronics engineers working across Robins AFB. In 2006, Ms. Brigance moved to the 752 Combat Sustainment Group as Chief Engineer for Common Avionics. She transitioned to the position of Squadron Director when the common avionics group became part of the Air Force Global Logistics Center as the 407th Supply Chain Management Squadron. In June 2010, Ms. Brigance was transferred to the chief engineer position for USAF Electronic Warfare, from which she retired.

Ms. Brigance completed two terms as president of the Dixie Crow Chapter of the AOC, served as current Past President for four years, and Chairperson for four Dixie Crow EW/IO Technical Symposiums. She has served as Southern Regional Director on the AOC Board of Directors for three years. Ms. Brigance was Chair for the Audit and Inspection Committee and an active member of the Membership and Awards committees for one year.

2020 Online Voting Instructions

Beginning October 1, 2020, AOC members can visit the AOC homepage, www.crows.org, where they will see election information and a link to Elections On-Line, the independent vendor conducting this year's online election. You will receive an email with login instructions shortly before the elections start. The website will direct you to your ballot, where you can make your selections. Your AOC dues must be current as of September 20, 2020 in order to vote. As with past AOC elections, your ballot is secret.

Elections On-Line will hold all completed ballots, tabulate them and send the results to the AOC when the election is complete. Once you have cast your online vote, Elections On-Line will send you an email confirming that they have received your completed ballot.

Paper Ballots

For those AOC members who cannot vote online, the AOC has provided a paper ballot below. Members may cut out the paper ballot, mark it – including your member number (available on the front label of your *JED*) and your name and contact information – and mail it back to the AOC. Paper ballots must be postmarked after October 1, 2020, and before October 31, 2020, and be addressed to:

Association of Old Crows – 2020 Ballot
1001 N. Fairfax Street, Suite 300
Alexandria, VA 22314

Campaign Rules

Please Remember – Campaigning or electioneering on behalf of any candidate for AOC International office, with or without their knowledge or consent, is prohibited.

2020 AOC Election Ballot

Ballots accepted October 1-31, 2020

Name .....

AOC Member Number .....

Email address .....

AT LARGE (vote for 2 candidates)

- ☐ Vince Battaglia
- ☐ Joe Koesters
- ☐ Gary Lyke
- ☐ Jeff Malone
- ☐ Steve Oatman
- ☐ Greg Patschke
- ☐ Chuck Quintero
- ☐ Mike Ryan
- ☐ Daljit Singh
- ☐ Steve Tourangeau

NORTHEAST REGION (vote for one candidate)

- ☐ Nino Amoroso
- ☐ Tuhin Das
- ☐ Myles Murphy
- ☐ Melinda Tourangeau

INTERNATIONAL REGION 2 (vote for one candidate)

- ☐ Lee Kar Heng
- ☐ Jurgen Opfer

SOUTHERN REGION

- ☐ Karen Brigance

HONORING AN AOC CHARTER MEMBER: MAJ GLEN A. ROBBINS USAF (RET.)

Major Glen A. Robbins (aka Robbie) passed away unexpectedly in his home in Bullhead City, AZ, on June 6. Robbie was born in North Platte, NE, on January 20, 1933, to Fay and Carol Robbins. Robbie is survived by his wife of 29 years, Della; daughter Gloria Spurlock (Richard) of New Mexico; six grandchildren and thirteen great grandchildren. He was preceded in death by his son, Donald Glen Robbins and grandson Travis Robbins.

Robbie was a proud member of the Veterans of Underage Military Service (VUMs). He decided at an early age he wanted to be in the military. At age 15, Robbie misrepresented his true age to the Selective Service and was issued a draft card. Robbie joined the Oregon Air National Guard on April 5, 1948, using his fraudulent draft card and his mother's consent signature. His unit, a P-51 fighter squadron, was called to active duty by President Truman at the start of the Korean War.

In March 1952, he was given the opportunity to re-enlist in the regular Air Force and was assigned to the Far East. In 1956, Robbie corrected his erroneous birth date, took a test for officer candidate's school and started his Air Force career legitimately.

During the Cuban missile crisis in October 1962, Robbie was an electronic warfare officer in a B-52. Flying out of Grand Forks AFB, ND, on 24-hour alert sorties, Robbie contracted the mumps. "A small price to pay for how miserable he felt, since it helped quell the Cold War," was all he would say about that subject.

In 1964, while assigned to Hq Strategic Air Command, Robbie was tasked to select candidates for a new program, Wild Weasel, to perform dangerous missions over North Vietnam. Robbie took the task seriously, even recommending himself, but his commander would not release him to the program.

At that time, a new, professional electronic warfare organization was created, the Association of Old Crows, and Robbie became a charter member of that international organization. Robbie served much of the remainder of his Air Force career as a B-52 electronic warfare officer, retiring as a Major in June 1975.

His military decorations include:

Joint Service Commendation Medal, SOG-102, Hq SAC, 71; Meritorious Service Medal, SOG-50, Hq AFSC, 73; National Defense Service Medal w/1 Bronze Service Star; United Nations Service Medal; Korean Service Medal; AF Longevity Service Medal w/4 Oak Leaf Clusters; and Good Conduct Medal w/2 Oak Leaf Clusters.

After retirement from the Air Force, Robbie continued service to his country by working for a Department of Defense contractor testing electronic warfare equipment on an open-air-range. He was a "connector;" if you needed something (anything), just mention it to Robbie and, most likely, it would show up on your doorstep in the not-too-distant future. There are never-ending stories of Robbie helping people (no one was a stranger to Robbie). Robbie was a lifetime VFW Post 10005 member. Robbie was the epitome of a patriot, who gave 65 years of his life to the service of the United States. The high point of his retirement years was in 2018, when he was accepted by Southern Nevada Honor Flight to Washington, DC. Mike Whitaker was Robbie's companion and caregiver during the excursion.

Rest in eternal peace.

A memorial gathering to share "Robbie Stories" will be scheduled.

PALMETTO ROOST TRAINING NEXT GENERATION OF CYBERPATRIOTS

The Palmetto Roost, in collaboration with Charleston Southern Cybersecurity (CSU), partnered with employees from the Medical University of South Carolina (MUSC) and Dixon Hughes Goodman to offer an all-female, CyberPatriot camp the week of June 8, using the Air Force Association's CyberPatriot curriculum.

CyberPatriot is the National Youth Cyber Education Program created by the Air Force Association to inspire K-12 students toward careers in cybersecurity or other science, technology, engineering and mathematics (STEM) disciplines critical to our nation's future. At the core of the program is the National Youth Cyber Defense Competition, the nation's largest cyber defense competition that puts high school and middle school students in charge of securing virtual networks.

The young women, ages 12-15, learned about overall cybersecurity safety measures and careers, had hands-on instruction securing Windows 10 and Ubuntu operating systems, and were able to compete in a mini-CyberPatriot competition.

Camper Angelina, rising eighth-grader, said, "I loved it! I learned a lot about cybersecurity, and I learned more about my parents' jobs. I also loved taking electronics apart and seeing how they worked."

Dr. Valerie Sessions, Palmetto Roost education chair and affiliate professor of computer science at Charleston Southern University, said, "CSU has degrees in cybersecurity and computer science. Women are underrepresented in this field, and we are working to increase participation by middle and high school girls."

The New York Times recently cited Cybersecurity Ventures' prediction that more than three million cybersecurity jobs will go unfilled globally in 2021. Rich Nelson, president of the Palmetto Roost, is interested in developing new professionals and believes that it is key to the country's technological edge. "The Palmetto Roost and the AOC are focused on developing, promoting, and delivering electronic warfare and cyber warfare tools and professionals who are dedicated to furthering the profession and helping to protect our country and our freedom."

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EWEUROPE.COM

Electronic Warfare Europe

16-18 November 2020
Exhibition Centre Liverpool, UK

READY TO KICKSTART YOUR BUSINESS ACTIVITIES?

The 2020 edition of AOC EW Europe, originally scheduled in June, will now be held on 16-18 November.

As organisers, Clarion Events are developing and working to an ALL SECURE framework to ensure the health and safety of all attendees in response to Covid-19. For more information on new and enhanced safety measures, please visit the event website.

Registration for the event has re-opened, and we look forward to re-uniting the electronic warfare community in Liverpool.

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ASSOCIATION OF OLD CROWS

SEPTEMBER 29, 2020 Online Virtual Event

CEMAlite Virtual Summit

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In recognition of current travel restrictions and limitations on indoor gatherings, and for the safety and well-being of all involved, the CEMA 2020 Conference will now be a virtual event with a shortened program. The one-day, virtual event will provide attendees an update on EW policy, emerging requirements, Science & Technology (S&T) initiatives, programs, leadership perspective and operational feedback from the field. Join us for one last fall fling as we transition to the spring of 2021 to continue this popular event!

If you are interested in sponsoring this event, please contact Sean Fitzgerald, fitzgerald@crows.org, 703-549-1600 ext 222.

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