Chesapeake Bay Roost Newsletter

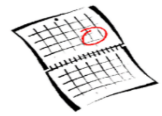
ASSOCIATION OF OLD CROWS

March, 2025

This Issue:

- Second session of series of EW Environment Generation Tech Talks completed Feb 19
- ELF/VLF Communications

Upcoming Events



Please mark your calendars for our upcoming events:

Mar 20, 11:30AM: Lunch & Learn
Rohde and Schwarz: EW Environmental Generation Part 3
Walks the user through the basics of EW environmental generation and considerations on setting up and configuring a simulation of the electromagnetic spectrum (EMS).

Pizza lunch to be provided, please RSVP at
https://evite.me/MvQxPpB7zd

Onsite at :
Johns Hopkins University APL
11100 Johns Hopkins Rd, Laurel, MD
Kossiakoff Center KC7/8 Rooms

Also on Zoom (but you will miss provided lunch!):
https://jhuapl.zoomgov.com/j/1614067492?pwd=miatIuoXUgYksLxKcZ9VOmukfvshUL.1

May 29, 11:30AM: RF Scene Generation, Syncopated Engineering
Johns Hopkins University APL
11100 Johns Hopkins Rd, Laurel, MD
Kossiakoff Center KC7/8 Rooms

syncopated ENGINEERING

Thanks to Our Chapter Sponsors!

Our chapter provides scholarships to local youth and chapter events for EW professionals. These activities quickly exceed what the chapter can achieve simply on AOC national chapter funds. We are truly thankful for Axillon Aerospace (previously Parker Meggitt), Annapolis Micro Systems, and Keysight Technologies for contributing financially in support of these endeavors. Please consider working with them for your product needs.

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We are seeking financial sponsorship to support our club activities and scholarship benefits we provide to the community. Please contact the board at AOC.ChesapeakeBay@gmail.com for reasonable rates.

Note: The content of articles is taken directly from open source, unclassified materials cited below each article for the purposes of stimulating relevant EW discussions between chapter members.

ELF/VLF Electromagnetic Spectrum

Extremely Low Frequency/Very Low Frequency Electromagnetic Spectrum

The February issue of JED (Journal of Electromagnetic Dominance) addressed a topic not often covered, the aspects of "Underwater EW." The journal article discusses ES (Electronic Support) systems on board a submarine to provide awareness of surrounding enemy vessels. The Lockheed Martin AN/BLQ-10 Submarine EW system was highlighted, as it was recently awarded a $311M contract for technology upgrades. This system provides … "situational awareness about the presence and location of potential threats." Specially designed masts on the submarine can provide ES awareness while minimizing detection of the mast; tethered buoys can be sent to the surface with ES sensors as well."[1] Submarines operate well below the surface most of the time, but it is essential for crews to have environment awareness. One of the most vulnerable moments is when the submarine must cruise at periscope depth or along the surface. The periscope radar detector was discussed in a past newsletter[2].

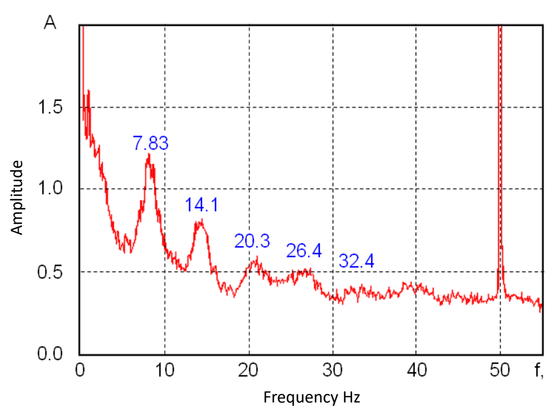
AN/BLQ-10 Submarine EW System, from https://www.lockheedmartin.com/content/dam/lockheed-martin/rms/photo/electronic-warfare/surface-ew/an-blq-10-brochure.pdf

One item neglected in the article is the aspects of communicating with submarines. The Navy implemented the TRIDENT weapon system which was used on nuclear submarines starting in 1979 (Klessig). [3] Communications to submarines worldwide is an important part of an integrated defense system. In the underwater domain, traditional communications methods are challenging as the signal strength rapidly deteriorates as it transverses through seawater. Sea water is highly conductive, and while it works well to "hide" the submarine, it likewise makes communicating with the outside world a challenge.[4]

While the need to propagate RF energy through sea water can be eliminated by rising masts or buoys to the surface, these acts do increase the chances of identifying the presence of a submarine. The degree in which a signal is attenuated through sea water is a strong function of frequency. The lower the frequency, the less the signal is attenuated.

The early days of radio started at low frequencies, using transmitters that generated arcs in the range of 15-1000 KHz. These low frequencies require very large antennas. A typical antenna can be a quarter of a wavelength long, so at 1 GHz (near cellular bands), the quarter wave is only an inch. The same quarter wave antenna at 100 Hz would be 466 miles.

ELF has unique global features. "the wavelengths in air are very long ... and, in practical situations, the electric and magnetic fields act independently of one another..." The typical spectrum of ELF electromagnetic waves in the Earth's atmosphere exhibit peaks (frequencies marked in blue in figure below) caused by the Schumann resonances. The attenuation of ELF waves is so low that they can travel completely around the Earth several times before decaying to negligible amplitude, and thus waves radiated from a source in opposite directions circumnavigating the Earth on a great circle path interfere with each other. At certain frequencies these oppositely directed waves are in phase and add (reinforce), causing standing waves. In other words, the closed spherical Earth–ionosphere cavity acts as a huge cavity resonator, enhancing ELF radiation at resonant frequencies, called Schumann resonances after the German physicist Winfried Otto Schumann, who predicted them in 1952. Lightning strikes can cause the cavity to "ring" like a bell, causing peaks in the noise spectrum.[5]



By AdmiralHood - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=9226843

Schumann Resonances in the ELF Spectrum from (5)

The rise of the noise at low frequencies (left side) is radio noise caused by slow processes in the Earth's magnetosphere.[5]

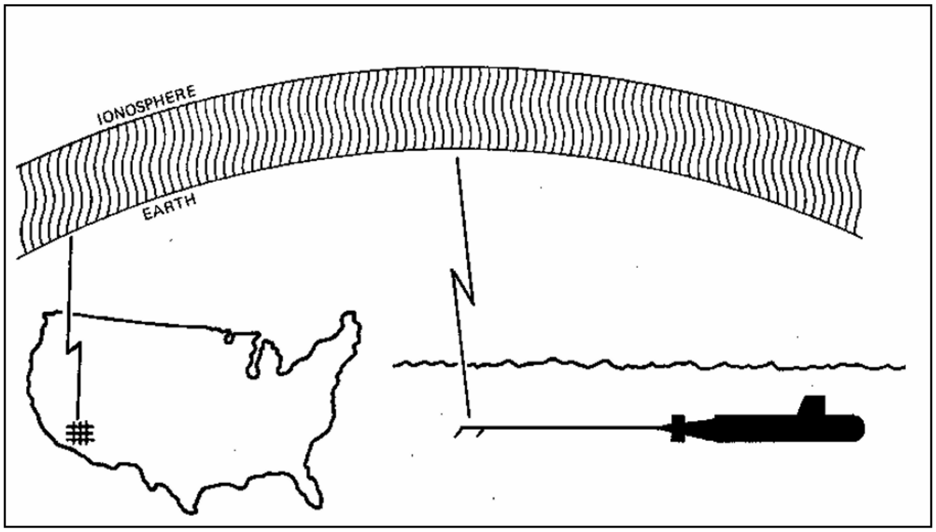
Navy officials had become interested in ELF radiation back in 1958, when they learned that these radio wave frequencies could penetrate seawater sufficiently to provide communication with deeply submerged submarines.[6] It was also known that ELF would still successfully propagate through a nuclear blast wave, maintaining communications with the nation's fleet during critical events (Kruger). However, the extremely large antennas required at first glance made accomplishing ELF communications not practical. This problem was solved by Nicholas Christofilos, a brilliant Greek-born physicist working for the Department of Defense, who suggested that a portion of the earth's interior could be used as a launching pad to propagate ELF signals. By using frequencies in the ELF range, the nation's commander-in-chief can maintain the link with the submarine force at considerably deeper depths.[6]

During the early 1960s, testing Christofilos's concept was pursued. "Project Sanguine was officially proposed in 1968. Originally, the proposed system would create a giant antenna consisting of 6000 miles of buried cables. The cables would be assembled in a rectangular grid that would span over 22,500 miles, covering nearly 40% of the state of Wisconsin. This grid would be powered by 100 underground power plants in concrete bunkers. The cables themselves would be grounded at their ends, with loops of AC current flowing 6 feet deep through the bedrock layer, resulting in the generation of ELF waves. The project was on track to cost billions of dollars and consume 800 megawatts of power. This large cost was justified in the minds of the supporters because it was a matter of national security. This system was able to survive nuclear attack, enemy jamming, deep water, and inclement weather. This is all to ensure that in a moment of need, the signal is available for emergency messages. The key idea is to being able to withstand anything because without having a guarantee of constant communication, it no longer acts as a viable deterrent from foreign attacks (Kruger)."[6]

A project that is planning on covering 40% of the state of Wisconsin is a huge undertaking, especially if the system did not work as designed. This measure was thought of and countered with the creation of the Sanguine Test Facility in Clam Lake, Wisconsin in 1968 (Klessig). This was a small-scale test of the much larger system, but the project needed to be tested and verified on a much smaller scale in order to ensure that all will work as designed. The Clam Lake test facility was built not only to ensure the project would work, but also to test and find limits of ELF communication, allowing for future modifications to be made and have the whole system improved upon. The field tests that were conducted were sending ELF transmissions around the world to a submarine that was traveling underneath the polar ice cap above the Artic Circle.[3]

Clam Lake, Wisonsin Transmitter Site from (5)

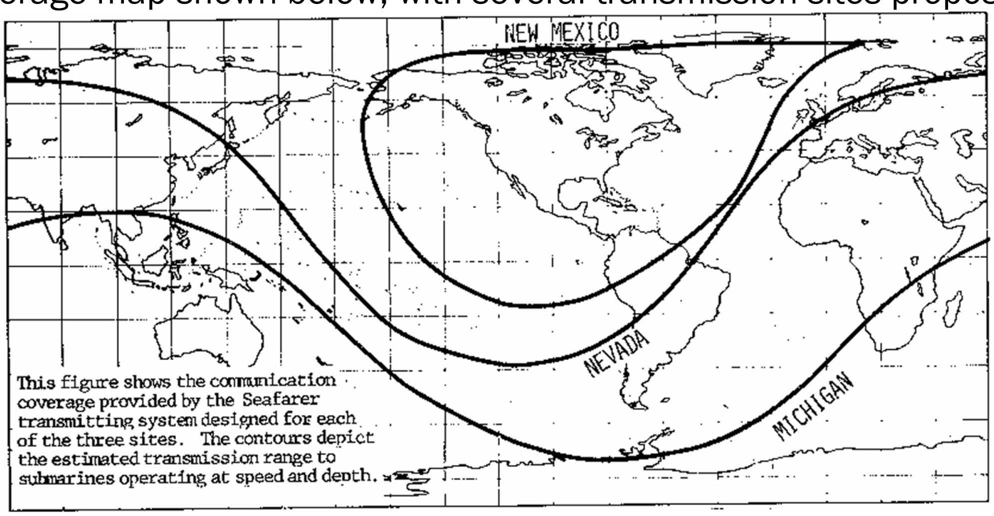
The very first ELF transmission from Clam Lake took place in May 1982, when a message was successfully received by a submarine submerged at a depth of 400 feet in the Atlantic Ocean off the Florida coast.[6]



The submarine detects a Nevada-site ELF signal with a long trailing antenna that stretches for several hundred yards behind and above its deck.

ELF Submarine Communications from (6)

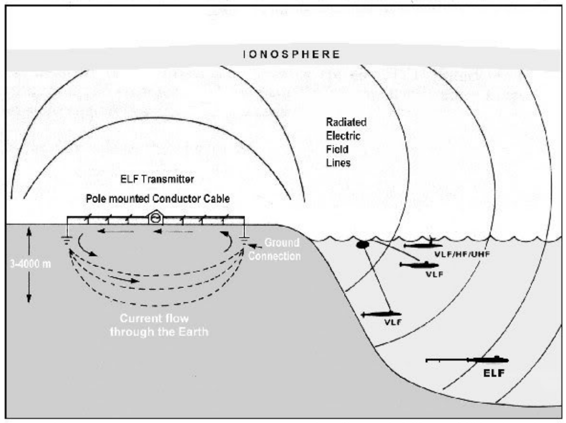
The goal was to establish a worldwide submarine communications capability, with an estimated coverage map shown below, with several transmission sites proposed.



Coverage Estimates from (6)

Russia, China, India, and the US have constructed ELF broadcast stations [5]

VLF was used to augment communications, offering higher data rates, but lacking the large depth sea water penetration of ELF. The USA ELF facilities closed in 2004, with VLF continuing use. The local Annapolis, MD Navy station was upgraded in 1969 to support VLF submarine communications, allowing submarines to remain submerged at 50-60ft below the surface to receive communications.[3]



Submarine Communications from (3)

The Annapolis station served across a variety of frequencies over the years, and had issues with weld integrity and other aspects of the original installation, at one point having multiple massive towers supporting communications across the spectrum, but was ultimately decommissioned entirely during base consolidation and cost reductions.[7]

1994 Photo of Annapolis Transmission Facility from (8)

(1) White, Andrew, "Underwater EW", Journal of Electromagnetic Dominance(JED), February, 2025, Vol 48, Issue 2

(2) "GRAB, the First Orbiting RF Signal Surveillance Satellite", Chesapeake Bay AOC Newsletter, March 2024

(3) "Military History of the Upper Great Lakes", https://ss.sites.mtu.edu/mhugl/2019/10/30/project-sanguine-gecooper/

(4) "Extremely Low Frequency Communications Program" https://pe2bz.philpem.me.uk/Comm/-%20ELF-VLF/-%20Operations/Info-101-SubmarineXmit/S5/elf.htm

(5) "Extremely low frequency", WikiPedia, https://en.wikipedia.org/wiki/Extremely_low_frequency

(6) Altgelt, Carlos A., "The World's Largest Radio Station" https://pages.hep.wisc.edu/~prepost/ELF.pdf

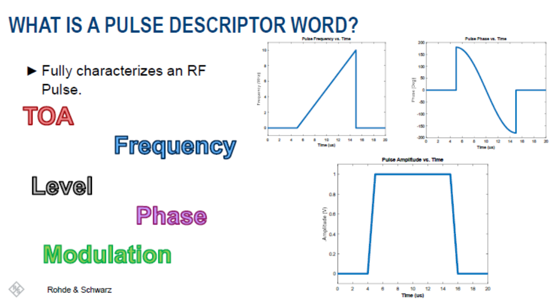
(7) "Naval Radio Transmitting Facility NRTF Annapolis – NSS" https://www.navy-radio.com/commsta/anna.htm

(8) https://www.navy-radio.com/commsta/anna/annapolis-ant-1994.jpg

Second Session in Series of EW Environmental Generation Engineering Series of Technical Talks Held on February 19th

Chapter members enjoyed pizza while doing a deep dive on the parameters and methods of generating signals for an EW test environment in the second talk in a series of three events provided courtesy of Rohde & Schwarz held at Johns Hopkins University/APL in Laurel, MD.

Duncan d'Hemecourt of Rohde & Schwarz discusses Electronic Warfare Stimulus Architectures during a Lunch & Learn on February 19



The parameters of a Pulse Descriptor Word were introduced, a method of fully characterizing emitters in an RF signal environment. This provided a foundation to expand to the aspects of frequency agility and instantaneous bandwidth of a signal, which are common features of modern emitters. The aspects of generating a composite multi-emitter environment were then detailed, including a discussion of the pulse-on-pulse aspects and comparisons when this occurs in the digital and analog designs. The nuances of establishing the calibration of channels over large frequency bands were discussed, as well as maintaining precise amplitude, phase, and timing between emitters. Afterwards, the complex methods of obtaining a truly coherent representation of the composite of all the signals present in a dense RF environment were analyzed, including the methods of maintaining clock phase synchronization between multiple emitter channels.

This presentation provided a very in-depth view of everything needed to replicate the dense RF spectrum for real world emulation for Electronic Warfare.

The next page provides information on the March 20th Part 3 session of the series of Rohde & Schwarz technical talks!

ROHDE&SCHWARZ
Make ideas real

Attend the Part 3 Technical Lunch & Learn on EW Environmental Generation March 20th

The series of technical talks will address challenges of testing Electronic Warfare equipment. Simulating an electromagnetic environment relevant for testing electronic warfare devices is a challenging engineering problem that is full of trade-offs and design complexities. This multi-part presentation series will walk the audience through common engineering challenges and design considerations to help the test engineer be more knowledgeable about the intricacies of creating an EW environment. The next generation of EW devices and platforms bring new difficulties: modern threats get faster, more agile, and more complex. The testing challenges for our friendly devices scale accordingly with these modern threat enhancements. This presentation series is meant to frame those problems and allow the test engineer to consider multiple possible solutions, the engineering design trade-offs of each one, and to more intelligently go about solving these environmental generation test challenges in the future.

Part 3 – Calibration and Uncertainty for Angle-of-Arrival (AoA) Simulation

(11:30AM-1:00PM March 20, 2025)

Abstract: In this presentation, we discuss calibration and uncertainty for angle-of-arrival (AoA) simulation using RF signal generators. After reviewing the three dominant types of direction finding (DF) used in radar warning receivers (RWRs), we explain how to calibrate for AoA according to each DF method. For phase AoA calibration, we show how the vector network analyzer is the gold standard and explain the three contributors to uncertainty in phase AoA simulation – systemic error, random error, and drift. Finally, we show how to scale calibrations for RWRs with higher port counts and distributed apertures.

Join us to Lunch & Learn (light pizza fare) at
Johns Hopkins APL, Kossiakoff Center KC7/8, 11100 Johns Hopkins Rd, Laurel, MD

Please RSVP if attending In Person to ensure enough pizza is provided:
https://evite.me/MvQxPpB7zd

Remote Zoom link:
https://jhuapl.zoomgov.com/j/1614067492?pwd=miatIuoXUgYksLxKcZ9VOmukfvshUL.1

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Our membership represents major EW centers in this area, including:

- Parker Meggitt
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- Boeing
- Booz Allen Hamilton
- CACI
- CEA Technologies
- Johns Hopkins Applied Physics Laboratory
- Multiple branches of the Department of Defense
- Northrop Grumman Corporation
- Rohde & Schwarz
- Raytheon
- Textron Systems
- WGS Systems
- And many others!

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Space is available here to target your advertisement/ announcements to our select membership!

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AOC Events

Apr 29- May 1
Cyber Electromagnetic Activity (CEMA)
Aberdeen Proving Ground, MD

June 3-4
Cyber/Electronic Warfare Convergence
Charleston, SC

July 23-24
First annual EMSO Research Conference (EMSO ReCon)
Atlanta, Georgia,