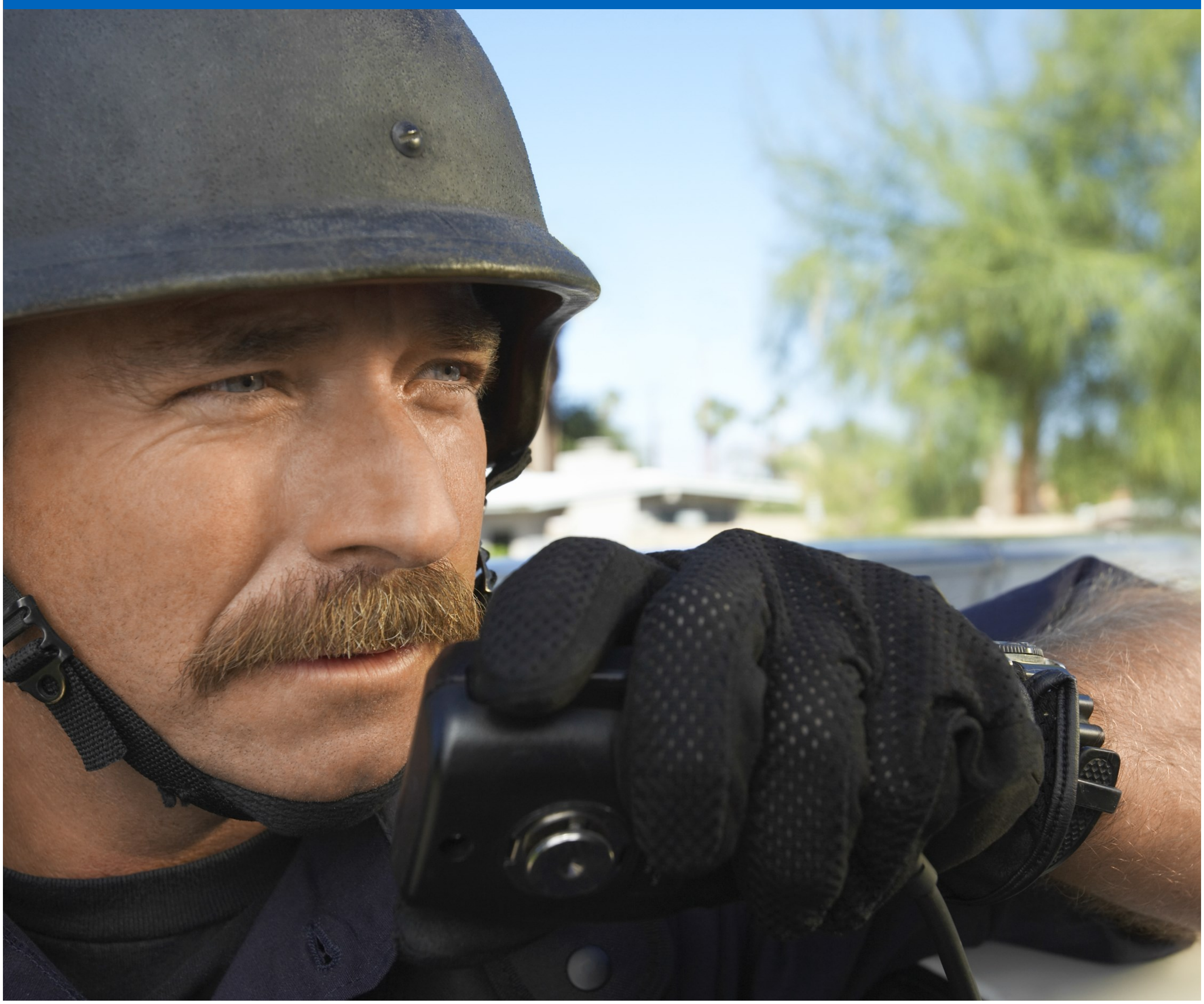
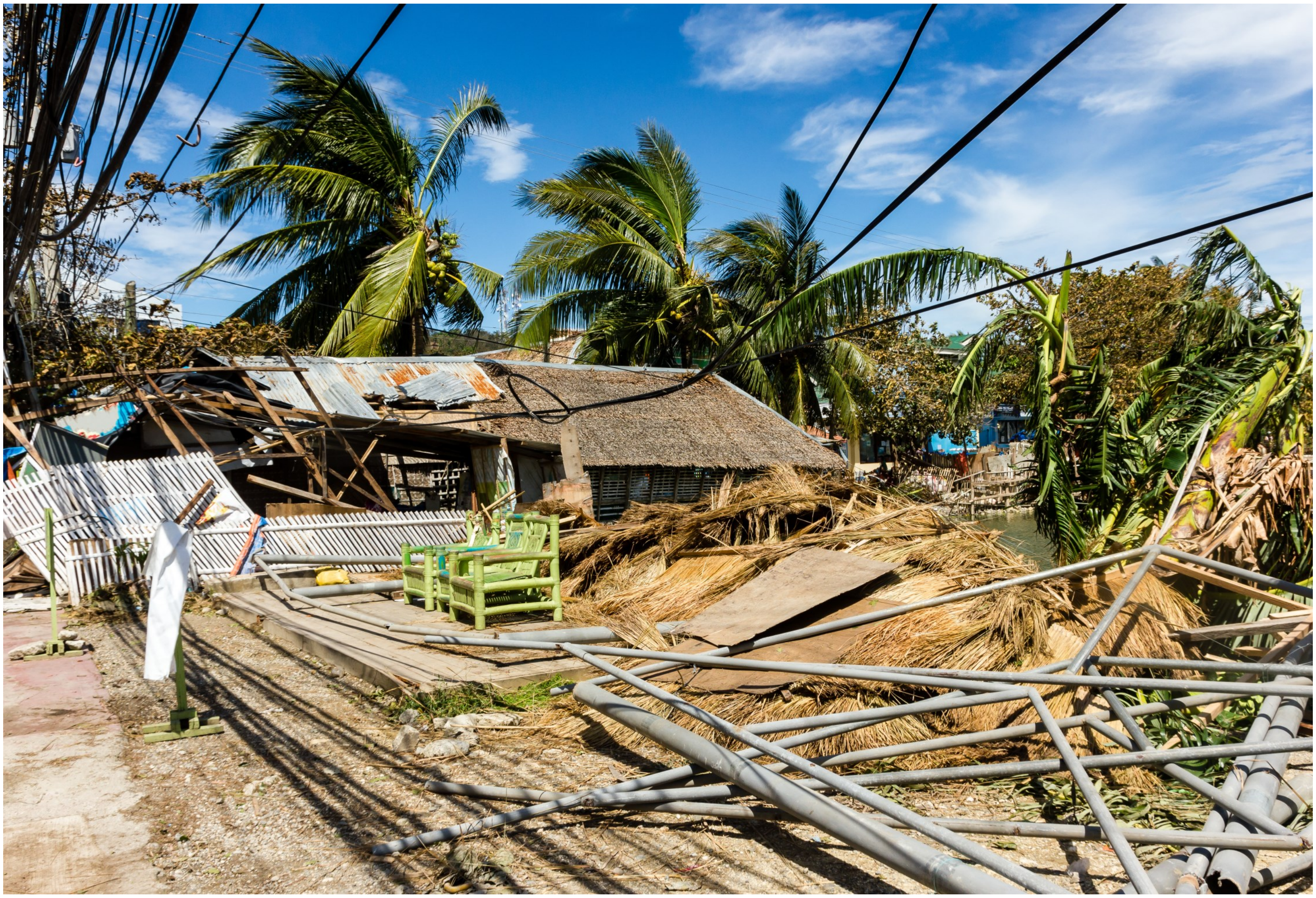
WHITE PAPER

Exploring Radio Frequency Drift and Its Impact on Homeland Security and Disaster Response Operations





Executive Summary

When teams are deploying to disaster sites or engaging in routine operations, safety is paramount. Communications equipment must work without fail and without the threat of interference or disruption. In modern communication systems, radio frequency issues can and do occur for a myriad of reasons. Whether the reason is due to malicious intent, user error, or equipment misalignment, RF interference can threaten the safety, security, and effectiveness of field operatives and support staff, as well as public and private stakeholders.

Radio frequency error or RF drift is a common issue that occurs when a two-way radio falls out of alignment and off-channel. When this happens, affected subscribers lose the ability to transmit and receive vital information. Equipment users and operations staff may be unaware that signal interference is occurring until after a critical transmission is missed or the communication link is terminated. Because frequency drift often replicates network coverage issues, it is easily misdiagnosed or brushed off as a one-time event.

Highlighted as a critical communications issue by both the Federal Emergency Management Agency (FEMA) and the National Institute of Standards and Technology (NIST), radio frequency error can result in high liability and expensive operational failures. Therefore, service radios must be regularly tested and assessed to ensure optimal performance during operational use[1]. The lack of time and resources creates a reactive stance on detecting and correcting this problem, which is neither logical nor cost-effective, especially in instances where equipment is either subject to continuous use or stored idly for months on end, waiting for the next critical deployment.

Common causes of RF drift include improper maintenance, normal wear and tear, adverse environmental conditions, equipment malfunction (including frequent battery drainage), and improper calibration[2]. Drift can occur in both new and old equipment and even on models featuring Automatic Frequency Control (AFC) safeguards. Typically, the only way to confirm if a radio is experiencing radio frequency error is through routine diagnostic testing and physical inspection of individual subscribers.

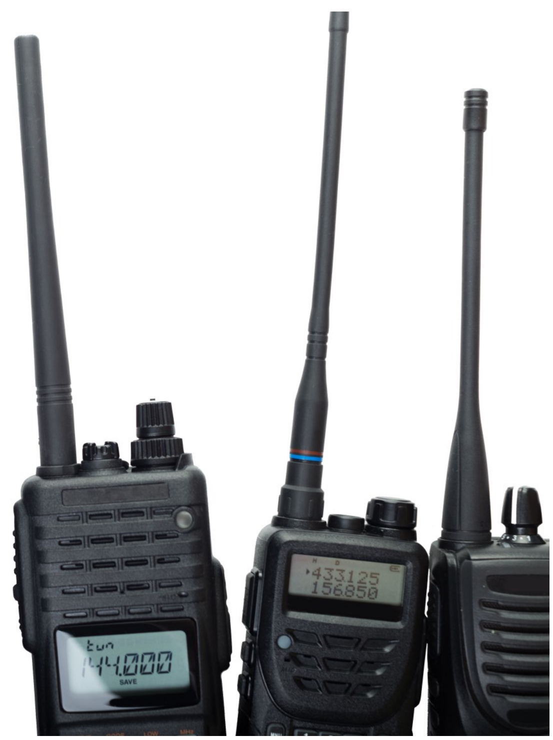
As an alternative to costly and inefficient bench checks or dangerous and disconcerting in-field failures, more organizations are choosing to invest in diagnostic instruments to help proactively identify and correct instances of radio frequency drift. Technology such as over-the-air (OTA) radio analyzers can measure the accuracy and health of both networks and subscriber radios while also acting as an ever-present maintenance indication tool. Taking this concept further, new portable models can be effortlessly stored and immediately implemented for grab-and-go use during critical, time-sensitive missions.

This paper discusses the hazards and consequences of radio frequency error or RF drift in homeland security and disaster operations, as well as the benefits and advantages of deploying radio analyzers to recognize issues of RF interference.

Uncovering RF Drift as a Source of Interference

In today's risk-averse environment, RF interference is a rising concern. No matter the hazard nor the mission, situational awareness, and resilient communications are vital to an agency's operational success. Furthermore, in keeping with federal best practices for mitigating and managing communication failures, it's imperative to monitor equipment and networks for signs of RF interference and interruption[3].

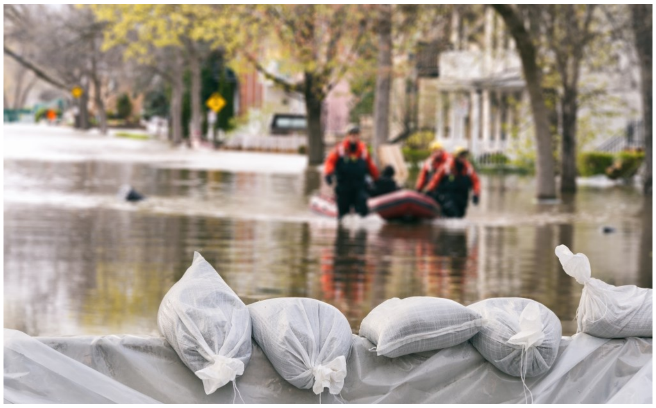
Radio frequency drift is often overlooked as a source of interference. This problem can contribute to dangerous and debilitating conditions ranging from seemingly sporadic signal loss to complete radio communications failure for individual subscribers or other subscribers trying to communicate on the network. Radio frequency drift occurs when the crystal oscillator circuit inside a radio becomes damaged or diminished due to age or adverse conditions[4]. If not detected, these deficiencies can result in two-way radios falling out of alignment and off the baseline. The end result being the radio is not transmitting nor receiving centered on the correct frequency assignment, thus rendering them unfit for the field.



Equally important, RF drift often masks as channel instability or a battery drainage issue. However, this problem requires more attention than simple repositioning or recharging. Diagnostic confirmation and manual realignments are the only ways to verify and correct radio frequency error, thereby ruling out other common radio ailments, such as loose battery casings, inadequate coverage, user error, or external/intentional interference.

Regular preventative maintenance and testing are not always feasible, and therefore do not adequately identify radios that may be creating problems. In federal security and disaster operations where crews must coordinate and deploy at a moment's notice. For these 24/7 agencies, communications equipment must remain mission-ready and fit for service whenever a crisis strikes.

Likewise, land mobile radio (LMR) solutions and their safeguards must also fit into agency operating budgets. As funding for top-tier replacement equipment is notoriously limited,



communications specialists must work proactively to ensure their current radios are capable of supporting both fiscal and operational objectives.

Therefore, in an attempt to analyze the risks and probability of RF drift occurring within the realm of homeland security and disaster response, we've identified several areas of concern. Highlighted challenges include the risk of interruption or failure due to inconsistent testing and maintenance, exposure to adverse environmental conditions, and excess wear and tear from prolonged use.

To illustrate these concerns, the following examples demonstrate how radio frequency error factors can progress to impact mission-critical communications across three distinct Department of Homeland Security divisions, including the Federal Emergency Management Agency (FEMA), the United States Coast Guard (USCG), and the United States Customs Border Patrol (USCBP).

Challenge #1 - Prolonged Storage and Inconsistent Use Cycles

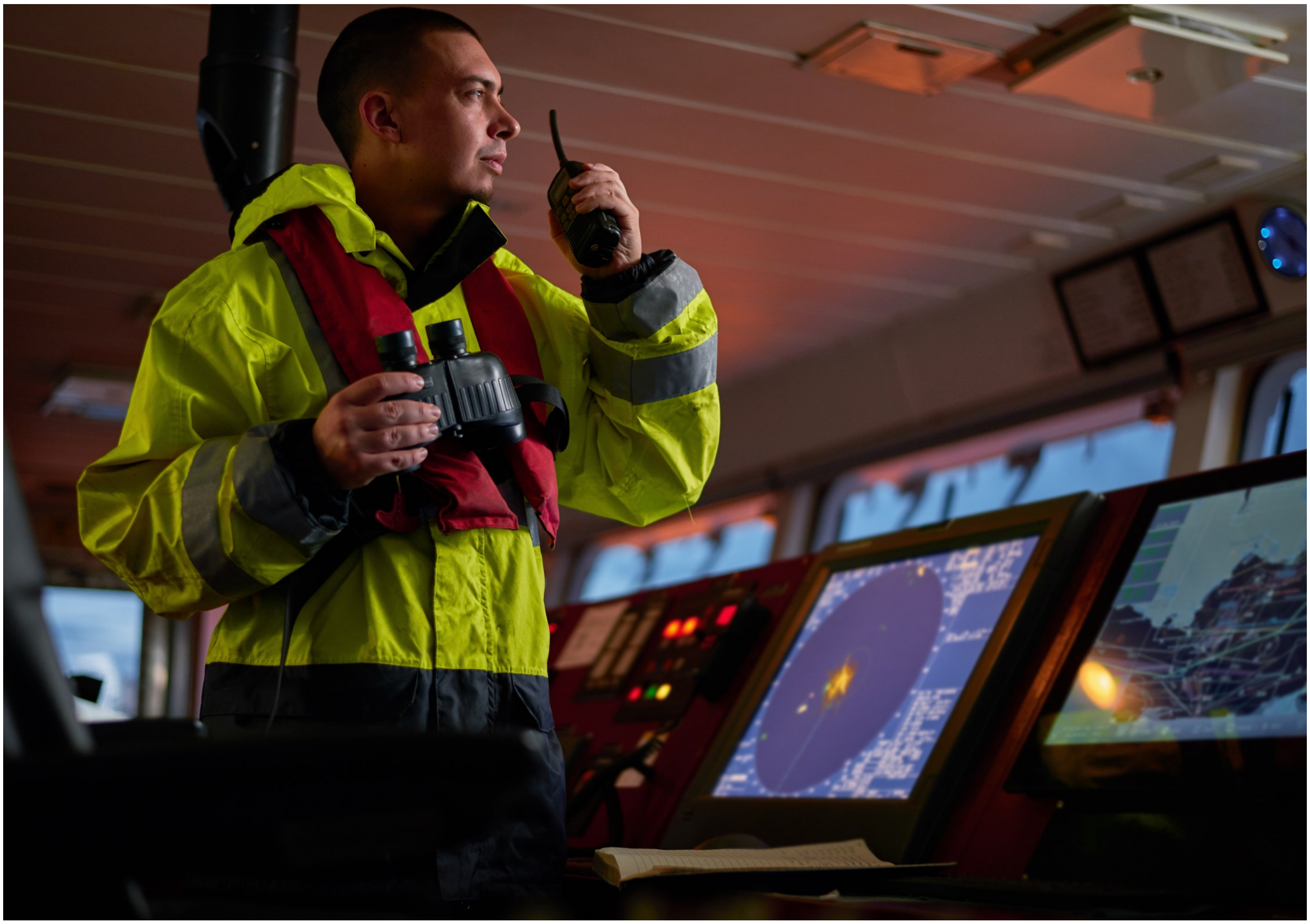
Although cell phones are the primary communications method of deployed FEMA crews, adverse environmental conditions, and infrastructure damage can render these tools improbable and obsolete. As evidenced by the operability obstacles encountered during the agency's response to 2017's unprecedented hurricane season, infrastructure and critical lifeline damage often leads to the degradation and impairment of cellular service, thereby restricting these tools' use and effectiveness[5]. Because of this, LMR is still the gold standard for onsite communication during disaster and recovery operations.

While two-way radios remain the backbone of emergency communications, they are still subject to technological and physical limitations. They are also prone to instability and failure if stored for prolonged periods and not regularly checked for proper calibration and channel alignment. Additionally, as noted by the NIST, constant environmental changes, varying use, and recurrent power-supply fluctuations can all contribute to the invisible risk of crystal oscillator deterioration and drift[6]. Therefore, diagnostic inspections and calibration tests must be performed regularly according to the specific manufacturers' guidelines.

In the case of FEMA Disaster Emergency Communications (DEC) deployments, time, circumstance, and lack of staffing may prohibit communications personnel from assessing and measuring every responder's two-way radio for optimal functionality and health. However, skipping these steps dramatically increases the risk of introducing improperly calibrated radios into an already hazardous situation. Absent glaring coverage issues or immediate transmission failure, users may not notice the effects of radio frequency error until they experience an intermittent interruption, weak signal strength, or diminished sound quality during live activations.

With these factors in mind, let's examine FEMA's 2017 deployment to Puerto Rico. Whereas, in the wake of Hurricane Maria, FEMA operatives identified widespread communication outages and lack of situational awareness as being a chief inhibitor to response effectiveness. As noted in the Government Accountability Office's (GAO) official after-action report, resource exhaustion and logistical barriers plagued FEMA's efforts from the onset, while also giving host to a whole other set of challenges[7]. In forecasting the variables presented by this dynamic situation, the dangers of equipment fatigue and unstable radio networks were overwhelmingly elevated. In hindsight, had any lone workers or isolated assessment crews experienced a debilitating occurrence of RF drift, it's reasonable to conclude the results would have proven calamitous if not fatal.

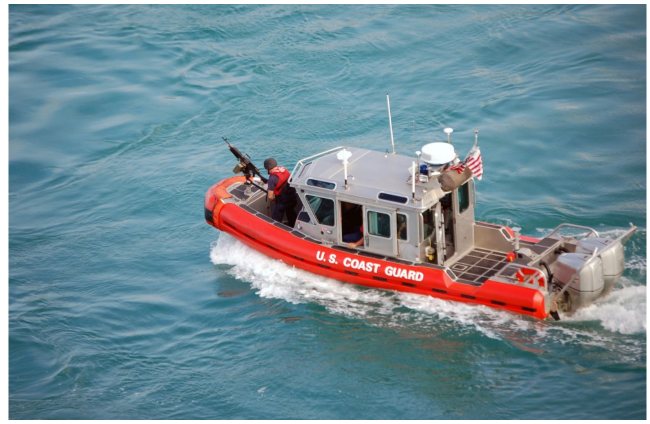
Thus, when considering the frequency and urgency of the agency's deployments, alongside its generally inconsistent radio maintenance and usage patterns, FEMA should seek out adaptable lifecycle management and diagnostic instruments that allow for streamlined, preemptive testing and continuous monitoring of all mission activated subscribers. Implementing this technology not only reinforces the communication resiliency objectives contained in FEMA's 2018-2022 Strategic Plan but also ensures drift-induced interference issues are detected early and appropriately managed throughout operations[8].



Challenge #2 - Extreme Operating Environments and Multiple Interference Paths

Similar to FEMA, the USCG operates in harsh environments. Fluctuating temperatures and continuous exposure to elements such as saltwater, wind, and sunlight can impact the physical condition and technological components of critical communications equipment.

Adding to the challenges, USCG Arctic units may be especially susceptible to radio frequency error and interference stemming from a combination of limited communication infrastructure and extreme environments. In particular, communication challenges specific to the agency's cold weather operations were most recently spotlighted as part of a federally funded research project[9]. Key findings from the study underlined numerous gaps in communication and investigative functions. Apart from advancing response elements and hardening existing communication infrastructure, study participants also reflected on the need to invest in safety and security technology to boost situational awareness, ruggedize equipment, and better support all stakeholders.

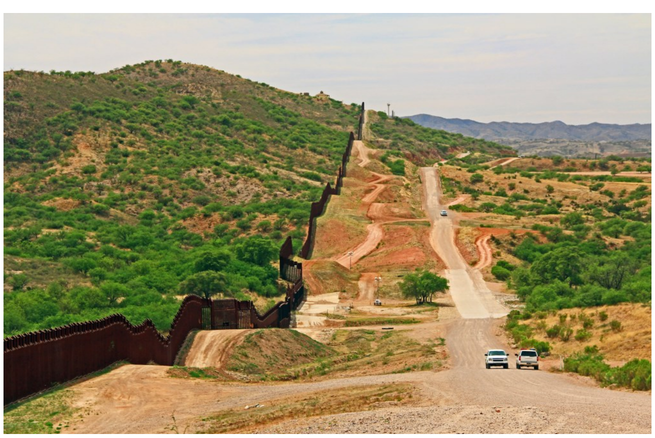


Along these lines, because the USCG operates along the coast and offshore, it relies heavily on VHF radio to communicate between units and command as well as other vessels. However, hollow audio, excess noise, and erratic signal strength are notoriously known for creating frustrating and lengthy complications during both routine operations and search and rescue missions. Besides exacerbating already hazardous assignments, RF interference sources can be notoriously difficult to isolate and resolve.

Initial instances of RF drift can mask as other interference paths such as those caused by auxiliary equipment. For example, frequency interference originating from LED lighting positioned along the agency's watercraft has resulted in evolutionary communication disruptions and unnecessary delays for USCG personnel. As recorded in DHS Marine Safety Alert 13-18, radio frequency interference, and Automatic Identification System (AIS) degradation caused by LED lamps have become a dire concern. To date, there have been notable instances of communication failures occurring between rescue coordination centers and involved operational assets[10]. As expected, in addition to standard operations, identifying and confirming both the radio frequency interference catalyst and affected radios has become an arduous and time-consuming task. Besides adding to the inherent risks, recurrent instances of radio frequency error may be erroneously diagnosed, dismissed, and discounted without further investigation. Even worse, fully functional auxiliary equipment may be prematurely shuttered as a precautionary measure. In this case, neither option is favorable.

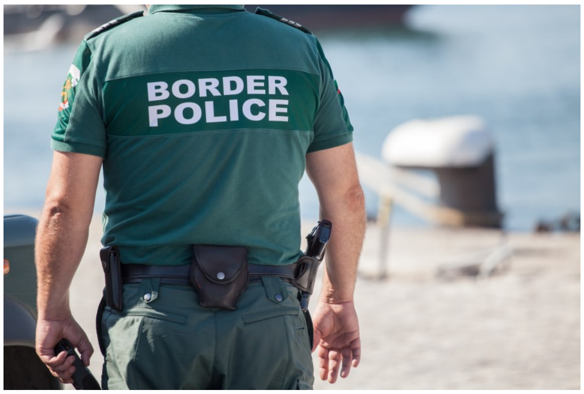
Strategically speaking, as the USCG occupies a critical position in both a security and rescue capacity, the agency must prepare for and safeguard against preventable and hazardous sources of communications failure and RF interference. Under this premise, a flexible and dynamic signal monitor and waveform analyzer could serve as a proactive instrument to enhance capabilities while also identifying and confirming both misaligned communications equipment and potentially dangerous interference or failure.

Challenge #3 - Aging Equipment and Adverse Use



As one of the 22 agencies operating under the DHS umbrella, USCBP is one of the nation's largest law enforcement organizations with a staff of more than 60,000. In addition to enforcement and protection duties across 328 ports and 95,000 miles of shoreline, the agency also patrols a combined 24,000 miles along the United States' northern and southern borders[11]. As part of their duties, USCBP officers work on the front lines of some of the most unforgivable terrain in the country. Because of the demanding conditions and high-risk aspects of their job, reliable and robust LMR equipment is vital to ensuring security, safeguarding personnel, and preserving mission integrity.

However, as part of a multi-agency organization, operating budgets remain stringent and subject to scrutiny. As part of its lifecycle equipment management strategy, DHS forecasts LMR systems, including radios, to last an average span of 15 years[12]. Still, while this lifecycle goal is attainable, proper attention must be given to ensure radios utilized by USCBP officers function as expected with all components and circuitry operational and intact. Given the instance of crystal oscillator damage increases over time, agencies such as USCBP must direct special attention to ensure all subscribers are inspected for proper frequency alignment. Failure to do so heightens the probability of misdiagnosed radio frequency interference, drift-induced communications failure, and diminished equipment longevity.



Likewise, adverse utilization is also a hindrance to subscriber health. Without question, USCBP officers are at risk of communications failure and equipment damage due to operating hazards inherent to their assignments. For example, excess vibration stemming from an off-road vehicle and ATV mounting brackets can dislodge batteries and degrade the operational integrity of an officer's two-way radio. Accidental drops can yield a similar effect. Further still, fatigue stemming from constant shifts between the radios on/off positions may result in irreparable internal damage and unpredictable occurrences of frequency drift.

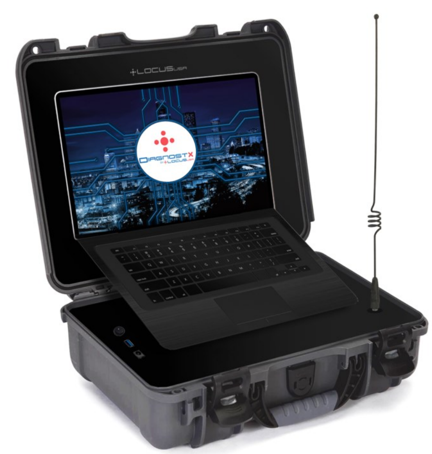
Because multi-source radio frequency interference remains a persistent problem in USCBP, the agency should continuously monitor all in-field subscribers for signs of irregular waveforms and frequency deviation[13]. As identified in numerous DHS publications, multi-source RF interference remains a chief concern throughout USCBP. With this in mind, the agency should continuously monitor all in-field subscribers for signs of irregular waveforms and frequency deviation indicative of internal radio frequency interference.

Compounding the challenges, the USCBP faces in maintaining and advancing LMR capabilities, it's paramount the agency approaches these tasks from a position of strength. Besides the numerous hazards and increasing vulnerabilities driven by outside control factors, inside risk drivers such as communications failure and equipment degradation can threaten and dilute mission safety and security. Thus, as crystal oscillator damage and radio frequency error are both diagnosable and preventable interference vectors, USCPB officials must consider deploying and distributing preemptive mitigation tools such as radio analyzers throughout the agency.

Introducing a Portable and Innovative Solution

Over-The-Air Radio Analyzers are diagnostic instruments that capture and measure radio waveforms in real-time while a device is in use. Acting as an ever-present monitoring system that assesses the health and operability of all subscribers on a system, these instruments can also proactively detect and identify instances of crystal oscillator damage, RF drift, and related radio frequency interference before these incidents lead to hazardous conditions and communication failures.

This technology has been recently re-imagined and retooled to accommodate mobile operations. With the development of smaller, portable versions of these instruments, organizations can easily store and deploy radio analyzers on the go without ever having to compromise on quality, accuracy, or effectiveness.



DiagnostX™ PX-900 Portable Instrument

As a result of this evolution, it is simpler and more cost-effective than ever to ensure mission-critical communications equipment is properly aligned and fit for duty, while simultaneously mitigating the hazards caused by frequency error.

Looking to the Future

Boosting communication resiliency and situational awareness during security and disaster operations remains priority one. As the rate and complexity of these incidents increase, there is a growing urgency for flexible and adaptable devices to support both mission objectives and the people behind their success.

Although not always preventable, RF interference, communications failure, and equipment malfunction can compromise the safety and effectiveness of all stakeholders. In light of these facts, agencies must take of proactive stance toward detecting and preventing hazardous conditions stemming from radio frequency error.

Therefore, from both a technological and tactical perspective, portable radio analyzers represent a favorable future-facing investment for agencies engaged in critical communications throughout dynamic and hazardous environments.

About LocusUSA

LocusUSA is an engineering and software development company located in West Melbourne on the Space Coast of Florida since 2001. It is a leader in radio frequency (RF) capture for radio analysis and location. The ability to capture and analyze the actual waveform of a radio transmission led to the development of DiagnostX™, a patented system that can measure the alignment and operating characteristics of a radio, touch-free, over-the-air (OTA) in real-time and without user intervention.

Additionally, with the launch of its new portable version of DiagnostX, LocusUSA has reimaged its solution to adapt to the dynamic needs of disaster response and security organizations. With the DiagnostX PX-900, convenient in-field testing and monitoring can be implemented and maintained without compromise, throughout challenging environments and crisis operations.

LocusUSA supports government customers across the United States and Canada on the local, state, and federal levels with this first-of-its-kind, proactive instrument, ensuring the optimal performance of a radio system. For more information on how DiagnostX can help keep your personnel safe while ensuring operational readiness, contact us at 321.727.3077 or visit us online at www.locususa.com to schedule your DiagnostX demonstration today.

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Sources

[1] United States Fire Administration., and International Association of Fire Fighters. (2016). Voice radio communications guide for the fire service. Emmitsburg, MD. United States Fire Administration.

[2] Davis, W. D., Donnelly, M. K., Selepak, M., & National Institute of Standards and Technology. (2006). Testing of Portable Radios in a Fire Fighting Environment. NIST Technical Note #1477.

[3] Cybersecurity and Infrastructure Security Agency (CISA). (2020). Public Safety Radio Frequency Interference Best Practices Guidebook. Washington DC. Cybersecurity and Infrastructure Security Agency.

[4] Elbert, B. R. (2016). Radio frequency interference in communications systems. Boston: Artech House.

[5] Federal Emergency Management Agency. (2018). 2017 hurricane season FEMA after-action report. Washington, DC. Federal Emergency Management Agency.

[6] Lombardi, Michael. (1996). An Introduction to Frequency Calibration Part II. Cal Lab: International Journal of Metrology. 3. 28-34.

[7] Government Accountability Office (2018). 2017 hurricanes and wildfires: Initial observations on the federal response and key recovery challenges. Washington, DC. Government Accountability Office.

[8] Federal Emergency Management Agency. (2018). FEMA strategic plan 2018-2022. Washington, DC. Federal Emergency Management Agency.

[9] Tingstad, A., RAND Homeland Security and Defense Center, United States & Rand Corporation. (2018). Identifying potential gaps in US Coast Guard Arctic capabilities.

[10] US Coast Guard, Spectrum Management and Telecommunications Policy Division. (2018, August 15). Let us enlighten you about LED lighting! Potential interference of VHF-FM Radio and AIS Reception. Safety Alert 13-18.

[11] United States Customs and Border Patrol. (2016). Performance and accountability report: fiscal year 2016. Washington, DC. United States Customs and Border Patrol.

[12] Government Accountability Office. (2016). Emergency Communications: Improved procurement of land mobile radios could enhance interoperability and cut costs: report to congressional requesters. Washington, DC. Government Accountability Office.

[13] Department of Homeland Security. (2018). Emergency Communications System Life Cycle Planning Guide. Washington, D.C. Department of Homeland Security.