ASSOCIATION OF OLD CROWS
Advancing Electromagnetic Warfare TOGETHER
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January 2021 Vol. 44, No. 1

JED

Journal of Electromagnetic Dominance

US Navy's HAVOC Hones AEA Expertise

- Soft-Kill Protection for Europe's Ground Vehicles
- EW 101: Jamming Satellite Uplinks
- 2020 AOC Award Recipients

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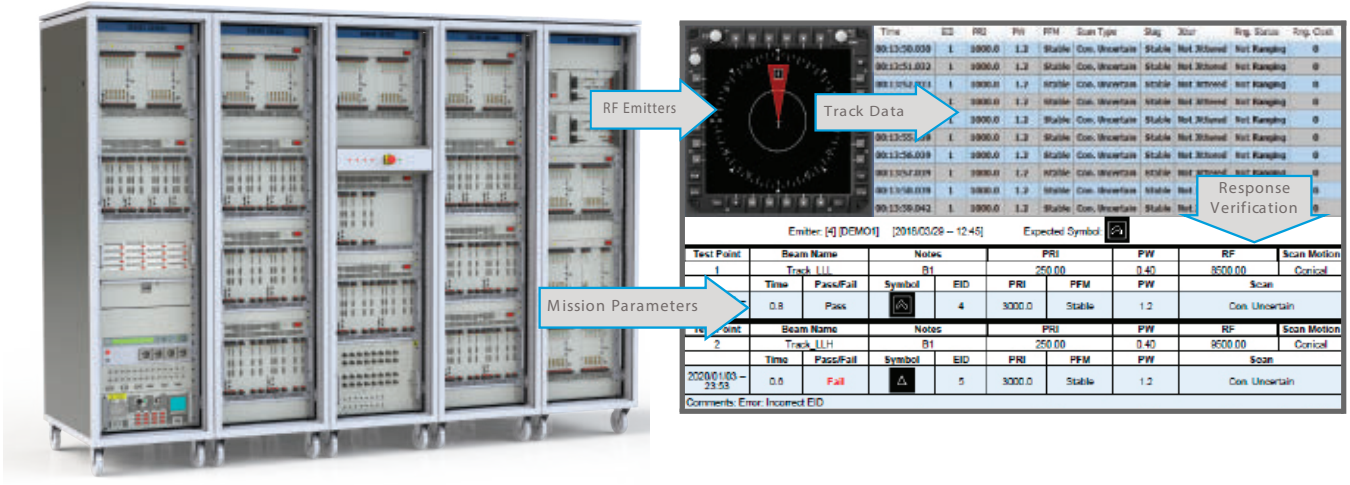

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Journal of Electromagnetic Dominance

CONTENTS

January 2021 • Volume 44, Issue 1

The US Navy has a long history of providing Airborne Electronic Attack (AEA) capabilities for its own and Joint mission needs, as well as the needs of other Services. In an endeavor to develop and refine AEA expertise within its ranks, the Navy established its Airborne Electronic Attack Weapons School in 2011, call sign "HAVOC," to address Electronic Warfare (EW) needs, including EA-18G Growler training and tactics development. US NAVY

Members of the US Air Force's 51st Maintenance Squadron at Osan Air Base, Republic of Korea, celebrate a successful test of an ALQ-184(V) electronic countermeasures pod that had been out of service for more than 10 years. The pod's A3 and A4 canisters had been damaged more than a decade ago, but the needed parts were not part of the ALQ-184's normal supply chain. The External Electronic Attack Pod IPT at Robins AFB, GA, was part of a larger network of EA pod sustainers who located the parts and shipped them to Korea, allowing the Osan team to return the pod to service.

US AIR FORCE PHOTO BY TECH SGT NICHOLAS ALDER

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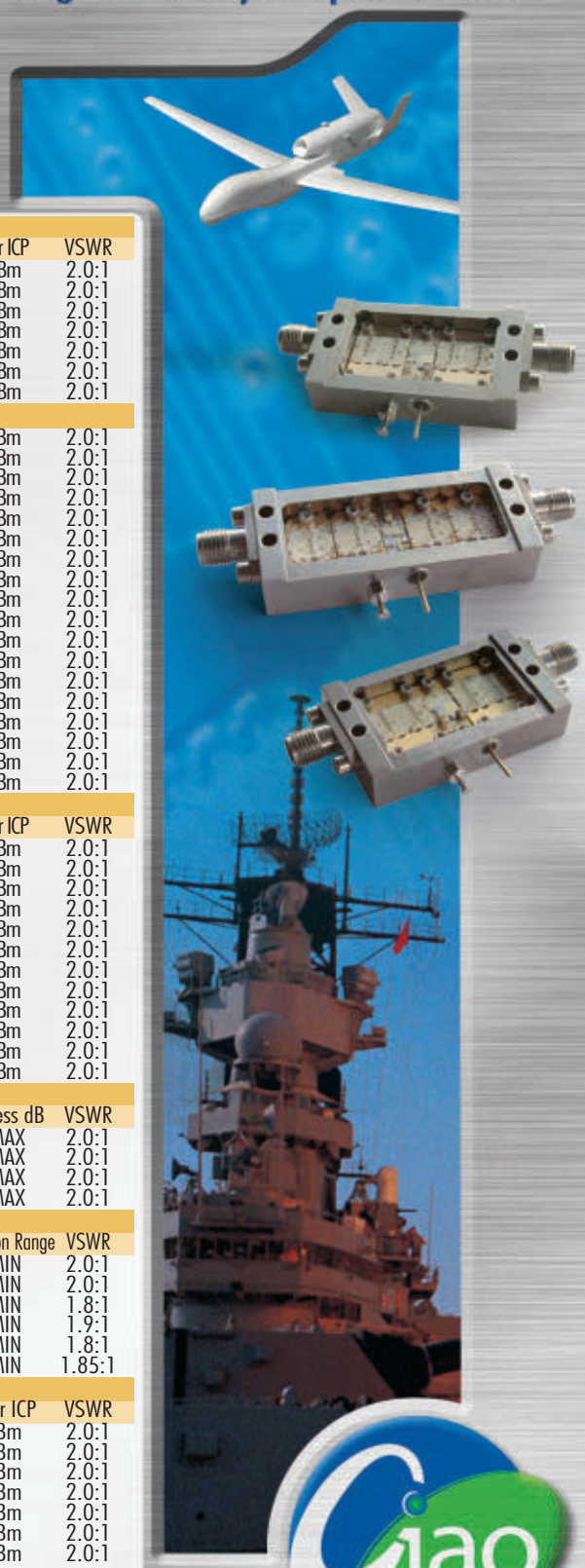

OCTAVE BAND LOW NOISE AMPLIFIERS

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

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
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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UNDER PRESSURE

The next few months will be a critical period for the DOD's Electromagnetic Spectrum Operations (EMSO) strategy, and the Department is feeling the pressure. In September, the DOD issued its EMS Superiority Strategy (EMSSS). The document, crafted by the EMSO Cross Functional Team (CFT), laid out several goals for establishing EMSO across the DOD. And while the EMSSS presents a vision for EMSO, it is the EMSSS Implementation Plan (due to be released by the EMSO CFT in late March) that will determine the strategy's success.

One reason the DOD is feeling the pressure is because last month, the US Government Accountability Office (GAO) released a report, "Electromagnetic Spectrum Operations – DOD Need to Address Governance and Oversight Issues to Help Ensure Superiority," which dissects why the DOD's two previous EMSO-related strategies (released in 2013 and 2017) failed to be fully implemented. Hint: the problems are mentioned in the title. The report also looks at what the DOD must achieve in its Implementation Plan in order to get the EMSSS right this time. The report makes five recommendations, which you can read about in this month's News section. Whether you agree with all of the recommendations or not, the GAO team that wrote the report deserves a lot of credit for unpacking a complex topic and making it understandable.

The other reason the DOD is feeling pressure on EMSO is because Congress passed the FY2021 National Defense Authorization Act (NDAA) last month (also covered in this month's News section). It contains a provision (Sec. 152) that directs the DOD to transfer all of the Joint EMSO activities from US Strategic Command to another DOD organization and report on this to Congress 180 days before the transfer occurs. In addition, the language calls for the Vice Chairman of the Joint Chiefs of Staff (VCJCS), who is also the Senior Designated Official for the EMSO Cross Functional Team, to submit annual reports on the Services' EMSO efforts and the EMSO progress in three major combatant commands. (Congress established the VCJCS as the Senior Designated Official for the EMSO CFT in the FY2019 NDAA.)

Why is Congress putting so much pressure on the DOD over EMSO? Well, as pointed out by the GAO, the DOD has already had two cracks at establishing an EMSO strategy (in 2013 and 2017), and the DOD has failed to fully implement both strategies. Congress is fully aware of the DOD's bureaucratic resistance to EMSO, and it does not want the DOD to fail again (in its third attempt) with the 2020 EMSSS. As the GAO report pointed out using the example of the DOD's Cyber strategy, the Department can implement major strategies very successfully when it wants to. The DOD should not have to struggle with EMSO strategy the way it has. Yet it has left a lot of important "nuts and bolts" in the EMSSS to the upcoming Implementation Plan. Congress expects the DOD to follow its words with more meaningful actions this time around. – *J. Knowles*

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Journal of Electromagnetic Dominance

EDITORIAL STAFF
Editor: John Knowles
Publisher: John Bacon
Senior Editor: John Haystead
Managing Editor: Hope Swedeen
Technical Editor: Barry Manz
Threat Systems Editor: Doug Richardson
Contributing Writers:
Dave Adamy, Luca Peruzzi, Richard Scott, Dr. David Stoudt, and Andrew White
Proofreaders: Ken Janssens, Shauna Keedian
Sales Manager: Tabitha Jenkins
Sales Adminstrator: Amanda Glass

PRODUCTION STAFF
Layout & Design: Barry Senyk
Advertising Art: Elaine Connell
Contact the Editor: (978) 509-1450, JEDeditor@naylor.com
Contact the Sales Manager: (800) 369-6220 or tjenkins@naylor.com
Subscription Information: Please contact Glorianne O'Neilin at (703) 549-1600 or e-mail oneilin@crows.org.

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General John E. Hyten

Vice Chairman of the Joint Chiefs of Staff
Jan. 6 | 1:30 PM ET

Honorable Dr. Bruce D. Jette

Assistant Secretary of the Army for Acquisition, Logistics & Technology (ASA(ALT)) & Army Acquisition Executive (AAE)
Feb. 10 | 1 PM ET

General David "DT" Thompson

Vice Chief of Space Operations, United States Space Force
Jan. 13 | 2 PM ET

General Charles Q. Brown, Jr.

Chief of Staff, Air Force
Jan. 27 | 1 PM ET

Air Chief Marshal Sir Stuart Peach

Chairman of the NATO Military Committee, NATO Headquarters
Feb. 3 | 10 AM ET

Vice Admiral Jeffrey Trussler

Deputy Chief of Naval Operations for Information Warfare, N2/N6, Office of the Chief of Naval Operations/Director of Naval Intelligence
Feb. 24 | 10:30 AM ET

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Calendar *Conferences & Courses*

JANUARY

AOC Program Manager Briefing Session 3
January 5
1300-1500 EST
www.crows.org

AOC EMSO Leadership Discussion: Gen John E. Hyten
January 6
1330-1430 EST
www.crows.org

European Microwave Week 2020 – Virtual
Conference: January 10-15
www.eumwa.org

Electro-Optic and Infrared Systems 2
January 11-15
Swindon, UK
www.cranfield.ac.uk

Surface Navy Association 33rd Annual National Symposium – Virtual
Conference: January 11-15
Arlington, VA
www.navysna.org

AOC EMSO Leadership Discussion: Gen David "DT" Thompson
January 13
1400-1500 EST
www.crows.org

AOC Virtual Series Webinar: An Overview of IADS (Integrated Air Defense Systems)
January 14
1400-1500 EST
www.crows.org

AOC Program Manager Briefing Session 4
January 19
1300-1500 EST
www.crows.org

Fundamentals of Radar Signal Processing – Online
January 25-28
www.pe.gatech.edu

AOC EMSO Leadership Discussion: Gen Charles Q. Brown, Jr.
January 27
1300-1400 EST
www.crows.org

AOC Virtual Series Webinar: When Crows Break Codes
January 28
1400-1500 EST
www.crows.org

TechNet Augusta – Virtual
Conference: TBD Sessions January - July
www.afcea.org

FEBRUARY

DEPS Joint Conference on T&E Support to Prototyping and Experimentation – Virtual
Conference: February 1-4
Albuquerque, NM
www.deps.org

Radar Electronic Warfare
February 1-5
Swindon, UK
www.cranfield.ac.uk

AOC Program Manager Briefing Session 5
February 2
1300-1400 EST
www.crows.org

AOC EMSO Leadership Discussion: Air Chief Marshal Sir Stuart Peach
February 3
1000-1100 EST
www.crows.org

Aero India 2021
Conference: February 3-7
Bengaluru, India
www.aeroindia.gov.in

AOC EMSO Leadership Discussion: Honorable Dr. Bruce D. Jette
February 10
1300-1400 EST
www.crows.org

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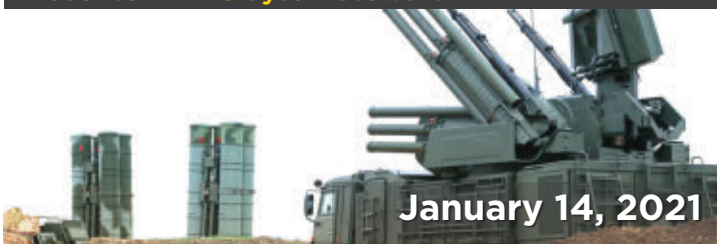
AOC Virtual Series Webinars

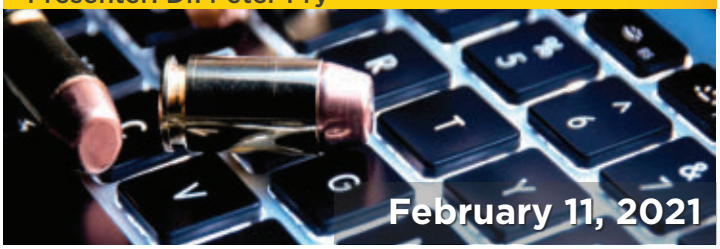
AOC Virtual Series has been a tremendous asset providing the AOC's audience with learning, advocacy, and the exchange of information. Register today to hear from subject-matter experts on all things EW!

An Overview of IADS (Integrated Air Defense Systems)
Presenter: Dr. Clayton Stewart

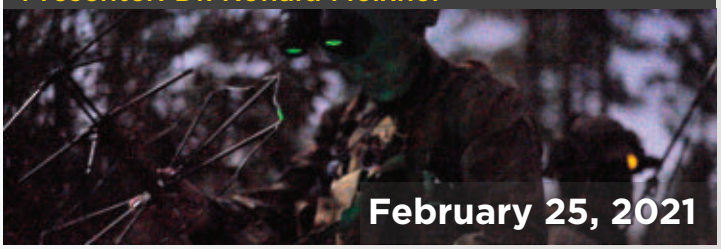


When Crows Break Codes
Presenter: Mr. John Kolm

From Sarissa To Cyber Warfare
Presenter: Dr. Peter Pry



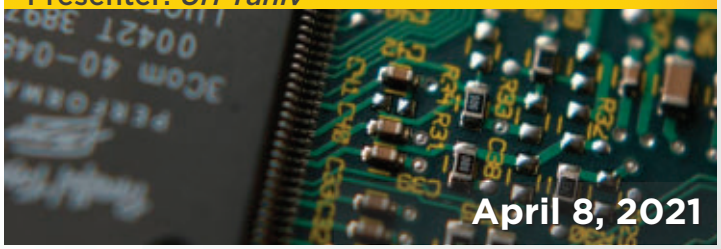
HF meets Big Data – Intercept in an era of HF Renaissance
Presenter: Dr. Ronald Meixner



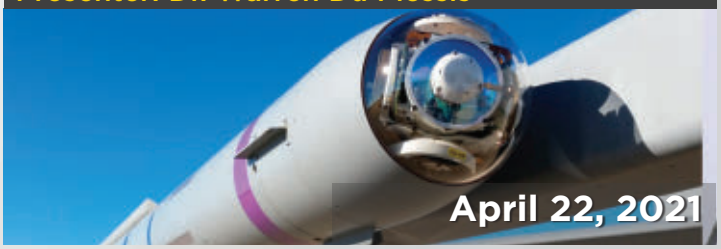
Cyber Electromagnetic Activities and Signals Intelligence: a Command and Control framework
Presenter: Claudio Santo Malavenda

The Year in Review - GPS/PNT Disruptions and Improvements
Presenter: *Dana Goward*

Fast Switching Synthesizers for Emerging EW Systems
Presenter: *Uri Yaniv*



Reticle Based Seekers
Presenter: Dr. Warren Du Plessis



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

ASSOCIATION OF OLD CROWS

Calendar *Conferences & Courses* cont'd.

AOC Virtual Series Webinar: From Sarissa to Cyber Warfare
February 11
1400-1500 EST
www.crows.org

AOC Program Manager Briefing Session 6
February 16
1300-1500 EST
www.crows.org

IDEX 2021
Conference: February 21-25
Abu Dhabi, UAE
www.idexuae.ae

Communications Electronic Warfare
February 22-26
Swindon, UK
www.cranfield.ac.uk

AOC EMSO Leadership Discussion: VADM Jeffrey Trussler
February 24
1030-1130 EST
www.crows.org

AFA Aerospace Warfare Symposium – Virtual
Conference: February 24-26
Orlando, FL
www.afa.org

AOC Virtual Series Webinar: HF Meets Big Data – Intercept in an Era of HF Renaissance
February 25
1400-1500 EST
www.crows.org

MARCH

AOC Program Manager Briefing Session 7
March 2
1300-1500 EST
www.crows.org

Advanced Radar
March 8-12
Swindon, UK
www.cranfield.ac.uk

AOC Virtual Series Webinar: Cyber Electromagnetic Activities and Signals Intelligence: a Command and Control framework
March 11
1400-1500 EST
www.crows.org

MILIPOL Qatar 2021
Conference: March 15-17
Doha, Qatar
https://en.milipolqatar.com

Aircraft Survivability
March 15-19
Swindon, UK
www.cranfield.ac.uk

AOC Program Manager Briefing Session 8
March 16
1300-1500 EST
www.crows.org

AUSA Global Force Next – Virtual
Conference: March 16-18
www.ausa.org

Dixie Crow Symposium 45
Conference: March 21-24
Warner Robins, GA
www.dixiecrowsymposium.com

AOC Professional Development Live Web Course: RF Theory for ES Operations
March 22-26
www.crows.org

Advanced Sensor Data Processing
March 22-26
Swindon, UK
www.cranfield.ac.uk

AOC Virtual Series Webinar: The Year in Review – GPS/PNT Disruptions and Improvements
March 25
1400-1500 EST
www.crows.org

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

AOC SPONSORSHIP OPPORTUNITIES IN 2021

The AOC bridges the gap between Electromagnetic Warfare practitioners, Industry partners, Policymakers, and procurement decision-makers.

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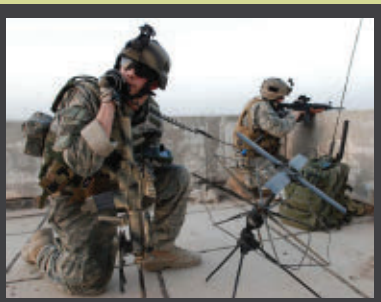

ASSOCIATION OF OLD CROWS

LOOKING FORWARD TO A GREAT YEAR

Happy New Year. I am sincerely honored and humbled at being entrusted to serve as the 35th AOC President. 2021 marks my 35th year in the AOC, and if you had asked me in 1986 where I would be today, I can honestly say that having the opportunity to serve the AOC in this role would have been a distant thought. You never know what opportunities may be presented in life, so to all our members, please be open to serve and one day it could be you writing this letter.

I have been and continue to be very passionate about EW, Cyber, Information Operations and especially EMS Operations (EMSO). 2020 threw us and the world a number of curveballs and obstacles, and I thank Muddy, the Board and especially our professional staff for navigating the pandemic and meeting the many challenges it presented us – individually and as an organization.

This month, the AOC is kicking off a new program, "AOC Discussions," in which we talk with senior military leaders about EMSO and larger EMS-related issues. During each discussion session will use these senior-leader conversations to stimulate further dialog in an open forum with military, government, industry and academia. Our first guest is Vice Chairman of the Joint Chiefs of Staff Gen John Hyten, USAF, on January 6. General Hyten is also the DOD's Senior Designated Official for the EMSO Cross Functional Team, and he serves as the co-chair of the Department's EW Executive Committee (EW EXCOM). I am very interested to hear what General Hyten will tell us about what is expected in the coming months for EMSO, the challenges the DOD is facing in the EMS, and the Department's long-term goals for EMSO. Other guests include Gen David Thompson, Vice Chief of Space Operations, United States Space Force, on January 13; Gen Charles Brown, Chief of Staff, US Air Force, on January 27; Air Chief Marshal Sir Stuart Peach, Chairman of the NATO Military Committee, on February 3; Hon. Dr. Bruce Jette, Assistant Secretary of the Army for Acquisition, Logistics & Technology (ASA(ALT)) & Army Acquisition Executive (AAE), on February 10; and VADM Jeffrey Trussler, Deputy Chief of Naval Operations for Information Warfare, N2/N6, Office of the Chief of Naval Operations/Director of Naval Intelligence, on February 24. AOC Discussions is a great opportunity to hear from informed senior leaders and engage with other leaders within our community. I hope you won't miss it.

As the AOC charges into 2021, we will continue to nurture and grow our membership, chapters and sponsors of our great Association; supporting our strategic tenets: Advocate, Educate and Support. We will further our influence in the global EW, Cyber and Information communities, adapt to change, overcome challenges and find opportunities to thrive, even as we emerge from the pandemic later this year. Again, I am honored and humbled to be your 35th president. – *Glenn "Powder" Carlson*

FEATURED LIVE COURSES

RF Theory for ES Operations

Dr. Patrick Ford

Tuesdays & Thursdays
1:00 - 4:00 PM ET | March 22 - 26, 2021
This course will also provide a survey of propagation modeling techniques and an update on modern RF operating trends.

Fundamental Principles of Electronic Warfare

Dave Adamy

Mondays & Wednesdays
1:00 – 4:00 PM ET | 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
1:00 – 4:00 PM ET | 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.

C4ISR Requirements, Principles, and Systems

Dr. Clayton Stewart

Mondays & Wednesdays
1:00 – 4:00 PM ET | June 7 – 30, 2021
This 24 hour web based course delivers a thorough overview promoting an understanding and building a successful Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR) architecture.

Aircraft Radar Cross Section Engineering

Renan Richter

Mondays, Wednesdays & Fridays
1:00 – 4:00 PM ET | July 12 – 30, 2021
This course introduces students to Radar Cross Section (RCS) engineering and its basics fundamentals inside the modern EW context. Stealth technology will be addressed by presenting current challenges and future perspectives.

Direct Energy Weapons

Kyle Davidson

Mondays & Wednesdays
1:00 – 4:00 PM ET | August 2 – 18, 2021
This course introduces students to the fundamentals of Direct Energy Weapons (DEW) across the electromagnetic spectrum. The goal is to provide an understanding of the operation of laser and high-power microwave DEWs in military applications, including their design trade-offs, and target effects.

Introduction to Satellite Communications (Satcom)

Dr. Patrick Ford

Mondays & Wednesdays
1:00 – 4:00 PM ET | September 1 – 22, 2021
This course will cover the core material required for participants to understand and discuss basic Satcom theory and operations.

= Web Course, no travel required!

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GAO RELEASES EMSO REPORT

The Government Accountability Office last month published a new report that says the DOD must improve its Electromagnetic Spectrum Operations (EMSO) governance and oversight. The report (number GAO-21-64) provides well informed assessment of the DOD's EMSO challenges and shortfalls to date and makes several recommendations to improve governance.

The report begins with a background on EMSO and the DOD's dependence on the EMS. It then provides an overview of the many studies that have described the strategic steps that China and Russia have taken to challenge US control of the EMS. Next, the report takes a look back at the DOD's previous efforts to strengthen its EMS Enterprise, including two EMS-related strategies issued in 2013 and 2017. It then provides a brutally honest discussion of why the DOD has not fully implemented these previous EMS-related strategies and explains why the DOD is at risk of failing to achieve its long-term EMSO goals unless its implements its 2020 EMS Superiority Strategy (EMSSS). It concludes with five specific EMSO-related gaps and recommendations to close those gaps.

In the section titled "DOD and Other Organizations Have Identified Multiple Challenges to Ensuring DOD's EMS Superiority," the GAO lists the major EMSO-related shortfalls recognized by multiple DOD and think-tank studies. Among the problems identified are: 1) dispersed governance of the EMS; 2) full-time EMSO responsibilities are located at lower organizational levels; 3) outdated EMS-related technologies; 4) lengthy acquisition process; 5) absence of a holistic, overarching EMS operational concept; 6) increased competition and congestion in the spectrum; 7) issues with electromagnetic battle management (EMBM); 8) shortages of staff with EMS expertise; and 9) challenges for EMS training. The GAO adds, "Based on several DOD reports and our interviews with DOD officials from multiple components, we found that DOD recognizes these challenges."

The next section of the report describes the DOD's two EMS-related strategies issued in 2013 and 2017 as well as its more recent 2020 EMSSS that was released in September. The report states, "DOD officials we interviewed recognize that action is necessary and the 2020 strategy updates and consolidates the 2013 and 2017 strategies into a new document. The 2020 strategy seeks to align EMS resources, capabilities, and activities across DOD to support core national security objectives while remaining mindful of the importance of US economic prosperity. Additionally, according to the strategy, DOD believes the strategy lays THE foundation for a robust EMS enterprise, prepares EMS professionals to leverage new technologies, and focuses on strengthening alliances to achieve the department's vision of freedom of action in the EMS."

The report goes on to describe how the DOD failed to completely follow-through on the 2013 and 2017 strategies and could fail to achieve the goals laid out on the 2020 EMSSS. The GAO writes, "The three strategies provide direction to help DOD improve EMSO and EMS-related issues. However, the department did not fully implement the 2013 and 2017 strategies, and is at risk of not achieving the goals of the 2020 strategy because DOD has not taken critical governance and oversight actions such as those Congress established in section 1053 of the FY19 NDAA to support DOD EMS. Specifically, DOD has not (1) issued process and procedures to integrate EMSO across the department, (2) proposed and implemented governance reforms, (3) assigned a senior official with appropriate authority to oversee strategy implementation, and (4) articulated oversight processes for strategy implementation."

The GAO identified five areas where the DOD could "capitalize on progress that it has already made and better support ensuring EMS superiority." These are: "(1) the processes and procedures to integrate EMSO throughout the department; (2) governance reforms to correct diffuse organization; (3) responsibility by an official with appropriate authority; (4) a strategy implementation plan; and (5) activities that monitor and assess the department's progress in implementing the strategy."

In response to these areas, the GAO made five recommendations for the DOD. These are:

Recommendation 1 The Secretary of Defense should ensure that the Vice Chairman of the Joint Chiefs of Staff, as Senior Designated Official of the CFT, identifies the procedures and processes necessary to provide for integrated defense-wide strategy, planning, and budgeting with respect to joint electromagnetic spectrum operations, as required by the FY19 NDAA.

Recommendation 2: The Secretary of Defense should ensure that the Vice Chairman of the Joint Chiefs of Staff as Senior Designated Official of the CFT proposes EMS governance, management, organizational, and operational reforms to the Secretary.

Recommendation 3: The Secretary of Defense should assign clear responsibility to a senior official with authority and resources necessary to compel action for the long-term implementation of the 2020 strategy in time to oversee the execution of the 2020 strategy implementation plan.

Recommendation 4: The Secretary of Defense should ensure that the designated senior official for long-term strategy implementation issues an actionable implementation plan within 180 days following issuance of the 2020 strategy.

Recommendation 5: The Secretary of Defense should ensure that the designated senior official for long-term strategy implementation creates oversight processes that would facilitate the department's implementation of the 2020 strategy.

The DOD concurred with the first and second recommendations, and partially concurred with the remaining three. The DOD's EMSO Cross Functional Team is due to release its EMSSS Implementation Plan by the end of March. – *J. Knowles*

CONGRESS PASSES NDAA WITH EMSO PROVISIONS

As this issue of *JED* went to press, congressional leaders in the US House and US Senate had ironed out the differences in their respective versions of the FY2021 National Defense Authorization Act (NDAA), and the both houses had passed the bill, which President Trump had threatened to veto. The NDAA emerged from the House-Senate conference with a number of important Electromagnetic Spectrum Operations (EMSO) provisions being retained.

Section 152, Transfer of Functions and Responsibilities Related to Electromagnetic Spectrum Operations, represents the most significant development for EMSO since the Cold War. This language, which originated in the Senate version of the NDAA, directed the DOD to take a number of measures to strengthen its EMS Enterprise and report its progress to Congress in a number of areas. Specifically, it calls in the DOD to transfer "all the responsibilities and functions of the Commander of the United States Strategic Command that are germane to electromagnetic spectrum operations (EMSO)" to "an appropriate entity within the Department of Defense" within two years. This includes "advocacy for joint electronic warfare capabilities; providing contingency electronic warfare support to other combatant commands; and supporting combatant command joint training and planning related to electromagnetic spectrum operations."

In support of this transfer, the NDAA also calls for the DOD to develop a plan for this transfer and to report it to Congress at least 180 days before the move is made. The language leaves it to the DOD to determine which organization will receive these EMSO activities. This could include, "elements of the Joint Staff, the functional and geographic combatant commands, Department of Defense offices and agencies, and other organizations, including the establishment of a new entity for that purpose…" The conferees also asked that the report indicate "Whether the receiving electromagnetic spectrum operations organization should have a unitary structure or hybrid structure (in which operational and capability development and direction are headed by separate organizations)." Finally, it asks the DOD to explain what resources are needed for the receiving organization to take on these new EMSO responsibilities.

In addition to the report for the transfer of STRATCOM's EMSO activities, the conference report language also calls on the DOD to provide Congress with an annual analysis from the Chief of Staff of the Army, the Chief of Naval Operations, the Chief of Staff of the Air Force, the Commandant of the Marine Corps, and the Chief of Space Operations that evaluates their service's ability to perform electromagnetic spectrum operations missions required by the EMS Superiority Strategy (EMSSS), which was released in September 2020; the Joint Staff concept of operations (CONOPs) for EMSO; and the operations and contingency plans of the combatant commands. Each evaluation will cover current programs of record (PORs); future PORs, including "the need for distributed or network-centric electronic warfare and signals intelligence capabilities; and the need for automated and ma- chine learning- or artificial intelligence-assisted electronic warfare capabilities"; order of battle; and individual and unit training.

Just as with the report on the Services progress in EMSO, the NDAA is calling for a similar annual report about the major combatant commands, specifically European Command (EUCOM), Indo-Pacific Command (INDOPACOM) and Central Command (CENTCOM), with regard to the EMSSS and the Joint Staff-developed CONOPs for EMSO. The report will focus on each COCOM's "operation and contingency plans; the manning, organizational alignment, and capability of joint electromagnetic spectrum operations cells (JEMSOCs); mission rehearsal and exercises; and force positioning, posture and readiness."

Finally, the Section 152 language calls for a semi-annual briefing from the Vice Chairman of the Joint Chiefs of Staff (also the DOD's Senior Designated Official of the EMSO Cross Functional Team) to the House and Senate armed services committees about the implementation of Section 152.

Other provisions:

- The NDAA also contained a provision (Sec. 128) calling for a report from the Secretary of the Navy about its "strategy to ensure full spectrum electromagnetic superiority using the ALQ–249 Next Generation Jammer." The report will include "a description of the current procurement strategy for the ALQ–249, and the analysis of its capability to meet the radio frequency (RF) ranges required in highly contested and denied environment conflicts; an assessment of the compatibility and ability of the ALQ–249 to synchronize non-kinetic fires using other Joint Electronic Warfare (EW) platforms; and future model of an interlinked/interdependent electronic warfare menu of options for commanders at tactical, operational, and strategic levels."
- The bill also included a provision (Sec. 138) that extended the timeframe that limited any funding the DOD could use to retire RC-135 aircraft. This provision was originally adopted in the FY2020 NDAA, and the new language extends its coverage to FY2021.
- Finally, the NDAA included Sec. 804, which encouraged the DOD more extensively utilize modular open system approaches in the acquisition and sustainment of weapons systems.

At the time this issue of *JED* was going to press, the House and Senate had both passed the NDAA with large majorities. President Trump had vowed to veto the legislation over several provisions in the bill, but had not yet done so. – *J. Knowles*

ITALY REQUESTS G550 AISREW

Italy has been approved by the US Government to procure two Gulfstream G550 aircraft equipped with Airborne Intelligence, Surveillance, Reconnaissance, and Electronic Warfare (AISREW) mission systems. The proposed Foreign Military Sale, (FMS) estimated to be worth US$500 million, was notified to Congress on 15 December. The principal contractor will be L3Harris (Greenville, TX).

According to the announcement from the Defense Security Cooperation Agency, the AISREW mission systems will be installed on two G550 aircraft provided by Italy as government furnished equipment (GFE). The full equipment scope of supply comprises four Multifunctional Information Dis-

tribution Systems – Joint Tactical Radio System (MIDS JTRS) terminals (two installed/two spares), three Embedded/GPS/INS with GPS security devices (two installed/one spare) and four Rio communications intelligence systems (two installed/two spares). Also included in the FMS package are missile warning sensors, AN/ALE-47 countermeasure dispenser sets, MX-20HD electro-optical/infrared systems, Osprey 50 fixed-face active electronically scanned array radars, AISREW ISR equipment, secure communications, IFF systems, aircraft modification and integration, and ground systems for data processing.

In addition to the AISREW mission equipment, the proposed FMS sale also includes crew training, ground support equipment, publications and technical data, and other program support.

The G550 AISREW standard being eyed by Italy is broadly similar in configuration to the MC-55A Peregrine aircraft being procured by Australia under its Project AIR 555 Airborne Intelligence Surveillance Reconnaissance Electronic Warfare Capability program. Four MC-55A aircraft – again based on the G550 business jet airframe – are being acquired by Australia under a AUS$2.46 billion program. Work on the MC-55A Peregrine programme is being carried out at L3Harris's Greenville, TX, facility and at Gulfstream in Savannah, GA. The program is being managed through the US Air Force's 645th Aeronautical Systems Group, which specialize in the acquisition, modification and support of special purpose aircraft. Deliveries to the Royal Australian Air Force are due to commence in early 2023. – *R. Scott*

IN BRIEF

The **Honorable James Geurts**, Assistant Secretary of the Navy for Research, Development and Acquisition has approved the Next Generation Jammer Low Band (NGJ-LB) program for transition to the Engineering and Manufacturing Development (EMD) phase. Two industry teams, led by L3Harris and Northrop Grumman, have developed NGJ-LB technology demonstrators over the past two years. As this issue of *JED* went to press, the Navy was expected to downselect to one contractor team for the EMD program by late December. In a Naval Air Systems Command press release, **CAPT Michael "Bobby" Orr,** Program Manager for Airborne Electronic Attack Systems (PMA-234) said of his NGJ-LB team, "They have executed the program flawlessly to date, completed a major shift in acquisition strategy this summer by transitioning from a Middle Tier Acquisition program to an Acquisition Category (ACAT)-1B program of record, completed a Demonstration of Technologies effort, and conducted a major source selection – and they did it all during a worldwide pandemic. I cannot be prouder to be associated with such an excellent team."

The US Army's **Product Manager, Vehicle Protection Systems** (PdM VPS) under Program Executive Office Ground Combat Systems (PEO GCS) (Warren, MI) has issued a Request for Information (RFI) for soft-kill active protection system (APS) capabilities for Army combat vehicles. The RFI was issued last month to collect comments about countermeasures and sensor packages from system developers and subsystem/component technologies developers. Officials at PdM VPS expect to host a virtual industry day this month to present their soft-kill program plans in advance of a Request for Prototype Proposal (RPP) that they expect to release in July through the National Advanced Mobility Consortium (NAMC). The soft kill suite includes threat sensors that cue obscurant countermeasures and electronic attack devices to degrade the sensors on targeting systems and the seeker mechanisms on anti-tank guided munitions (ATGMs). The Solicitation Number is W15QKN_17_9_SK_APS_SystemDevelopment. The contracting point of contact is Drew Depalma, e-mail drew.e.depalma.civ@mail.mil.

The US Army's Project Director Sensors-Aerial Intelligence (PD SAI), **Product Manager Aerial Enhanced Radar, Optics and Sensors** (AEROS) (Aberdeen Proving Ground, MD) has issued an RFI for Aerial Intelligence, Surveillance and Reconnaissance (AISR) payloads for the MQ-1C Gray Eagle Unmanned Aircraft System (UAS) platform that meet the Joint All-Domain Operations (JADO) environment. Payloads if interest include electronic intelligence (ELINT), communications intelligence (COMINT), Air Launched Effects (ALE), radar warning receiver (RWR), synthetic aperture radar (SAR) and moving target indicator (MTI). The RFI precedes a "potential Fiscal Year (FY) 2022 Gray Eagle sensor payload JADO demonstration where systems will be quantitatively compared to identify the highest performer and best value based on Technology Readiness Level (TRL) and production unit cost." The desired ELINT capability is approximately 350 lb, draws 1.5 kW and capable of integration onto the wing or into the forward payload bay of the MQ-1C Gray Eagle. The ELINT payload should provide 90% probability of detection at 300 km and geolocate emitters with a target location error of 6 meters or less at 30 km distance. The COMINT capability must provide similar performance with a maximum weight of 50 lb. and draw less than 0.5 kW of power. The ALE platforms should fly up to 300 km range, with those featuring EW, SAR/MTI, COMINT and/or ELINT capabilities weighing no more than 180 lb and those providing decoy and/or EO/IR capabilities weighing no more than 25 lb. RFI responses are due by January 15. The PdM AEROS point of contact is Mr. Adam Terio, e-mail adam.a.terio.civ@mail.mil.

The Naval Information Warfare Systems Command (NAVWAR), Naval Information Warfare Center Atlantic and Naval Information Warfare Center Pacific participated in an **Information Warfare Research Project (IWRP) Consortium** Virtual Quarterly Industry Day on December 9. The event included briefings on eight Requests for Prototype Project (RPP) topics, including an Electronic Maneuver Warfare Mobile Module (EMWMM) (Project Number 21-LANT-0177). Under this effort, the Navy is seeking a prototype for electronic emitter detection, identification, classification and localization, capable of remote operation. Proposals for this effort are due on January 15. More information is available to consortium members at https://www.theiwrp.org.

US NAVY'S HAVOC H

By John Haystead

The US Navy has a long history of embracing the Airborne Electronic Attack (AEA) mission. Even in the 1990s, when the US Air Force retired its F-4G Wild Weasels and EF-111 Ravens and shrank its cadre of EW experts, the US Navy fortunately continued to stay-the-course and even managed to improve its capabilities and training. As a result, today, the Navy is still able to provide advanced AEA capabilities for its own and Joint mission needs, as well as to help other Services plan and train for the future AEA mission.

The heart of its efforts can be found at the Naval Aviation Warfare Development Command (NAWDC). Located at Naval Air Station Fallon (Fallon, NV), NAWDC is the Navy's overall center for aviation training and tactics development, providing flight training, instructional classes and direct operational and intelligence support. The command flies and maintains F/A-18C/D Hornets, F/A-18E/F Super Hornets, E/A-18G Growlers, F-16 Fighting Falcons and MH-60S Seahawk helicopters. As described in its mission statement, NAWDC also "provides subject matter expertise to support strike group commanders, numbered fleet commanders, Navy component commanders and combatant commanders; to lead training and warfighting effectiveness assessments and identify and mitigate gaps across all platforms and staffs for assigned mission areas."

One of these mission areas is fulfilled by the Navy's Airborne Electronic Attack Weapons School, call sign "HAVOC," which was formed in 2011 to address Electronic Warfare (EW) and specifically EA-18G Growler training and tactics development. As described on the NAWDC website, HAVOC is "comprised of highly-qualified Growler Tactics Instructors (GTIs) that form the 'tactical engine' of the EA-18G community, developing the tactics that get the most out of EA-18G sensors and weapons," as well as training Growler aircrew and intelligence officers on those tactics.

Speaking broadly, HAVOC's commanding officer, CAPT Brett Stevenson, says NAWDC performs three primary missions, the first being air-wing training. "As a part of every carrier air-wing's training cycle, they will come together at NAWDC and mission plan and fly events on the range here in order to integrate and be ready to go out and perform with the carrier strike group and maximize their capabilities there." Every carrier air wing includes a Growler squadron, and HAVOC generates all of the tactics, techniques and procedures for the Growler. These are presented to Growler squadrons as they go through their normal workup training cycles through an advanced readiness program known as the Growler Weapons and Tactics Program (GWTP), at both Fallon and by the wing type's Electronic Attack Weapons School (EAWS) at Whidbey Island, WA. The EAWS is collocated with operational and training squadrons. Says Stevenson, "The GWTP is the training continuum that all Growler aircrews progress through as they attain tactical qualifications of increasing skill and responsibility in effectively employing the Growler's capabilities."

> "We put the GTI candidates through a PhD-level course of instruction that is really focused on the precise execution of the latest Growler tactics generated here at HAVOC and really how to integrate the platform's capabilities with Naval and Joint forces," says Captain Stevenson.

The NAWDC's second mission is to take junior officers and transform them into tactics instructors – ultimately returning them to their community as experts on their platforms. NAWDC is responsible for all of the Navy's Weapons, Tactics, Instructor (WTI) courses including Top Gun; HAVOC; Carrier Airborne Early Warning Weapons School (CAEWWS), which provides graduate-level command, control, communication, battle management, and training to E-2 Hawkeye aircrew; and the Navy Rotary Wing Weapons School for the helicopter community.

As described by Stevenson, when arriving for the HAVOC GTI course, "these lieutenants are really coming off their first squadron tours and are at the top of their game professionally and tactically." A typical flow is that of a freshly-winged pilot first reporting to the VAQ-129 ("Vikings") Growler Training Squadron. Also located at Whidbey Island and known as the fleet-replacement squadron (FRS), VAQ-129 is where new aviators and flight officers will receive their initial training on the Growler, spending approximately a year (8-14 months) learning how to operate the platform before reporting

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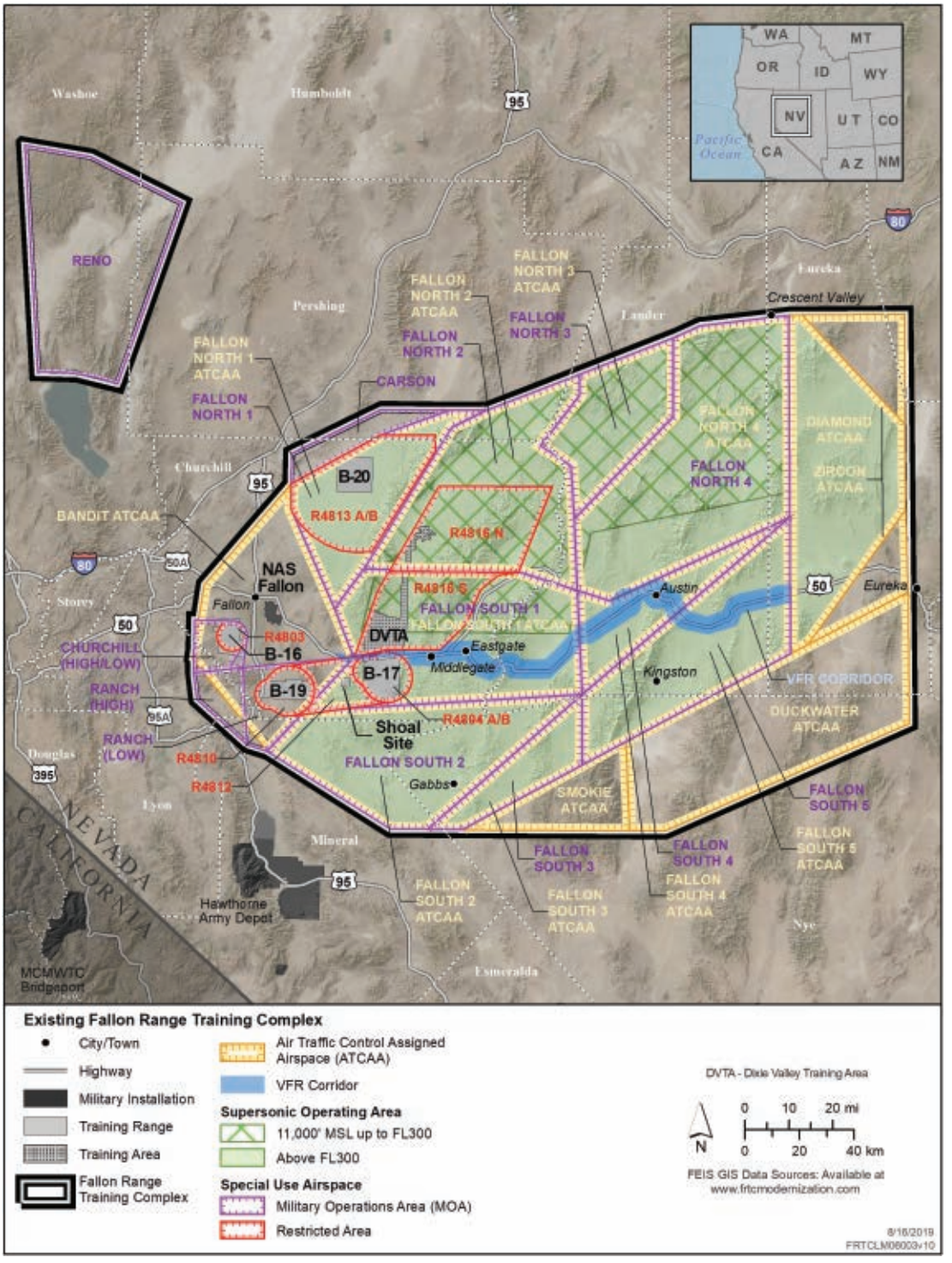

The Fallon Range Training Complex is made up of 12,256 square nautical miles of airspace and approximately 232,000 acres.
US NAVY

to their first operational squadron for about a three-year operational tour. "At the conclusion of that, and having deployed and gained qualification, they will then be ready to apply to the GTI course," says Stevenson.

Stevenson says the GTI course is intended to take the talent and expertise of junior Growler officers to the next level. "We put the GTI candidates through a PhD-level course of instruction that is really focused on the precise execution of the latest Growler tactics generated here at HAVOC and really how to integrate the platform's capabilities with Naval and Joint forces. We focus on developing their instructor skills. We have a rigorous debriefing process after each course event, and this really provides the basis for honing their skills as instructors, which is ultimately what they will do when they finish the course."

The GTI course consists of a 14-week syllabus of academic, simulator and live-flight events. Says Stevenson, "Our goal here is to first introduce material in the classroom and then focus on honing those skills in the virtual environment and simulator. We then build muscle-memory in perfecting the tactical execution before moving on to performing those skills in an aircraft."

Live-flight events at both the Fallon Range Training Complex (FRTC) (east of Reno) and the Nevada Test and Training Range (NTTR) (northwest of Las Vegas), are used to capture learning points during the debrief process and then "we'll go back into the simulator to drive those lessons home. So, it's really a process that gives our students the best exposure to the latest tactics, and it teaches them a methodology to become effective instructors themselves." For the live-flight exercises, HAVOC has five Growler aircraft of its own at NAWDC and also receives Growlers drawn from the squadrons at NAS Whidbey Island.

TRAINING RESOURCES

The Fallon range training complex was conceived in the 1970s and 1980s as a place where carrier air wings could conduct strike warfare against an air defense system that replicated the capabilities and tactics of the Soviet Union. Says Stevenson, "As we continue to look at the capabilities of our adversaries today and in the future, we have to be sure to make the right investments in our training systems to provide threat-representative EW training on the Fallon range. Today's National Defense Strategy clearly re-establishes the great-power competition as the new reality, and the importance of that task for us in getting those training systems is really important. Fallon is the only place in the entire Naval aviation enterprise where a carrier air wing can come together and operate in an integrated fashion and experience that end-to-end validation of our tactics and the sensors and weapons systems on our aircraft. That end-to-end testing is truly essential. It is the last time that an air wing will be able to get that validation before deploying. As a Naval aviation enterprise, we're focused on ensuring that this range is resourced and equipped with the right types of training systems that will prepare our air wings to be successful in the great-power-competition fight. We've got to strike the right balance here to ensure that this range is properly resourced."

Live-flight training for the GTI course takes place both at NAS Fallon and at Nellis AFB ranges. As described by Stevenson, there are three phases to the process. "We begin with an air-to-air phase that hones the overall skills of our students to make them better in the aircraft and give them the tools and expertise to be able to teach basic fighter maneuvers and master the latest tactics in the beyond-visual-range arena. We then move into the Airborne Electronic Attack phase, which focuses on the skills that are needed to effectively integrate sensors together with both kinetic and non-kinetic capabilities on the Fallon Range Training Complex, as well as in simulators and the academic environment. The third and final phase of the course involves an entire month spent with the Air Force Weapons School at Nellis AFB, where our students will learn to integrate in a Joint environment."

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JOINT TRAINING IS CRITICAL

Stevenson emphasizes the importance of including Joint training and exercises as part of the GTI program. "When we think about an air-defense system, we try to approach it in a systematic way, where we will bring everyone together that has capabilities both kinetic and non-kinetic and figure out what the most effective means are to degrade that system. It may be jamming, it may be a HARM or AARGM coming off of a Growler, or it could be a Growler directing another Super Hornet or F-16 to deploy the weapon if that makes the most sense. It's really about understanding what capabilities the Growler and other platforms have at their disposal in prosecuting that air-defense system and then using that in the most effective way to accomplish the task."

Says Stevenson, "The Air Force also brings some unique non-kinetic capabilities to the table that provides a fantastic opportunity for us to collaborate and mission plan on live-flight events at the Nellis range. When you bring together all those non-kinetic players in a joint environment, including the Growler, the F-35, Compass Call, cyber and space looking at an air defense system in a holistic way, using all those capabilities, that kind of synergy of effects allows us to take down an air defense system in a much more effective and efficient manner. It is this kind of joint integration that is really the focus and capstone event of our course. These are the same weapons-school students on the Air Force side that will be mission planning in future deployments and conflicts, and so it is really an operation to understand what each of those platforms brings to the fight and how to integrate and mission plan together. So these relationships will last our GTI students throughout their careers and are a key part of our training."

A typical GTI class comprises eight students – four pilots and four Electronic Warfare Officers (EWOs). It will also include anywhere from one to three intelligence officers going through the intelligence officer portion of the course. These will become Growler Intelligence Officers (GIOs) or non-kinetic "targeteers." GIOs are fully integrated in the mission planning, execution and debriefing process together with the Growler operators. They integrate into the broader Carrier Air Wing Intelligence Team, applying their non-kinetic targeteering expertise to aid in mission planning and to inform the efforts of intel collection managers for the entire carrier strike group. Upon completion of the course, GIOs will either go back to their squadrons to complete their tour, while others will end up on the NAWDC staff at HAVOC or at Strike, or at the EAWS at Whidbey Island. As Stevenson says, "the goal is to fully-leverage their experience and expertise by putting these intelligence officers into key spots in the Growler community."

Speaking with regard to the relative importance of the Growler Intelligence Team, Stevenson emphasizes that, "Intelligence support is absolutely essen-

tial in EW, and that mindset begins at HAVOC. We teach the only platform-specific intelligence officer WTI course in Naval aviation. Though it is tailored for the intelligence mission, Growler intelligence officers go through the same 14-week GTI instructor course, fully integrated in the mission planning and the execution and debriefing process. This approach is mirrored in our operational Growler squadrons, where our intelligence teams, the officers and the enlisted intelligence specialists and cryptologists specialize in non-kinetic targeteering. This is a unique capability that we continue to build because kinetic targeteers have always been embedded within carrier air wing staffs to provide specialized expertise for effectively employing in the kinetic realm. But we're building a cadre of subject matter experts so that our non-kinetic capabilities are also delivered to maximum effectiveness. These will also be resident within the carrier air-wing staffs, augmented by the Growler squadrons."

Similarly, tactics-instructor graduates of the GTI course will serve two-year instructor tours at either HAVOC or EAWS, before returning to fleet squadrons as training officers. Says Stevenson, "They are the conduit and connective tissue between HAVOC and the fleet squadrons, teaching their squadrons how to perform the latest tactics," says Stevenson. The GTI Tactics Instructor designation is the highest level of EA-18G tactical qualification. Both GTI and GIO graduates receive patches, with slightly different designs delineating their areas of expertise.

PREPARING FOR NEXT-GENERATION CAPABILITIES AND CONFLICTS

Captain Stevenson says that when he thinks about the overall mission of HAVOC, there are really three pillars to what they do. In addition to flight crew training and advanced instructor education, "we're in a continual process of understanding new threat capabilities and where our own capabilities might need to be modernized or updated to address them. When a new GTI arrives on staff here, they spend about a year just digesting everything they can about their particular area of expertise, and it is then that expertise that can inform everything else that we do. One of those things is tactics development and evaluation. Generating the tactics that make the procedures for the Growler platform is one of the primary missions here at HAVOC and that extends to informing all of the operational planning that happens across the theaters. There is a tremendous demand for this expertise so that decision makers will be operating at a highly-informed level."

Keeping pace with the threat, as well as own capabilities, necessarily means being highly informed and involved in ongoing technology and system development. In that regard, HAVOC is closely tied into next-generation AEA capabilities, primarily the Next Generation Jammer (NGJ) development program, helping to define requirements and testing to them. As the replacement for the ALQ-99 Tactical Jamming System, NGJ is considered the most significant leap in Navy EW since the introduction of the

SCALE FOR THREAT SIMULATION

Easily scale from a single threat source to a comprehensive multi-threat simulator

The workflow to test and evaluate an electronic warfare (EW) system involves stages ranging from system simulation to system integration, hardware in the loop, and an installed system prior to open air range testing. This process is time consuming and expensive. You want to avoid the cost of failure and the burden of finding out what went wrong. Conducting RF tests that most resemble real-life conditions early in the development process is critical, as moving into open air range testing increases the cost of error. Keysight has decades of RF expertise in test and measurement to help you confront these issues.

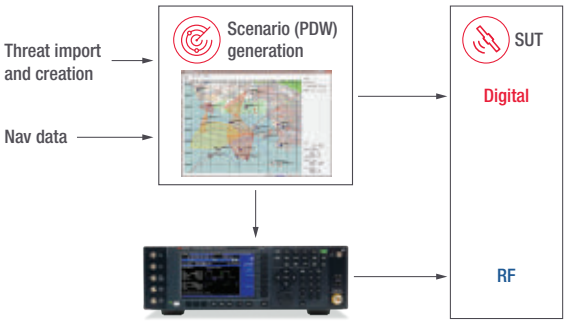
What Are the Benefits of Keysight's Approach?

The UXG is a versatile building block to achieve desired results at any stage:

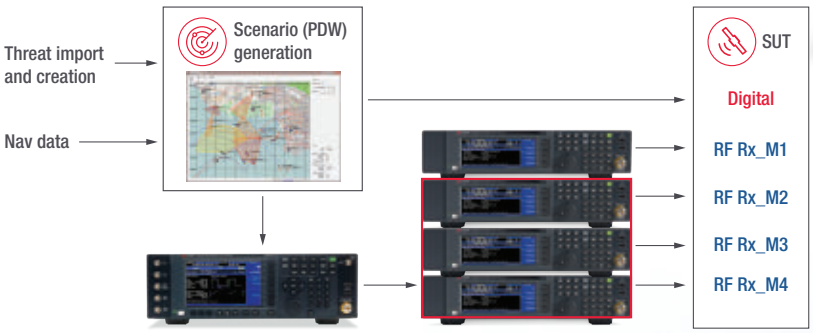
- High-Density Simulation
- All Test Environments & Fidelity Levels
- Open Architecture
- Variable and Scalable
- High-Performance Commercial Off the Shelf (COTS)

Got Benchtop?

Single agile signal generator: The UXG agile signal generator's ability to fast frequency hop with phase continuity and repeatability makes it an ideal building block to efficiently simulate complex threat environments including: multiple pulse-Doppler radars; EW scenarios; and high pulse density environments.



Add a UXG vector adapter: The digital IQ baseband system in the UXG Vector Adapter enables you to create more complex pulses with variable rise/fall times and arbitrary modulation within the pulse, including non-linear chirps and communications signals.



Scale to higher port counts by adding vector adapters

Generate PDWs

The UXG's flexible architecture and legacy threat library import capability replaces current RF sources or integration into new threat simulators. Simply use existing Pulse Descriptor Word (PDW) libraries or create them using a variety of tools such as Excel and MATLAB. Keysight's Multi-Emitter Scenario Generation Software (MESG) generates pre-scripted scenarios and Simulation View Software allows dynamic scenario creation.

Need an Integrated System Solution?

Keysight's threat simulation systems provide many options for scaling to higher port counts, higher performance calibrations, thermal control, customized switching, and more. Our systems team has decades of experience in delivering and supporting solutions across multiple industries, greatly reducing risk and long-term costs.

Create high-density angle of arrival (AoA) simulations with flexible multi-port configurations:

- Ensure coherency across multiple sources with calibration of amplitude, phase, and time
- Threat simulators compatible with MESG software or other dynamic, PDW-based scenario generation systems
- Perform automated, inline AoA calibrations for time, phase, and power that compensate for temperature drifts with constant thermal control using COTS equipment

Threat Simulation Solutions for Your Program's Duration

Whether you need a building block or a turnkey threat simulation system, Keysight can slash schedule risks with fast delivery of high-performance COTS equipment and optional maintenance, up-time support, and sustainment services.

For more information on Keysight Technologies' products, applications, or services, please contact your local Keysight office.

Visit http://www.keysight.com/find/scale4ew to find out more.

KEYSIGHT TECHNOLOGIES

The Navy NGJ Mid-Band pod began flight tests in August 2020. US NAVY

Growler itself, providing a significant increase in power, coverage, versatility and capacity. Says Stevenson, "We know that it's critical to HAVOC's success that we be fully embedded with the test community and with the program managers at PMA-234 [Naval Air Systems Command's Airborne Electronic Attack Program Office], and their industry partners so that the integrated test plan for NGJ would be informed as to how our tacticians would employ its capabilities." Indeed, HAVOC has been working alongside the NGJ flight test team as the NGJ Mid-Band (MB) system has gone through its developmental and operational testing program. "It's really so that we can validate the tactics and provide additional employment recommendations so that the first operational squadron that is equipped with it is able to bring its full range of capabilities to bear." The NGJ-MB system consists of two pods, or a shipset, to be carried by the Growler.

Early last year, the NGJ-MB Engineering Development Model (EDM) pods, developed by Raytheon (El Segundo, CA) completed more than 400 hours of basic functionality, Electromagnetic Environmental Effects (E3) data collection and performance testing over a period of three months in the Air Combat Environmental Test and Evaluation Facility anechoic chamber at Naval Air Station Patuxent River, Maryland. More recently, the program has begun flight testing the pods on an EA-18G. Initial operational capability of the AN/ALQ-249(V)1 NGJ Mid-Band (NGJ-MB) is expected sometime in 2022 to be followed by NGJ Low Band (NGJ-LB), which is in early development, and NGJ High Band (NGJ-HB), which is still in the study and planning stage. Initially, however, the NGJ-MB systems will serve to augment the legacy ALQ-99 Tactical Jamming System until the low- and high-band components are ready to deploy.

Further down the road, HAVOC is also deeply involved with the Growler Block 2 acquisition process. As described by Stevenson, "One of the other primary functions of HAVOC is to take the SMEs and use them to inform the acquisition process. We're right there informing requirements, and working with our industry partners and resource sponsors to make sure that we get the right capability out of Growler Block 2, so that will bring significant advances in sensor technology, raw processing power, improved crew vehicle interface with larger displays, and many other advances. It will really transform how aircrew effectively employ the full range of capabilities that the Growler Block 2 will offer." The Block 2 variant upgrade, expected to be fielded sometime in the mid 2020s, will reportedly include an improved AN/ALQ-218(V)4 ESM system, as well as the AN/ALQ-227(V)2 Communication Countermeasures Set (CCS), together with a new open architecture processor and advanced networking allowing the Growler to better operate with and leverage other aircraft, such as the Navy's F-35C stealth fighters, which also incorporate unique AEA capabilities.

INTERNATIONAL PARTNERS

The critical importance of effective Joint AEA operations extends beyond

just the Navy and its sister Services. It also includes international allies, and particularly in the case of the Growler, it includes the Royal Australian Air Force (RAAF) which also flies the aircraft. In fact, in July, the two countries expanded on their joint relationship with the signing of a new NGJ cooperative partnership for the NGJ-LB. The NGJ-LB Project Arrangement (PA) is intended to ensure commonality on future jamming variants and according to the announcement provides benefits to both countries to include shared costs and risks.

At the time of the announcement, the NGJ-LB program was in materiel solutions analysis phase "executing two Demonstration of Existing Technologies contracts with L3Harris and Northrop Grumman Corporation. The program will enter the next phase of acquisition when the Capability Block 1 contract is awarded fall 2020." NGJ-LB will utilize the latest digital and software-based technologies that will address advanced and emerging threats in the lower frequency bands of the electromagnetic spectrum.

The two countries also signed a second memorandum of agreement in May to enter production, sustainment and follow-on development of the NGJ-MB and follow-on variants. Says Stevenson, "We have a fantastic relationship with our RAAF partners, spending a great deal of time together to ensure that the relationship is a robust one. In that part of the world, they will be an important partner in any kind of peer fight."

Germany's Luftwaffe is also reportedly moving ahead with the acquisition of a number of EA-18G aircraft. Its Tornado EW aircrews already regularly fly and cross-train with VAQ-129 at Whidbey Island.

NAVY AEA IS HERE TO STAY

Although the Navy was more astute than others in recognizing the importance of maintaining and improving its AEA systems and, most of all, its expertise in AEA, the critical nature of the capability was not always universally appreciated in this Service either. As Captain Stevenson recalls, "It's been really fascinating to watch over the last twenty years where the legacy Prowler was not well understood within the air wing. The air wing knew that it could affect the IADS, but they didn't really seek to understand or integrate its capabilities. Fast-forward to today, the Growler is foremost for every person in the air wing from the Carrier Air Group (CAG) Commander on down, because non-kinetic capabilities are absolutely essential in every warfare area the carrier air wing conducts. This is true for our expeditionary squadrons also as they integrate with the Air Force. Whether its air defense or power projection or a strike mission, the Growler is absolutely essential and there is increasing awareness of this. It can be seen in the relationship that we've built here with our other weapons schools at NAWDC, particularly Top Gun, so that we can really synergize our capabilities and, at the end of the day, it's about making sure that the carrier air wing is as survivable as possible, so that it can be as effective and lethal as possible. The Growler is really what facilitates that."

Protecting Europe'

By Andrew White

The Great Power Competition is emerging as one of the most significant strategic challenge facing Europe. Following Russia's annexation of Crimea in 2014, Ukraine, the Baltic States and Poland, as well as other eastern European states, remain on high alert to repel any similar incursions. As a result, European and NATO partner forces continue to conduct extensive joint training programs aimed at enhancing conventional and unconventional capabilities in a bid to deter and potentially respond to enemy activity. Similarly, ground forces are considering how best to protect some of their most valuable battlefield assets (including main battle tanks (MBTs), infantry fighting vehicles (IFVs), armored personnel carriers (APCs) and other tactical ground vehicles) from increasingly mature weaponry emerging out of Russia, as well as the People's Republic of China (PRC). Threats include anti-tank guided munitions (ATGMs), armor-piercing fin-stabilized discarding sabot (APFSDS) rounds and other high-explosive (HE) projectiles.

Solutions available to European armed forces include "hard kill" active protection systems (APS) and passive protection systems (PPS), the latter of which includes "soft kill" capabilities. Indeed, many armed forces are seeking to implement a layered approach to vehicle protection by combining a mix of both hard-kill and soft-kill solutions, in addition to maturing concepts of operation and tactics, techniques and procedures to aid camouflage, concealment and distraction.

Anti-tank weapons have co-evolved with armored systems for more than a century, and the competition during World War II and through the Cold War to today. Rheinmetall's lead for soft-kill protection systems, Martin Fegg, warned of the ongoing proliferation of anti-tank weapons from Russia and the PRC. "Whether you are in the Gulf of Aden or Strait of Hormuz or in Syria, armed forces could be threatened by former eastern bloc technology, which has now proliferated to almost everybody," he warned before specifically referring to Russia's APFSDS laser-beam-riding 9M133 Kornet anti-tank missile and China's radar-guided C802 anti-ship missile. "These are the weapons which all navies, air forces and armies could be attacked with, particularly during international missions. It's difficult to understand their guidance systems. But this is the good thing about passive soft-kill solutions," Fegg added.

Discussing specific Russian-manufactured threats, industry sources described how emerging anti-tank solutions capable of penetrating NATO armor types included 9M123-series (Khrizantema) and 9M127-series (Vikhr) munitions, as well as 9M120-series (Ataka) munitions, which are launched at a faster velocity than the Kornet system.

This technology has been proliferating for years. At an October 10 military parade celebrating the 75th anniversary of The Workers' Party, the Korean People's Army displayed a series of next-generation anti-tank solutions integrated on board main battle tank (MBT) and mobile gun systems. Weapons bore striking resemblance to Russian-manufactured 9M133 Kornet-E and Israeli-manufactured Spike NLOS munitions.

ATGM threats, such as Russia's 9M133 Kornet (above), are susceptible to soft-kill countermeasures. RUSSIAN MOD

And these threats are not limited to simply defeating armor. Industry sources also explained emerging CONOPS and TTPs, which could deliberately target a ground vehicle's active or passive protection systems with high explosive projectiles or specially designed high-fragmentation, airburst designs. Additional threats include rapid or volley fire by armor-piercing APFSDS rounds and anti-tank guided munitions such as the Kornet. "What happens should one round damage and negate the APS system and potentially blind the vehicle?" one industry source asked.

INDUSTRY OFFERINGS

According to Stefan Thelin, Head of Technologies at BAE Systems Hägglunds,

s Ground Vehicles

active defense systems commonly utilize various means of protection which can be activated at close range and are designed to destroy, disrupt or degrade an incoming missile or projectile, thus eliminating or reducing its penetration capability.

remain very mature. "Our APS soft-kill system is fielded and has been used on our platforms since 2004, hence it is considered to be Technology Readiness Level [TRL] 9," Thelin said. "The APS hard-kill system is currently fielded on

egies for other platforms in the future." Some of these future programs are likely to include the integration of APS on board AJAX and MIV tactical ground vehicles, although any mix of hard-kill and soft-kill effects have yet to be decided.

Rheinmetall's ROSY (at left, installed as part of an integrated soft-kill system on the turret of a Leopard 2 MBT Revolution configuration) is also part of the UK MOD's Icarus program. (Rheinmetall Defence) RHEINMETALL DEFENCE

"APS commonly consist of an array of soft and hard kill technologies," Thelin explained. "Soft kill technologies are usually meant to confuse an incoming missile, using decoys, smoke and electro-optical signals, infrared or laser jamming – they are often a combination of all of these. Hard kill technologies are designed to intercept and destroy or reduce an incoming projectile or missile before it hits its target. Countermeasures include fragmentation charges, steel bars and high pressure shock waves that will destroy the threat, destabilize it or disrupt its flight path."

"We would define soft kill and hard kill capabilities within the APS umbrella in the following way; for soft kill, these are countermeasures that are capable of protecting the platform in a way that does not destroy the incoming threat but more likely changes the signature (visual, IR, RF) of the target to be protected. For hard kill, the countermeasures are actually capable of destroying the lethal part of the incoming threat," Thelin added.

Soft-kill protective solutions currently available to armed forces in Europe

fewer platform. However, the technology is mature enough. We will integrate such systems as part of an APS system on a CV90 for a customer in the near future," he added.

Just as industry is gaining more experience developing and manufacturing soft-kill and hard-kill systems, equipment users are also gaining experience with them, which helps with requirements, acquisition and support one a system is fielded. The British Army, for example, is one service that is in the process of considering APS to protect in-service and future vehicle programs.

A spokesperson for the UK's Defence Equipment and Support (DE&S) organization explained, "both active and passive protection systems could provide useful capability and should be considered as part of a layered approach." The spokesperson added, "DE&S is still considering the procurement strategy options. Future strategies will depend on how the technical and commercial landscapes mature. The current focus is on Challenger II [Life Extension Program]. This will not prejudice alternative strat-

Many of these requirements are being considered as part of the UK Ministry of Defence (MOD) Icarus Technology Demonstrator Program (TDP) which aims to "develop, demonstrate and verify a Modular Integrated Protection System (MIPS) architecture based on open systems and model driven principles that will provide an architectural and infrastructure foundation for the modular integration, affordable acquisition and safe deployment of 'best in class' APS sensors and effectors," explained Ray Hopkins, Leonardo's program lead for Icarus.

Led by Leonardo, the Icarus consortium includes Lockheed Martin, the Rheinmetall BAE Systems Land (RBSL) partnership, Roke, SCISYS CGI and Ultra Electronics. According to Hopkins, the contemporary spectrum of threats (comprising unguided and guided threats, as well as improved explosive devices) is anticipated to continue to evolve thereby demanding countermeasures solutions that feature mix of soft-kill and hard-kill defeat technologies to provide protection. "An integrated approach to platform

survivability that combines both active and passive defeat mechanisms is now an operational necessity," he explained. "The variety and performance of soft-kill (passive) and hard-kill effectors will also continue to develop at pace to counter the evolving threat space and for example, electronic counter-measures (ECM) and directed energy weapons (DEW) could also be integrated as part of a platform's modular integrated survivability solution," he continued.

According to Hopkins, passive solutions can be employed as part of a minimum escalation of force, particularly useful in cluttered and dense urban environments where the risk of collateral damage by hard kill effectors associated with APS remains high.

The Icarus TDP was scheduled to have conducted its latest demonstration in October. However, due in part to ongoing restrictions relating to the COVID-19 pandemic, the next demonstration is scheduled to run this month, featuring the integration of soft-kill effectors in order to highlight a more layered approach to vehicle protection. "The test event will see a holistic solution going through its soft-kill effects first. If not deemed capable of countering a specific threat, the solution will move to a more active (kinetic) countermeasure," Hopkins explained while describing how a "representative director mechanism" (provided by Moog) would be used to cue soft-kill and hard-kill effects.

The demonstration will feature Rheinmetall's multi-spectral Rapid Obscuring System (ROSY), which is designed to protect vehicle crews from "surprise attacks and ambushes during reconnaissance patrols or while travelling in convoy". "Unlike conventional smoke and obscurant systems, ROSY produces within one second an instantaneous, large-area, multispectral interruption of the line of sight that shields even moving vehicles with a dynamic, long-lasting smoke screen," according to Rheinmetall's description of the system. This 360-degree solution is also capable of protecting a ground vehicle via the effective screening of visual and infrared spectrums, including integrated IR jamming and decoying effects.

Hensoldt's's MUSS 2.0 is already integrated on board German Army Puma infantry fighting vehicles and will be available for the PUMA's second production lot. PSM

ROSY also counters weapons with optical devices and laser distance measurement. According to Rheinmetall's Fegg, ROSY interrupts the Line of Sight (LoS) of IR and laser beams between ground vehicles and the threat through the creation of a smokescreen. "ROSY counters all wavebands almost perfectly so a gunner cannot successfully aim at a target. With anti-tank missiles with semi-active command LoS [line-of-sight] guidance, obscurants confuse the incoming missile forcing it off course and into the ground," he explained.

ROSY, which can be integrated on board the full spectrum of tactical ground vehicles ranging from light utility vehicles up to MBTs and mobile artillery, is automatically cued by integrated sensors. Depending on the variant, between one and four ROSY launchers can be fitted on a ground vehicle with each launcher featuring up to three magazine rows. Each row measures less than 12 kg in all up weight when fully loaded, Fegg confirmed. The single launcher module ROSY "Mod" solution is designed for integration on board small weapon stations and light vehicles of the kind used by special operations forces. The ROSY "ISS" variant features an additional sensor suite comprising a series of built-in sensors for detecting infrared, laser and electro-optical threats. Additional options include the integration of a laser radar warner; thermal imaging TV; GPS; anemometer (the wind direction and speed determine where to deploy the obscurant around the vehicle); and an acoustic measurement device. Solutions also come with a manual control unit weighing 2kg.

Obscurant material is deployed by 40mm ammunition cartridges featuring multi-spectral red phosphorus smoke, which provides coverage in the near-IR, mid-wave IR and long-wave IR spectrums. The solution also provides effectiveness against electro-optical sensors operating between 400nm and 1,000nm in addition to laser systems operating in 550nm and 1,500nm.

The Icarus solution will also feature RADA radar technology in addition to thermal imaging camera technology provided by Leonardo, designed to collect IR signature data. Describing how a baseline soft kill capability could be integrated with a hard-kill system, Hopkins explained, "If you look at the majority of systems running around at the moment, that might be a basic fit. But the two are probably not that well integrated. In a baseline MIPS configuration, the two components would be integrated. Vehicle crews need to be directed by the system to move. And obscurant needs to be fired in the right arc to obscure the vehicle from the threat which is consistent with the direction it wants to move. For example, the vehicle must move behind the obscurant instead of moving outside of the screen created. That would be purely and simply soft kill with obscurant only and no active protection system," Hopkins added, before describing how such a basic fit might also include missile approach warning systems and

optical jammers to detect kinetic energy threats. "Obscurants can be used to protect a vehicle from a threat," he explained, "and if that doesn't work, vehicle crews can engage that same threat with a hard kill system."

DENSE URBAN ENVIRONMENTS

Discussing specific vehicle protection requirements associated with complex operations in dense urban environments, Hopkins described how soft-kill/passive protection systems could be used during peacekeeping support operations (PSO) in addition to full combat operations in built-up areas. "In the early days of the US armed forces getting into Baghdad in 2003, they took M1A2 Abrams MBTs into Baghdad. Everything fired at them were rocket propelled grenades [RPGs], and in that scenario, if you had it, hard-kill protection systems would be able to take down whatever was fired at them. But once the armed forces had transitioned into PSOs, commanders had an operational dilemma which focused on the need to be seen in order to maintain peace in the city while also being under threat from close range RPGs. In the urban scenario, insurgents could step out from behind a wall less than 100m away and fire an RPG. In that scenario, soft-kill is not effective," he added.

Hopkins also discussed how passive protection solutions lent themselves to operations in the GPC against peer and high-capability adversaries, including the Russian Armed Forces in Eastern Europe. "I can probably see a combination of sensors and soft kill, more appropriate to a more conventional [type of] maneuver warfare against a near-peer/peer threats. You potentially wouldn't want an active protection system to be transmitting permanently across the battlefield – you would be detected very quickly," he said. "Ideally, you would want a MIPS system to [passively] monitor the environment, to understand where the threat is being launched from and where it is heading. Radar and active sensors would then detect and track that threat and deploy soft-kill countermeasures allowing a vehicle to move away from the threat in the first instance. If that failed, a hard-kill effector could then be deployed. This is very much the way soft- and hard-kill sensors could be used depending upon the operation at hand, rules of engagement and ultimately, conflict scenarios. This is ultimately where we need to go to – the ability to detect a threat before it has been fired. If you can do that, you're able to bring other measures to bare which are less offensive than hard kill effects, including dazzle type solutions."

Similar sentiments regarding the integration of soft- and hard-kill systems were shared by Rheinmetall's Fegg who explained, "Soft kill is camouflage and deception. As a company, we are not working on jamming or active electronic countermeasures. So for vehicles, Rheinmetall is concerned with smoke systems for ground vehicles; decoys and smoke systems for surface vessels; and typical chaff and flares for aircraft. We worked in the past on an IR jamming device although we stopped this development a decade ago. But this could definitely be a way ahead in the future. Any jamming would be complimentary to passive protection."

Discussing alternative soft-kill solutions that would include jamming devices, Fegg warned how they must retain up-to-date knowledge regarding the guidance systems of anti-tank munitions. "Passive protection systems have to send specific modulated signals towards the missile guidance systems to confuse the system or to generate a misleading signal," he explained. "For this case, you need to know very precisely the algorithms and principles of the guiding systems. If you do it wrong, a jammer could attract a missile instead of misleading it. If you have a passive soft-kill system – independent from the guidance system – you're able to just interrupt the line-of-sight of the missile, meaning the weapon cannot be aimed at the target. That's the advantage of passive against active protection systems."

According to Fegg, the most effective protection system for ground vehicles comprises a layered approach feature both active and passive solution. "The first layer is the soft-kill to interrupt the LoS of an incoming threat. The second layer is hard kill. A third layer would be the passive ballistic protection. Active jamming could come together with passive soft kill but this has to be coordinated somehow. It's rather like driving a car. You have seat belts, airbags and the electronic stability control system. Everything contributes to the safety of the driver," he explained.

Similar sentiments regarding the integration of soft- and hard-kill solutions into a unified and layered capability were expressed by BAE Systems' Thelin who said, "We believe that there is no internal competition between hard-kill and soft-kill systems. It is most likely that a combination of soft- and hard-kill capabilities will be used to optimize the survivability of a platform. As an OEM, we believe that the system integration and therefore the capability of the APS system – combined with other key systems and characteristics on a typical Infantry Fighting Vehicle, like anti-tank guided missiles, sight system, signatures, etc. – is the most critical part."

Rheinmetall is also considering the integration of additional frequency coverage into its obscurant solutions. "There are lots of spin-offs relating to ongoing projects with the army and navy, the latter of which is more concentrated on the radar side [with] passive protection. This could give us a spin-off for future army applications with smoke. Perhaps we need a microwave capability for radar sensors and missile seekers," Fegg suggested. "However, we have to convince some customers who are unconvinced about soft kill. When we give them the right explanations and expertise, they get more and more convinced about this. Passive soft-kill for a lot of people is black magic. Sometimes they don't trust the advertisements of the brochures. But they have to talk to the technology experts and then the decision makers to accept this technology more and more as an effective system for self-defense," Fegg concluded.

GERMANY

Elsewhere in Europe, Hensoldt (Taufkirchen, Germany) continues to provide its soft-kill Multifunctional Self Protection System (MUSS) to customers, such as the German Army, which uses MUSS on its Puma infantry fighting vehicles. According to the company's head of business line for countermeasures and ground protection systems, Dr. Oliver Rudow, Hensoldt continues to upgrade

BAE Systems is in the process of upgrading CV90 armored vehicles with protection systems for an undisclosed customer. BAE SYSTEMS

the MUSS as a "soft kill based" active protection system. "MUSS offers infantry fighting vehicles and main battle tanks efficient protection against enemy laser and armor-piercing threats," he said. "These can be effectively countered by warning sensors that detect the threat from missiles or lasers and initiate appropriate countermeasures."

MUSS was originally developed in the late 1990s by Hensoldt's predecessor, EADS GmbH. The system comprises a passive missile warning system (a variant of the company's AAR-60 MILDS) a laser warning sensor, an IR jammer and a smoke/obscurant dispenser. The latest MUSS improvements being undertaken by Hensoldt as part of a MUSS 2.0 design, include the integration of a new laser detector covering all modern laser threats. "MUSS 2.0 now offers improved and extended sensor technology, significantly improved software and modern countermeasures," Dr. Rodow said. "MUSS is being further developed into a layered system and offers modern interfaces, which, among other things, enable the integration of a hard kill effector. In addition, MUSS 2.0 will be even smaller and lighter than before," he added.

RUSSIA

Russia has long held a keen appreciation for soft- and hard-kill countermeasures against anti-armor threats. During the Soviet era, the KBP design bureau developed the Drozd, which is considered the first hard-kill APS, in the late 1970s. This used a 24.5-GHz radar to cue a countermeasures system that fired a 107-mm fragmentation round at an incoming RPG. While Drozd was not widely fielded with Soviet forces, it did cut a technology path for later APS systems, such as the Shtora-1 soft-kill APS in the 1980s and the Arena hard-kill APS in the 1990s.

Today, the Russian MoD is concerned with upgrading its own passive protection systems for ground vehicles following similar upgrades in ATGM technology developed by NATO member states. At the Army 2019 exhibition, TsNIItochmash unveiled a passive protection system integrated on board the 2S42 Lotos Self Propelled Gun, although reports regarding its test and evaluation program with the armed forces have not been disclosed. The undesignated protection system features a series of missile warning receivers which automatically deploy multiple AOB-5 aerosol grenades out to a maximum range of 50m to interfere with the LoS of electro-optical, infrared and laser guidance systems of incoming missiles. Beyond its integration on board the 2S42 Lotos, the protection system is understood to be in the process of being made available to other next-generation ground vehicles in the MOD's inventory, industry sources confirmed.

FUTURE

Looking to the future, Rheinmetall's Fegg believes passive protection systems will feature on ground vehicles to an even greater extent. "The market needs to be creative and consider what will happen in the next 10 to 20 years," he said. "Everybody knows development time in the military environment takes a while, so this means we have to start very early with new developments and adaptations to emerging threats. This is the most challenging thing. How to develop effective solutions against the future technology?"

Fegg believes the market will soon witness emerging demand signals from the end user regarding protection systems for unmanned ground vehicles. "UGVs are becoming more and more valuable, so it could make sense to have UGVs protected by obscurant countermeasures for example," he said, before highlighting an ongoing project being led by Rheinmetall Canada to integrate ROSY on board the company's Mission Master UGV. The company is also working with other UGV providers, he added.

Finally, BAE Systems' Thelin described how the next 5 to 10 years would see soft-kill capabilities becoming more integrated into hard kill systems, thereby providing a more complete APS suite for customers in Europe.

"On a technical level, more advanced soft kill countermeasures could be introduced – perhaps even creating a different electromagnetic signature," he concluded.

Space EW – Part 26

Jamming Satellite Uplinks

By Dave Adamy

To jam the uplink to a satellite from the ground, the jamming signal must be received by the link receiver in the satellite. In order to determine the jamming-to-signal ratio (J/S), we must deal with the uplink from the ground station to the satellite and the link from the jammer to the satellite. Here is a problem that illustrates the process:

The satellite uplink has a 10-Watt (40 dBm) transmitter at 5 GHz with a 2-meter-diameter parabolic antenna. The jammer has a 1-kW (60 dBm) transmitter with a 4-meter-diameter parabolic antenna. The uplink receiving antenna in the satellite is a 1-meter parabolic antenna. All of these antennas have right-hand circular polarization, so all of the signals involved have matched polarization. The satellite is in a 300-km-high circular orbit. The satellite sub-vehicle point is at 100° East longitude, 40° North latitude. The ground station is at 103° East longitude, 42° North latitude. The jamming site is at 102° East longitude, 45°North latitude.

In this column, we will assume that the atmospheric and any rain loss are the same for the links from the ground station and the jammer, so they will not impact the calculations. To evaluate the effectiveness of the jamming, we must consider the jamming link and the satellite's uplink.

THE JAMMING LINK

Figure 1 is a spherical triangle formed by the satellite sub-vehicle point, the jammer location and the North Pole. *Side a* is the geocentric angle between the satellite sub-vehicle point and the jammer. *Side b* is 90° – the latitude of the sub-vehicle point. *Side c* is 90° – the latitude of the jammer. *Angle A* is the difference in longitude between the sub-vehicle location and the jamming site.

Side c = 90° – 40° = 50°

Side b = 90° – 45° = 45°

Angle A = 2°

The spherical law of cosines for sides is:

$$\text{Cos a} = (\cos b)(\cos c) + (\sin b)(\sin c)(\cos A)$$
$$= (\cos 50°)(\cos 45°) + (\sin 50°)(\sin 45°)(\cos 2°)$$
$$= (0.643)(0.707) + (0.766)(0.707)(0.999)$$

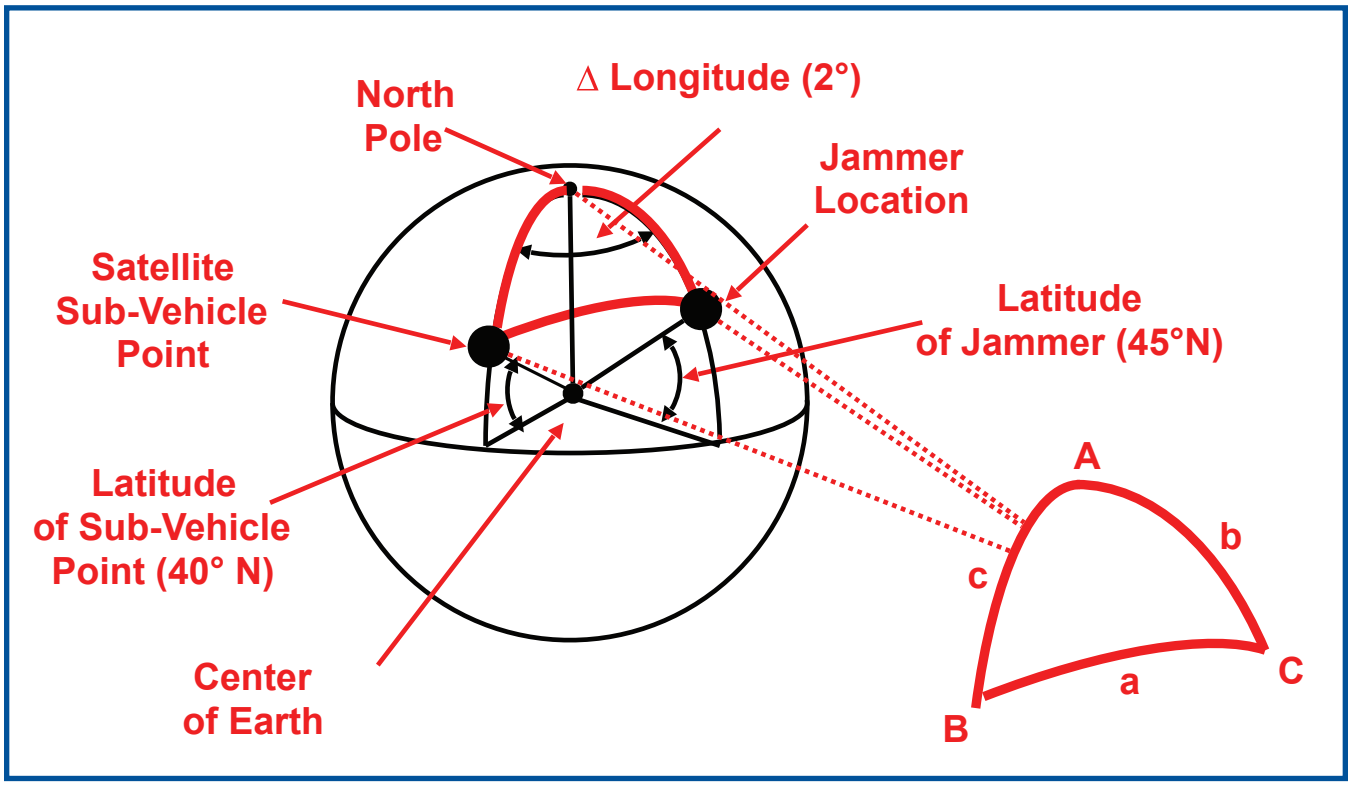


Fig. 1: *A spherical triangle is formed between the North Pole,the satellite sub-vehicle point and the jammer location.*

= 0.454 + 0.541 = 0.995

So *side a* = **5.73°**

Angle B in **Figure 1** is the azimuth from the satellite to the jammer. We can calculate this angle from the law of sines for spherical triangles:

Sin B = (sin b) (sin A)/(sin a) = sin(45°)(sin(2°)/sin(5.73°)

= (.707)(.0350)/(.0998) = .247

Angle B = **14.4°**

Now consider **Figure 2**. This is a plane triangle formed by the satellite, the center of the Earth and the jammer location. *Side d* is the range from the satellite to the jammer. *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 (5.73°) that we calculated as *side a* in the spherical triangle of **Figure 1**.

Angle D = 5.73°

Side e = 6,671 km

Side f = 6,371 km

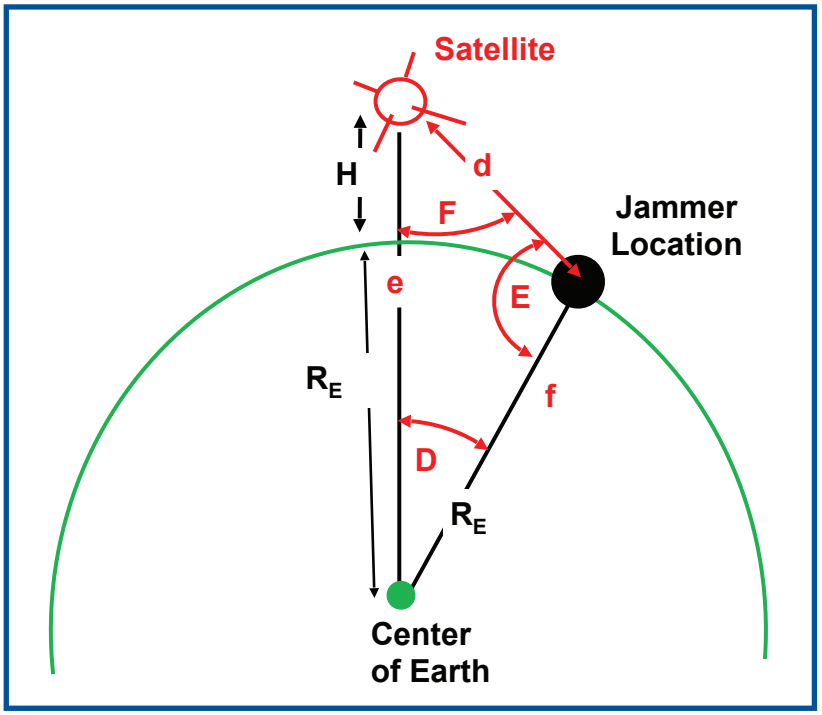


Fig 2: *The propagation distance between a receiving satellite and a jamming transmitter on the Earth's surface can be calculated from the plane triangle formed by the satellite location, the jammer location and the center of the Earth.*

The law of cosines for sides in plane triangles is:

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

= (6,671 km)² + (6,371 km)² – 2(6,671) (6371) cos 5.73°

= 44,502,241 + 40,589,641 – 84,557164 km²

= 534718 km²

d = sqrt(534718 km²)

= 731 **km**

JAMMING LINK LOSS

The propagation loss in the jamming link is line-of-sight:

$Loss_j$ = 32.4 + 20 log(d) + 20 log(F) = 32.4 + 57.2 + 74 = **163.6 dB**

Still in **Figure 2**, we can determine *angle F* from the law of sines for plane triangles:

Sin F = f sin D / d = 6371 sin(5.73°) / 731

= (6371)(.0998)/(731) = .871

Angle F = **60.6°**

GAIN OF 4-METER JAMMING ANTENNA AT 5 GHZ

The antenna bore-sight gain can be determined from the formula:

G = -42.2 + 20 log D + 20 log F

Where: *G* is the boresight gain in dBi,
D is the diameter of the antenna in meters, and
F is the operating frequency in MHz.

For the jammer antenna:

G = -42.2 + 20 log(4) + 20 log(5000)

G = -42.2 + 12 + 74 = **43.8dBi**

The ERP of the jammer is 50 dBm + 43.8 dBi = **103.8 dBm**

WHAT'S NEXT

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

Association of Old Crows

Award Recipients 2020

Every year, AOC recognizes individuals and units for their outstanding performance in furthering the aims of the Association of Old Crows in support of the United States or Allied Electronic Warfare (EW), Electromagnetic Spectrum Operations (EMSO), Cyber-Electromagnetic Activity (CEMA), and Information Operations (IO).

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2020 AOC NY METRO CHAPTER SCHOLARSHIPS – 'ABOVE AND BEYOND DURING COVID'

The Metropolitan Club Chapter of the Association of Old Crows has awarded STEM scholarships to worthy students for over five decades. In a typical year, the chapter has awarded two or three scholarships to proven STEM students in colleges and universities across the Metropolitan area in New York City, New Jersey and New York State. Though as we all know, 2020 is not a typical year.

COVID-19 changed many things this year. Many students are studying remotely, and even if studying on campus, masks, social distancing, and virus testing have become lead considerations and part of the daily routine. With COVID-19, though, one thing has not changed. Students still need to pay tuition, even if their school experience is fully or partially remote. However, in far too many cases, that burden is coupled with added pressure, as a result of COVID-19, on the students and their families to make ends meet. COVID-19 impacts included many students losing their part time work, not getting paid summer internships, or worst of all, entire families having to cut back due to lost employment or fewer hours for the parents. All of this is making that tuition bill seem, more than ever, a luxury. Yet we know that what our nation needs is more high performing STEM graduates to address the many challenges of the future, not less.

As with many large gatherings, this event was cancelled. Fortunately, the chapter was able to overcome all of these challenges in atypical fashion and exceed the planned 2020 scholarship awards. This year, the chapter was able to not only overcome challenges of COVID-19 on all fronts, but also increase this year's investment in STEM education through additional scholarships. The generous support of Northrop Grumman, BAE Systems, L3Harris and Comtech PST, coupled with the personal donations of chapter members, made all of this possible and created something good out of the challenges of COVID-19.

As a result of these efforts, the chapter is happy to report it has awarded four scholarships this year to Alfred Barlotta ($5,000 / Stony Brook University), Tejinder Mann ($5,000 / New York Institute of Technology), Eric Ciccotelli ($2,500 / Manhattan College), and Jason Huang ($2,500 / Stony Brook University). All are pursuing degrees in either electrical engineering or computer science. As is typical in this year of COVID-19, a Zoom award virtual ceremony was held on 12 November 2020 to recognize the outstanding accomplishments of these students and give the chapter the ability to gather.

2020 DIXIE CROW CHAPTER HONORS SwRI AWARD WINNERS

Lisa Frugé-Cirilli, AOC immediate past president, was honored to attend and represent the AOC at the SwRI (Southwest Research Institute) Warner Robins Office 2020 Dixie Crow Award Ceremony on Veteran's Day, November 11, 2020.

Pictured: Lisa Frugé-Cirilli, AOC Immediate Past President; Nils Smith, Vice President, Defense & Intelligent Solutions; Mike Quinn; William Glover; Rich Romano; Dave Brown; and Henry Sees. Not pictured: Jarrett Holcomb.

C. Nils Smith, VP Defense and Intelligent Solutions Division
Stanley B. Hall Executive Management Award

Michael Quinn, Staff Engineer EICTD
Joseph W. Kearney Pioneer Award

Richard Romano, Senior Research Technologist EICTD
Specialist 4 James Davis Maintenance Award

David E. Brown, Task Force Leadership, SwRI EICTD Consultant
Dixie Crow of the Year

William Glover, Engineer EICTD
Outstanding Young Crow Award

Jarrett Holcomb, Engineer EICTD
Test and Evaluation Award

Each of these local Dixie Crow Chapter award winners were entered into the AOC Annual Award competition as the candidate(s) from the Dixie Crow Chapter in their respective categories. Last year at the annual AOC conference, our very own Henry Sees, Director EICTD, was recognized as the winner of the Anton D. "Tony" Brees Lifetime Service Award.

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Glorianne O'Neilin
(703) 549-1600
oneilin@crows.org

JED Sales Offices

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Direct: +1 (352) 333-3469
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Advertising Sales Representatives:
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NAYLOR (Canada) Inc.
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