Emission Control, Radiation Hazards, and the Value of Intelligent RF Sensing for These Applications

PRIMER

Tektronix®

Contents

FIGURE 1. Military operations require RF situational awareness to comply with EMCOM orders and RADHAZ risks.

If you are involved in military, aerospace or defense and have been around radar and communication systems, with high-power RF transmitters and high-gain antennas, you are probably aware of the many risks associated with Radio Frequency Radiation (RFR) Hazards. You're probably aware that RF emissions from these systems have the potential to cause catastrophic damage to operations and maintenance personnel, ordnance and fuels, and associated equipment.

If you are responsible for Radiation Hazards (RADHAZ), Emission Control (EMCON), Communications-Electronics Command (CECOM) or the management of electromagnetic environmental effects (E3), you understand that in today's technological environment, it's not sufficient only knowing whether systems are exceeding appropriate levels. To support daily operation to ensure security and safety, it's more important than ever to be able to discover, locate, classify, record, and playback signals of interest through a combination of field surveying and deployed spectrum monitoring.

Government publications such as DODINST 6055.11, NAVSEA OP3565 / NAVAIR 16-1-529. Volume I and Volume II, MIL-HDBK-240 and others provide comprehensive information on the risks, Personnel Exposure Limits (PEL), hazard measurements, design criteria and safe operation guidelines. However, new technology advancements with increased RF emitting technology capabilities requires a higher level of RF situational awareness.

Not having awareness of the RF spectrum can cause catastrophic accidents. RF situational awareness means having awareness of the spectrum through the following:

- Electro Magnetic (EM) system design and development
- EM system RADHAZ/EM/EMI/EMC certification
- EM system integration and maintenance
- EM system monitoring with quick-response capability (QRC)
- EM system troubleshooting for maintaining mission readiness

For added security of personnel and to increase the odds of operational success, incorporating a real-time spectrum analyzer can provide significant benefits.

In this whitepaper, we will discuss electromagnetic radiation, EMCON and the three forms of RADHAZ. We'll conclude with a discussion of how incorporating a USB Real-Time Spectrum Analyzer, such as Tektronix' RSA500 series, can assist in identifying EMCON violations and mitigating RADHAZ risks. If you are concerned, or just learning, about RADHAZ, EMCON and managing E3, and how a network of Real-Time Spectrum Analyzers can improve your RF situational awareness, this primer will provide information for you.

Radiofrequency Electromagnetic Radiation

Radiofrequency (RF) electromagnetic radiation (EMR) is the transfer of energy by radio waves. RF EMR lies in the frequency range between 3 kilohertz (kHz) to 300 gigahertz (GHz). RF radiation is invisible and far-reaching. Excessive levels of exposure to Radio Frequency Radiation (RFR) can result in adverse effects on people such as involuntary muscle contractions, electrical shocks and burns and excessive heating of tissue. High-level electromagnetic energy produced by RFR can also induce electric currents or voltages that may cause premature activation of Electro-Explosive Devices (EEDs), interference with other electronic equipment and electrical arcs that may ignite flammable materials during fuel handling operations close to high powered radar and radio transmitting antennas.

For military operations such as EMCON and RADHAZ, awareness of the existence of non-ionizing RF EMR from devices ranging from cellular phones to radar, is critical to protect personnel, equipment and missions.

Emissions Control (EMCON)

While performing military operations, you may be familiar with EMCON and its purpose to prevent an enemy from detecting, identifying, and locating friendly forces. For EMCON management, the need to insure operations are complying with the appropriate level of EMCON orders is of utmost importance.

EMCON management consists of four primary levels. Each level requires different levels of situational awareness.

- The first, and lowest level is EMCON Delta and is used during normal operations. With Delta, there are no emissions restrictions, with operations allowed to radiate any sensor that is essential to accomplishing the mission.
- The second level is EMCON Charlie. Charlie allows the ship to radiate and transmit from mission-essential equipment and sensors, but it does require that sensors unique to that type of vessel be shut down in order to prevent adversaries from identifying the class of ship.
- The third level, EMCON Bravo further limits the ship's electronic emissions, but still allows for communication and data transfer with others. Bravo limits what is authorized to be radiated and transmitted from.
- The fourth level is EMCON Alpha, which is the most restrictive form of emissions control and is called when an operation requires absolute silence. During EMCON Alpha, no emissions or radiations from any sensor are permitted.

Given the ubiquity of RF enabled devices in today’s world, managing EMCON operations can be a challenge. Adding a portable RTSA to operations can be an important tool to discover, locate, classify and address offending signal situations.

FIGURE 2. The Military Sealift Command dry cargo and ammunition ship USNS Robert E. Peary and the aircraft carrier USS Dwight D. Eisenhower conduct a vertical replenishment. Approaching ships need to be cognizant of RADHAZ emitting devices.

Radiation Hazard (RADHAZ): HERP, HERO and HERF

RADHAZ procedures set the fundamental requirements to mitigate risks associated with RFR. For military personnel, RADHAZ risks can be especially high when two radar emitting vehicles or ships interact with each other. As an example, when two ships approach each other, each ship needs to be aware of the potential electromagnetic radiation hazards and their required safe distances and procedures during operation. Failure to monitor the RFR present can, and has, resulted in catastrophic accidents.

Per the Navel Safety Center, RF Hazards fall into three main categories:

- Hazards of Electromagnetic Radiation to Personnel (HERP)
- Hazards of Electromagnetic Radiation to Ordnance (HERO)
- Hazards of Electromagnetic Radiation to Fuel (HERF)

A brief description of each of these follows.

Hazards of Electromagnetic Radiation to Personnel, or HERP, may result in injuries to personnel in environments where radar and communications systems operate. The use of high frequency transmitters and high-gain antennas, and the complicated structure and rigging aboard ships has increased the probability of voltages being present on shipboard objects such as running rigging, booms and parked aircraft. Radiation from nearby transmitting antennas may result in voltage levels that are sufficient to cause burns or shocks. These injuries may occur from direct contact with a conductive object or from a spark discharge.

Hazards of Electromagnetic Radiation to Ordnance, or HERO, occurs when RFR enters sensitive electrically initiated devices (EIDs), or electro-exploding devices (EEDs) and may lead to triggering an unexpected explosion. RFR energy can enter an ordnance item through a hole or crack in its skin, or through firing leads and wires. First identified in 1958, the HERO risk has increased with the increased power output and frequency ranges found in modern radio and radar transmitting equipment. According to the Navy Safety Center, “EID systems are most susceptible during assembly, disassembly, loading, unloading, and handling in RFR electromagnetic fields.”1 Ordnance systems are classified into three categories; HERO safe, HERO susceptible and HERO unsafe based on their probability of being adversely affected by the RFR environment. Additional information is found in *NAVSEA OP 3565/NAVAIR 16-1-529/NAVELEX 0967-LP-624-6010/ Volume II, Electromagnetic Radiation Hazards (U) (Hazards to Ordnance) (U).*

Hazards of Electromagnetic Radiation to Fuel, or HERF concerns the accidental ignition of fuel vapers by RF-induced arcs during fuel-handling operations. Fuel-handling is defined as the transferring of fuel from one container to another. While the probability of a HERF event occurring is relatively low, accidental combustion is still possible with certain conditions being present. To reduce the probability of a HERF event, a number of measures have been advised for military operations. Included among these are prescribed safe separation distances and securing transmitting radar and communication systems during fueling operations.

For each of these RADHAZ threats, military operating guidelines provide extensive best practices related to Engineering Controls, Administrate Controls, and Personal Protection. However, additional steps can be taken to insure radar and communication systems aren't transmitting that may jeopardize personnel or operations.

EMCON, RADHAZ and Tektronix USB Real–time Spectrum Analyzer

Successfully monitoring the RF environment for EMCON compliance or RADHAZ risks basically involves similar steps.

The first step is discovering the offending signal. This is accomplished using a RTSA to perform wide band scans in real-time. Tektronix's USB RTSA architecture leverages overlapping fast Fourier transform (FFT) and a high-speed data transfer rate to pass-through raw data in real-time. This provides continuous processing of RF signals with no gaps, allowing a RTSA to overcome the measurement limitations of a Swept Tuned Spectrum Analyzer(SA) and a Vector Signal Analyzer (VSA) associated with transient and dynamic RF signals. Tektronix' DPX technology provides visibility of transient, low-duty cycle, or rapidly changing signals and spectral events, color mapped to indicate their duration and rate of occurrence. This allows the operator to see threats hidden under the primary signal and to display a live threat signal simultaneously.

For 24-7 monitoring, Tektronix USB RTSAs make the task simpler with the ability to apply frequency mask monitoring. Utilizing mask monitoring enables users to capture signals that violate user defined thresholds. Mask monitoring is just one of many capabilities provided by Tektronix' SignalVu-PC software, included at no additional cost.

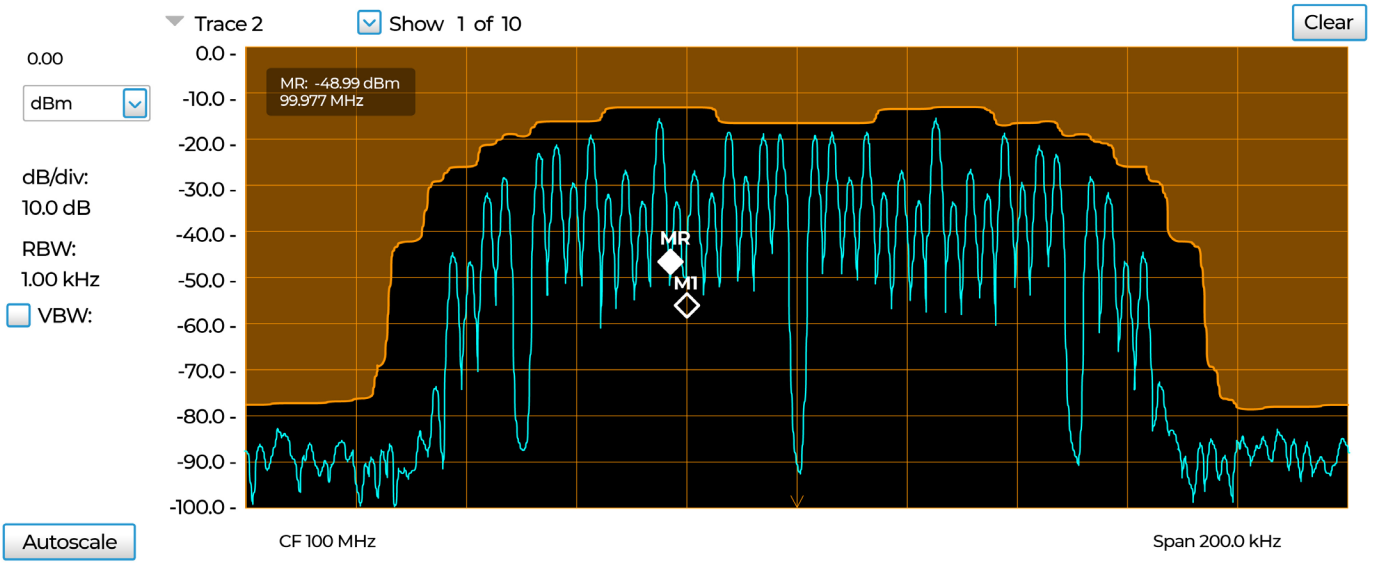

FIGURE 3. Frequency Mask test captures signals that violates user defined thresholds.

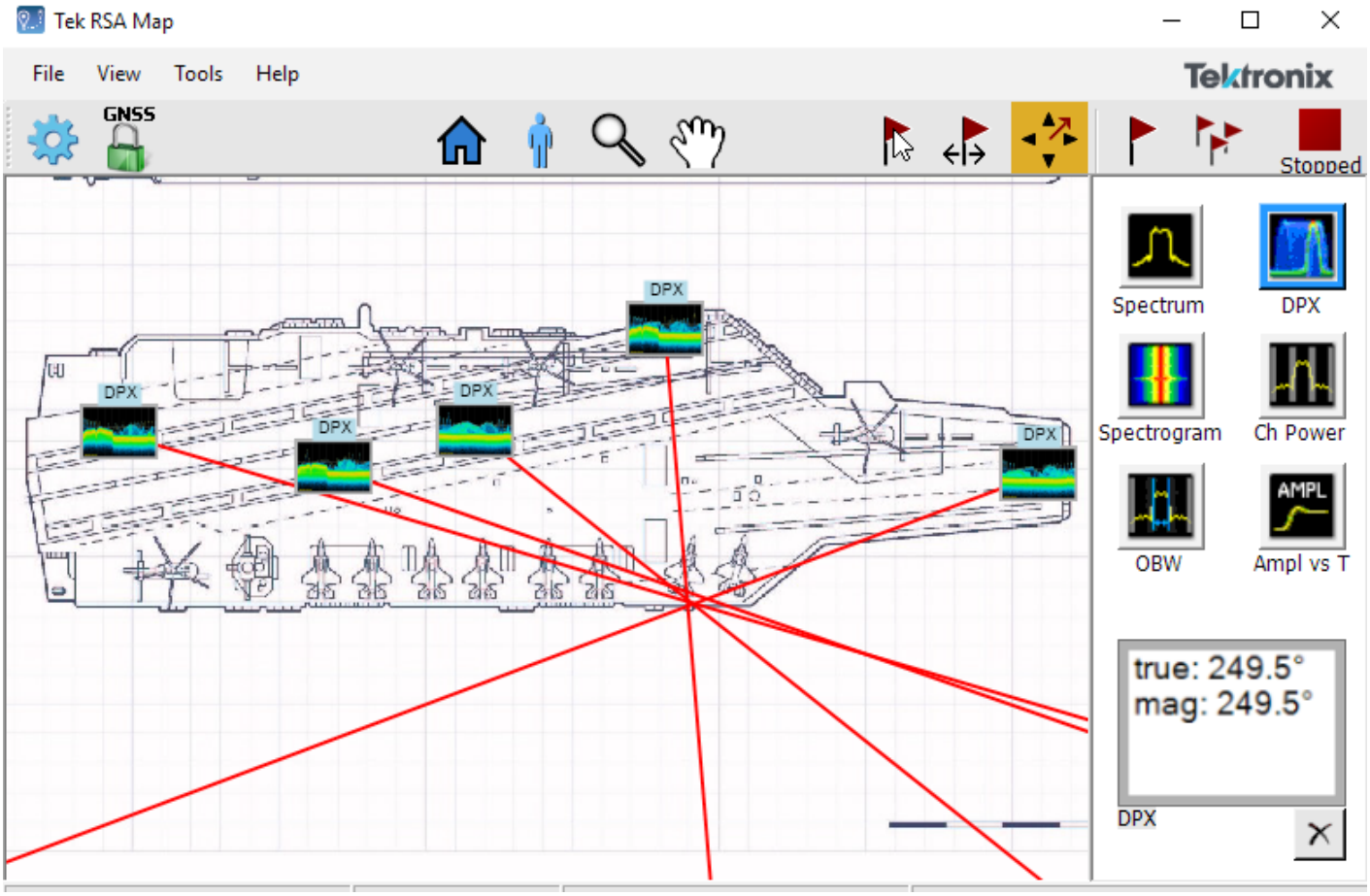

FIGURE 4. Map software with an azimuth function that lets you indicate on a mechanical image or map the location of the Signal of Interest.

The second step is to locate the signal's origin. This is accomplished by transitioning from wide band scans to narrow band scans and utilizing mapping software to triangulate the location. The architecture of Tektronix' USB RTSA provides the fastest narrow resolution bandwidth (RBW) sweep for measuring low power level signals in a portable spectrum analyzer to quickly find SOIs. Utilizing location capabilities provided by a GPS receiver, Tektronix' Map software integrates measurements from SignalVu-PC to pinpoint the location of the SOI on a map or mechanical drawing of a ship, plane or other structure.

The next step is to identify and classify the signal. Classifying the signal provides two benefits, the quick identification of the type of device that is causing the issue and, if the signal is unknown, the ability to log the signal's characteristics for further analysis. Utilizing real-time data from the Tektronix USB RTSA, Signal Survey and Classification software defines signals by frequency, bandwidth and shape and compares them with a library database that includes user-created database entries and custom surveys of your region to quickly determine new and unauthorized SOIs.

The final step is to record signals of interest for additional analysis. Tektronix's USB RTSAs capture spectral events in real-time and stream and record In-Phase/Quadrature (I/Q), .CSV, or MIDAS formatted data for playback and comprehensive signal forensics. Spectral events detected in a deployable RF sensor network coverage range are continuously logged, along with GPS time stamps and position data logging in an SQL database for analysis and report generation.

For each of these steps, Tektronix' USB RTSAs are designed to provide accurate information quickly and reliably to meet operational needs.

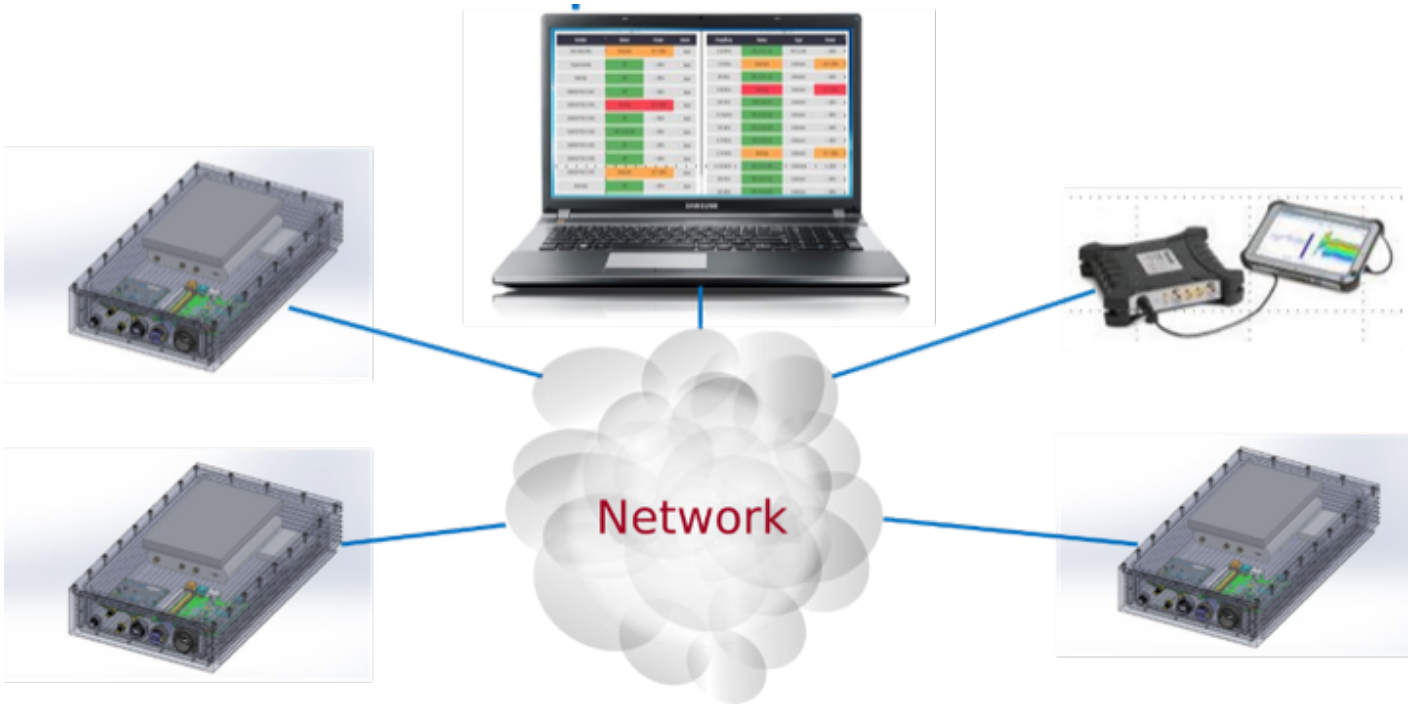

FIGURE 5. Tektronix USB Real-Time Spectrum Analyzers support network-ability to create a high performance, intelligent RF sensor network.

Deploying Tektronix USB Real–Time Spectrum Analyzers

As military applications may require the ability to monitor RF signals over a large field of operation, such as on a ship or on an airfield, the ability to network multiple RTSAs can be a significant benefit and one that is supported by Tektronix' USB RTSAs.

The architecture of the Tektronix RSA500 and RSA306B supports the integration of a RTSA with a small form factor NUC and software to create a cost-effective network of high performance, automated and intelligent RF sensors. This network is capable of functioning across large perimeter, 100s of miles apart, and small perimeter, less than 100 meters apart, in even the toughest environment. This enables a live 24-7 monitoring system, capable of recording user customizable spectral events for archival and analysis. In the discussion that follows, we will highlight SpectrumVu™ software available from Erisys, Inc., to demonstrate the capabilities of a RF Sensor network. Integration with other software solutions is supported through an API available with Tektronix' USB RTSA.

A powerful Intel multi-core embedded processor in the NUC allows for sophisticated Discrete Fourier Transform (DFT) processing of captured real-time digitized I/Q or trace spectrum data to be performed at each remote RF sensor node. This dramatically reduces the traffic transmitted over the network to just the post processing logged data.

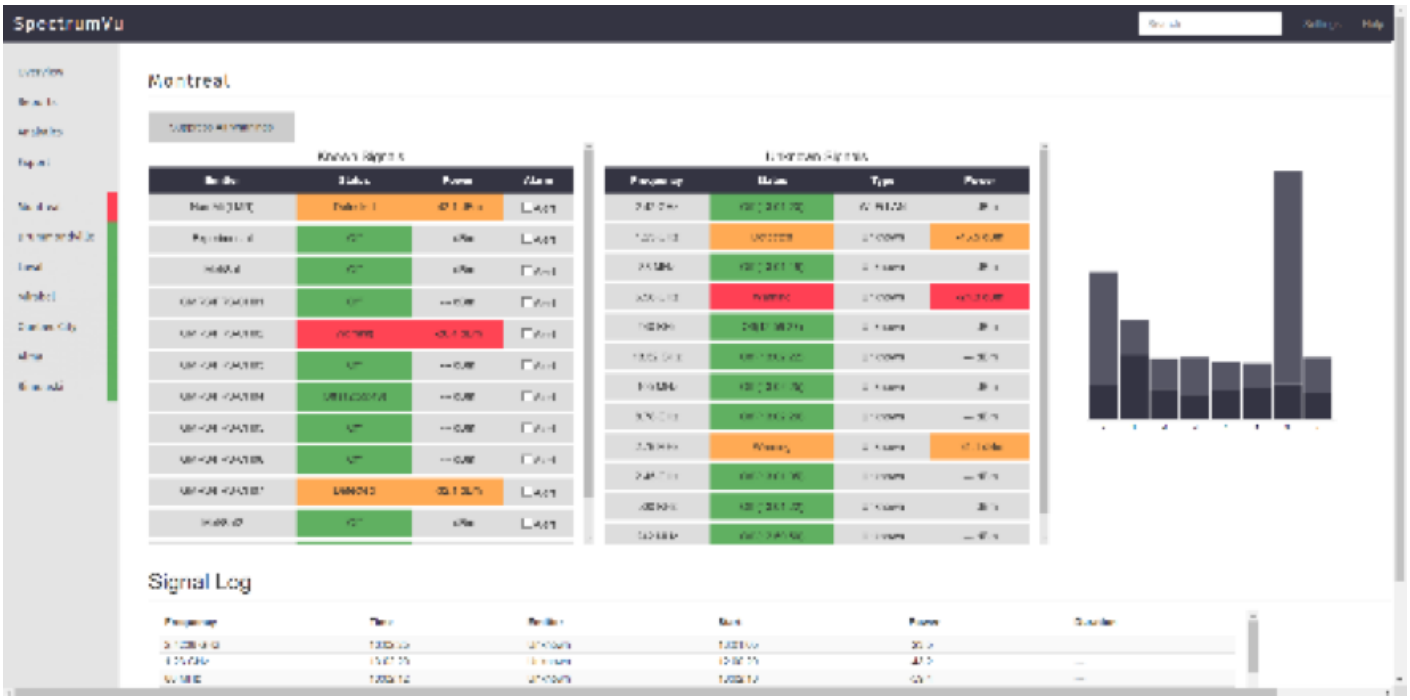

FIGURE 6. SpectrumVu software showcasing easy-to-read RTSA RF network monitoring with user-customizable event warnings.

The network is typically configured in the traditional hub-spoke star topology. Terrestrial or RF links connect the remote RF Sensor nodes to the command center hub. SpectrumVu automates the network operation and supports the setting of individually specified threshold conditions for each RTSA node to generate automatic “red” and “yellow” warning alerts. SpectrumVu software also provides signal analysis and mapping capabilities as well.

A final benefit from the architecture of the Tektronix RSA500 Series and the RSA306B is its Size, Weight and Power (SWaP). The low SWaP characteristics make them ideal for space constrained installation. Their relatively low weight and portable form factor make them ideal for transporting, and deploying in rugged environments.

Conclusion

For military operations, advancements in, and the ubiquity of, RF technology have necessitated a change in how threats to personnel, equipment and operations are viewed, identified and responded to. Looking forward, it is expected the RF innovation landscape will continue to expand, accelerate in pace and grow more complex and difficult to monitor.

To mitigate the risks for EMCON and RADHAZ operations, investing in technology that provides greater RF situational awareness takes on greater importance. Adding a portable Real-Time Spectrum Analyzer (RTSA), such as the Tektronix RSA500 Series or RSA306B, is the perfect tool for intelligent sensing to monitor EMCON compliance and complement RADHAZ safety procedures. The RTSA provides the ability to sense important signals of interest (SOIs) in a crowded spectrum and understand what RF signals exists at any given time. This is critical given the potential consequences of an EMCON violation or a RADHAZ event.

In this whitepaper, we have discussed EMCON, RADHAZ threats and the benefits a Tektronix USB Real-Time Spectrum Analyzer can offer in managing EMCON and RADHAZ operations. For additional information on Tektronix USB Real-Time Spectrum Analyzers, please visit tek.com/spectrum-analyzer.

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