WHITE PAPER

Assessing the Effects of Radio Failure in High-Risk Incidents

A Guide for Public Safety Agencies

Introduction

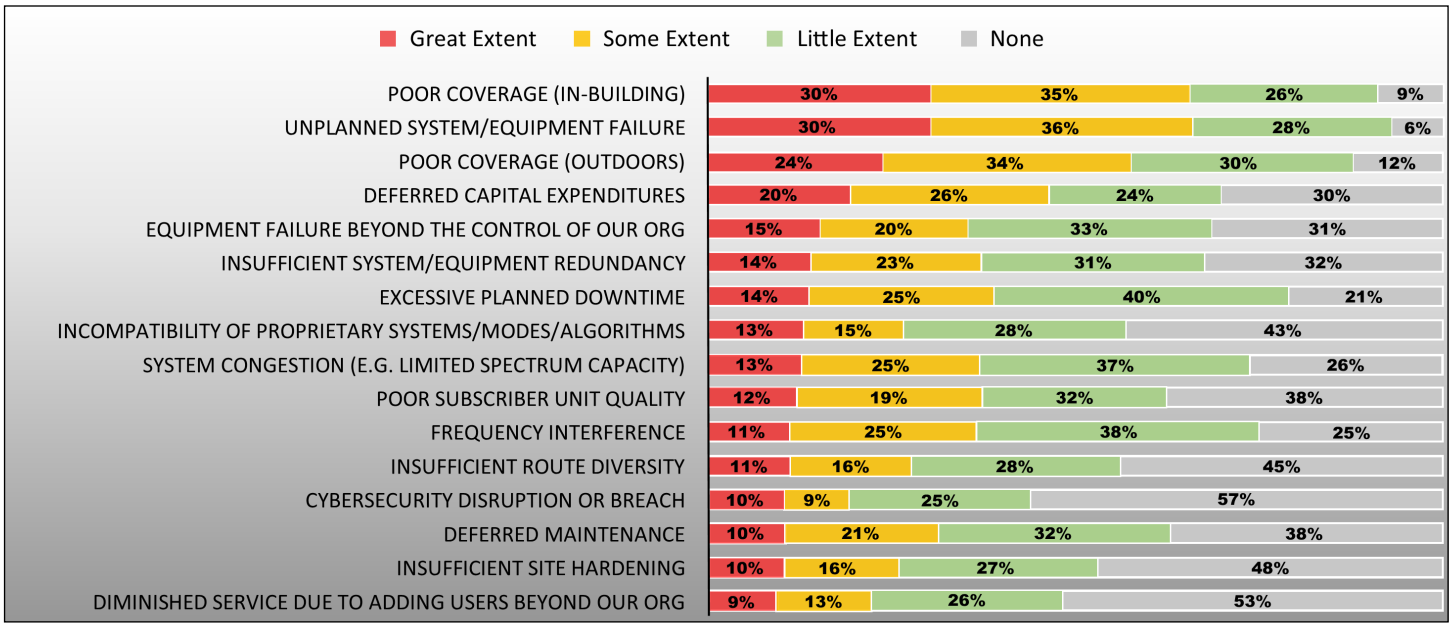
Monitoring, managing, and maintaining radio communications is paramount to public safety. Yet, time and time again, we are forced to bear witness as responders nationwide face scrutiny for failing to sustain communications during high-risk incidents.

Over the last decade, the media has taken an interest in tragically displaying their own colorful accounts of these failures. However, anyone who has ever been on the receiving end of a communications breakdown knows it is not that cut and dry.

Preparedness is rarely the problem. Nor is lack of training. Instead, most often, the real issue lies with malfunctioning communications equipment and the historical *fix it when it fails* approach.

According to a 2018 SAFECOM survey released by the U.S. Department of Homeland Security Office of Emergency Communications, over 30% of the responding participants report that unplanned system failures greatly affect their organization's ability to communicate. While 74% of participants admit to experiencing frequency interference during day-to-day operations. Even more surprising, 43% of all parties surveyed, cited deferred radio maintenance, as having some effect on the quality of their communications. [1]

Risk Factors That Affect an Organizations Ability to Communication



Still, even as we identify these risk factors as unacceptable, budget constraints and limited funding options threaten the operational readiness of public safety agencies everywhere. Unfortunately, these problems are not going to disappear anytime soon. As technology advances, the question of necessity versus nicety will grow more complex. With the industry evolution and new threat dynamics, it is imperative for agencies to adopt and deploy preemptive solutions to ensure the health and integrity of their vital communications equipment.

This white paper exposes the hidden dangers of communication failure and introduces a cost-effective way for agencies to proactively identify and detect Land Mobile Radio (LMR) frequency errors and signal disruptions before these issues transform into tragedies.

Analyzing the Evolution of Public Safety Communications

After the catastrophic events of the last twenty years, this country has made tremendous strides to ensure first responders have access to the essential equipment needed to coordinate with fellow rescuers and operations staff. With the creation of the National Incident Management System and the migration to a unified command structure, first responders receive better training, equipment, and support than any other time in history.

As the industry looks to the future, digital improvements in LMR and the implementation of real-time technology will enable public safety professionals to perform their duties with a higher degree of accuracy and improved insight into the human side of operations.

However, with this new level of heightened awareness, comes the underlying risk of false assurance, and a tendency to overlook four unwritten rules that have enabled agencies to operate for the last century.

Put another way:

- There are no absolutes in emergency services
- Contingency plans are not optional
- Technology is not foolproof
- Communication failures will always occur at the worst possible time

While upgrading your existing LMR systems and investing in digital solutions are a logical first step in decreasing risk, these actions are merely the tip of the spear. Like any technology, this equipment requires scheduled maintenance and constant monitoring.

Even brand-new communication systems are susceptible to failure. Most often, these problems remain hidden until the equipment fails. What's worse, when a failure occurs, it can create a gray area that results in radio system managers spending hours of trial and error chasing down the source of the issue before they can begin fixing it.

Uncovering the Hidden Danger Lurking Inside Your Radio

One of the most challenging problems to detect is radio frequency drift. Often this issue stems from poor calibration or improper signal alignment. Problems can range from inaudible transmissions and incomplete radio identifier displays, all the way up to calls being rejected by the system.

If a radio falls out of alignment, not only can it affect the individual subscriber's ability to transmit and receive, but it can also impact users on adjacent systems.

More specifically, in 2013, the FCC narrowband mandate allowed for entities to license frequencies closer together. [2]

This increased use of frequency spectrum elevated the probability of a misaligned radio interfering with an adjacent channel user.

Frequency drift has become such a problem that even the manufacturers have taken steps to alert customers to the risk.

Did You Know?

- At any given time, 15 to 20 percent of an agency's subscriber radios have drifted out of alignment, causing them to fail without warning.
- For every 100 radios on an LMR system, there are between 5 and 10 subscribers on the road in danger of experiencing a communications failure at any time.
- Even if a radio appears to be functioning normally, frequency drift can lie undetected - only surfacing when the problem becomes severe.

For example, Motorola Solutions spotlights radio frequency drift in the service manuals for two of its most popular products - the APX mobile and portable radios. The company encourages frequency alignment with every service, or at least once a year. [3]

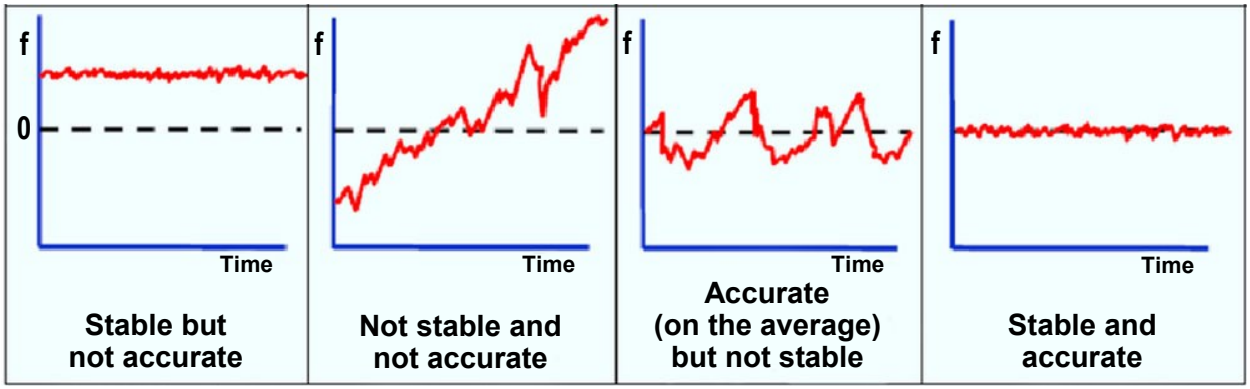
If a radio has been in storage for six months or longer, Motorola cautions that technicians should verify alignment before deeming it fit for service.

Recognizing the Causes of Radio Frequency Drift

Two-way radios rely on components known as crystal oscillators to provide precise frequency references for a radio's receiver and transmitter. [4]

Like any electronic component, crystal oscillators are vulnerable to aging and damage, which can cause them to fall out of alignment and eventually drift too far from the baseline.

Frequency Accuracy and Stability Dependencies of Crystal Oscillators



If left unchecked, an oscillator drift can result in signal interference or complete communication failure.

Factors that contribute to reference oscillator drift include: [5 - 6]

- Mechanical Vibrations - Bumpy roads, rough terrain, or accidental drops
- Power Supply Fluctuations - Poorly maintained batteries, interference from vehicle-mounted equipment or constant shifts between a radio's on/off position
- Environmental Changes - Excessive moisture, temperature fluctuations or exposure to extreme elements

Often, operators and technicians will dismiss signs of oscillator drift by attributing the problem to inadequate network coverage, defective batteries, or loose radio casings. However, these clues are warning signs that the radio's frequency is out of alignment.

What if Your Radio Has Automatic Frequency Control?

In recent years, radio manufacturers have tried to combat frequency drift by installing a feature known as automatic frequency control or AFC. [7]

This feature acts much like the lane assist in a vehicle, in that when a radio shifts out of alignment, AFC nudges it back into its lane, or in this case, frequency.

However, unlike a vehicle system that alerts the operator of constant lane departures and discloses the need for alignment, AFC functions without notifying the user when a correction has taken place. Therefore, there is

no cause to seek repair. Meanwhile, the problem continues until a radio falls so far out of alignment, that even AFC can't nudge it back into frequency. Eventually, the radio will fail to send or receive transmissions.

The verdict?

While AFC is indeed a useful feature for short-term corrections, it masks the underlying problem of radio frequency drift and produces a sense of false confidence.

To further understand the impacts of frequency drift, let's examine what could happen if one unit's radio fell out of alignment during a high-risk incident.

Before we start the scenario, it's important to put the story into perspective by defining the scene parameters.

In 2018, The Federal Bureau of Investigations reported a total of 213 casualties resulting from 27 mass shootings occurring nationwide. [8] Although tragic, these heavily publicized incidents only reflect a fraction of the risks law enforcement officers face every day.

Far more common but just as deadly, are the events that never make it past the state or local news stations. They happen every day in small towns and big cities. Some end peacefully, while other's end in tragedy. Most are spontaneous and involve everyday people who have crossed the line between fear and desperation. Sometimes drugs or alcohol play a role; other times, mental illness is to blame, but no matter the catalyst, the fact remains: Barricaded subjects are one of the most volatile and dangerous situations an officer will ever face. [9]

Barricaded Subject

"A criminal suspect who has taken a position in a physical location that does not allow immediate police access - whether fortified or not - and who is refusing police orders to exit."

A barricaded subject may be:

- Armed or unarmed
- Alone or with hostages
- Depressed, angry, or suicidal

- The International Association of Chiefs of Police

Assessing the Impact of Radio Frequency Drift in High-Risk Incidents

Even as you read this, know that somewhere, right now, an officer is responding to a routine request for assistance. This call may have come in as a domestic dispute, or a neighborhood disturbance; perhaps even a welfare check. In any case, there is a high likelihood that this call will escalate into a barricaded subject incident. When that moment comes, this officer's communications equipment will play a critical role in helping them stay safe while protecting the lives of those around them.

But what would happen if the officer were cut-off from communications?

How would they request assistance?

What if the suspect was armed?

How long would it take for dispatch to realize something was wrong before sending help?

Let's find out.

80 Minutes Before Incident Start Time

It's 22:41, on a Friday night in Anytown, USA. Sergeant Mike Smith has just relieved the on-duty road supervisor. While handing over the shift, his relief informs him of several missed calls that occurred earlier in the tour. As a precaution, the off-going sergeant advises Mike, the problem seems to have resolved itself, but it's worth keeping an ear out… just in case.

40 Minutes Before Incident Start Time

At 23:19, dispatch attempts to raise Officer Miller to assign him an incoming 911 call. After two additional attempts to contact, the officer finally acknowledges and proceeds to handle the request without further incident.

20 Minutes Before Incident Start Time

At 23:39, another officer reports an issue with her radio. In addition to low volume and scratchy transmissions Officer Johnson states she's having trouble reaching dispatch and has needed to repeat herself several times before receiving an acknowledgment.

13 Minutes Before Incident Start Time

By 23:46, Sgt. Smith has had enough of the issue. As the only supervisor on duty, he realizes it's his responsibility to protect his officers from unnecessary risks. In his mind, two of his units have already expressed difficulty transmitting. And the earlier tour voiced similar concerns. Continuing to operate on an unreliable channel would be foolish and negligent. Not to mention, an inherent threat to officer safety. So after some deliberation, he makes a judgment call. Deeming the network unstable, he decides to close the primary channel and advises all units to switch to Channel B until further notice. The sergeant also requests an after-hours callout for radio repair to investigate the problem.

Agency Overview
Organizational Mission
Law Enforcement

Location
Anytown, USA

Number of Employees
117 Sworn Officers
47 Civilians

Jurisdictional Size
377.41 Square Miles

Population
29,721

Incident Start Time
0001 Hours

Incident Resolved
0312 Hours

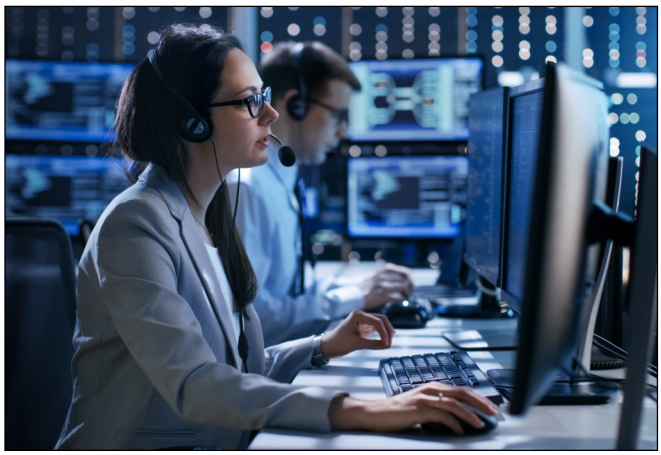
Incident Duration
311 Minutes

7 Minutes Before Incident Start Time

It's 23:53, and all is calm. Working on the backup channel isn't ideal, but the units are doing their best to coordinate with dispatch. Transmissions have cleared up, and it looks like the sergeant's suspicion was correct.

0 Minutes Before Incident Start Time

At 00:01, a call comes out for a suspicious person inside an apartment building at the edge of the district. Officer Johnson answers up right away, but the second unit doesn't acknowledge until after three additional attempts.



It's 00:17, the first unit arrives on-scene. However, Officer Johnson's arrival announcement never comes over the air. Officer Miller arrives 14 minutes later to find his fellow officer crouched down by her vehicle, and an armed subject pointing a weapon out the window. The suspect appears to have children in the apartment with him; it's unknown whether he is suicidal.

Officer Miller immediately alerts dispatch to the situation. Multiple units chime up in response. Sergeant Smith advises the other officers to keep their transmissions to a minimum, and once again asks the status of radio repair.

By 00:41, the radio channel becomes clogged with traffic. Aside from monitoring the barricade scene, dispatch is frantically attempting to field new calls and coordinate with officers responding to unrelated emergencies.

At 00:51, Dispatch requests Sgt. Smith reopen Channel A and allow them to divert normal radio traffic to a second channel. Sergeant Smith denies the request, as he stills blames the network for lost transmissions.

It's 01:00, by the time radio repair, arrives at operations. At the same time, the agency's commanding officer also enters the communications center. The CO is horrified when he hears the audio quality coming over the back-up channel. He paces the floor, radio in hand for forty-five minutes, before prodding repair technicians for a resolution to the system failure.

By 02:00, technicians from radio repair discover the network is fully functional. They determine the problems must have resulted from user or equipment error. In response, the CO advises dispatch to reopen channel A and divert excess traffic to the original band.

At 03:01, special units make entry and subdue the suspect without incident. They find three small children, under the age of five hiding under the kitchen table. Thankfully no one is injured. However, the incident had the potential for a vastly different outcome.

Two Days After the Incident

The agency determines that Officer Johnson's radio malfunctioned due to calibration issues, causing dispatch to miss her arrival announcement, and four additional requests for immediate assistance. They verbally reprimand Sgt. Smith for closing the primary channel before verifying the source of the initial transmission was indeed the result of a network error.

As luck would have it, the media never catches wind of the communications breakdown. But in hindsight, after experiencing frequency drift firsthand, the agency decides to prioritize preventative radio maintenance.

In Conclusion

While the previous event was fictitious, this scenario illustrates the importance of proactive frequency testing. Had the suspect turned his weapon on the children or fired at the officers, it could have resulted in life-altering consequences for the agency and the community.
In truth, there are millions of police officers who fit the profile of the characters in this story. They are out there in our neighborhoods every day, performing their duties and expecting to return home at the end of their shift.

And while innovative technology is at the top of most agency's equipment wish lists, it's crucial to take preemptive measures to manage the mission-critical equipment first responders rely on every second, every day.

Mitigating Radio Frequency Drift

Up until recently, there were only two ways to determine whether a system user was suffering from frequency drift.

The first being a reactive approach. Meaning that unless the user experiences a problem with their radio, the agency will not evaluate the equipment for frequency error or oscillator drift. However, as we just discovered,

this approach is hazardous and can result in unnecessary risks to personnel and the community.

Another way to identify frequency drift is through scheduled maintenance. This approach is a bit better as it takes a proactive stance towards maintaining operational readiness. Unfortunately, annual maintenance testing is costly and time-consuming. To measure a radio's alignment, a technician must physically connect the unit to an analyzer device.

As you can expect, this second practice presents obstacles for agencies tasked with protecting the public twenty-four hours a day, every day. In most cases, there is not enough time or resources to go around.

For one, taking units out of the field and away from their duties, is counterproductive to the mission. And second, there are no slow seasons or optimal times to conduct testing. While mobile servicing units are one option, if a call comes in during the scheduled downtime, response requests will always take precedence over maintenance activities.

If a unit is unable to keep with annual maintenance schedules, the agency may postpone testing that unit's equipment for another year or longer. Unfortunately, this deferred approach elevates the chance of frequency drift interfering with this responder's ability to communicate.

How Does Your Agency's Maintenance Schedule Stack Up Against the Status Quo?

Let's take a look.

In 2018, LocusUSA decided to investigate the radio maintenance issue by conducting a blind survey. The company polled 300 public safety and government agencies asking them to share their annual radio maintenance habits.

The results were unsettling.

Fifty-three percent of survey participants indicated their agency does use a preventative maintenance schedule to confirm their radios are function properly, while the remaining 47% have no plan in place.

Even more surprising, 63% of the participating agency's identified their current method for detecting equipment issues as reactive. Meaning unless there is a known problem with the equipment, the agency takes no action to ensure its subscribers can send and receive communications.

However justifiable, this practice of tabling radio maintenance endangers our first responders by jeopardizing their ability to communicate critical information. It also poses unnecessary risks to the public and opens agencies up to long-term reputational and legal damages.

Simply put, the industry must develop a plan to make the monitoring and maintenance process less tedious and more economical.

Thankfully, there is a solution that can accomplish both of these objectives while keeping units out in the field where they are needed most.

This solution employs first-of-its-kind technology to capture and analyze the radio waves of every subscriber on the system, over-the-air and long-range, thereby mitigating the chances of frequency drift

occurring without warning.

The best part?

It is essentially plug and play. Meaning it requires no additional steps or active participation by the user or agency.

The solution is known as an over-the-air waveform analyzer. And it is making radio maintenance more affordable for public safety agencies everywhere.

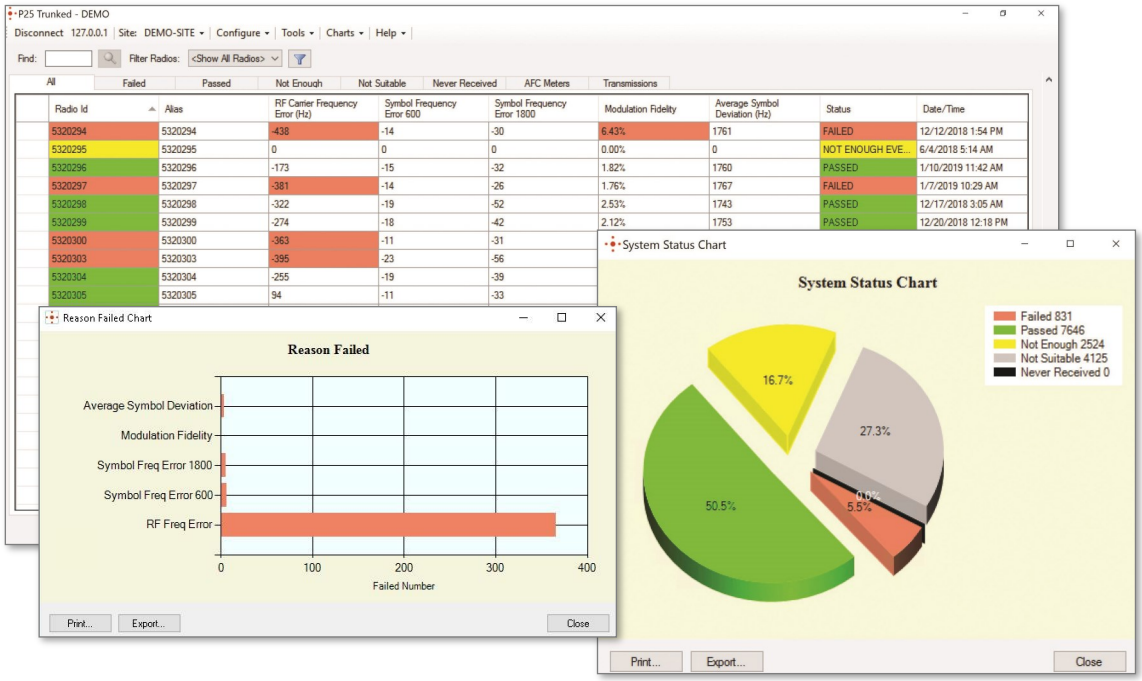
Introducing a Diagnostic Solution

An over-the-air waveform analyzer acts as an ever-present monitoring tool that continuously assesses the health and operability of all subscribers on a system. [10]

The solution works by capturing and measuring a radios waveform in real-time while units stay deployed in the field.

System users simply key up their radios for measurement, and from there, the solution analyzes the equipment to ensure optimal frequency performance 24 hours a day, 7 days a week, without user intervention.

The analyzer also generates and sends reports to system managers so they can prioritize maintenance schedules based on subscriber performance. There is never a need to waste precious time testing fully functional radios or tracking down the source of LMR interference. With one glance, managers can verify network health and identify which radios require recalibration.



The over-the-air waveform analyzer provides System Status reports identifying which radios need to be brought in for immediate service.

Managers can choose between a variety of coverage configurations and scalable options to align with their operational needs.

As an optional safeguard, analyzers can identify radios receiving a temporary correction from automatic frequency control. This feature provides yet another layer of protection for system managers dealing with multiple facets of mission-critical technology.

Which Maintenance Method Makes More Sense?

Proactive Radio Maintenance	Fix It When It Fails
Know which radios are at risk for frequency drift before they endanger life and safety	Wait until there is a problem and hope there are no injuries or lives lost in the process
Identify and determine the source of the signal disruptions at the onset so it can be managed and rectified accordingly	Spend incessant hours tracking down the cause of the problem while managing day-to-day and high-risk operations
Prioritize maintenance activities for pre-identified at-risk radios while cutting back on the need to test fully functional equipment	Schedule annual radio maintenance and perform time-consuming check-ups of all the radios on your system
Reduce repair costs and out of service time by identifying the need for recalibration	Send the equipment out for repairs and hope the technician checks the calibration before sending the unit back to the manufacturer
Monitor and manage your entire radio inventory 24x7x365 without the need for physical inspection or after-hours service callouts	Gamble on the chances that frequency interference will only occur Monday through Friday during normal business hours
Determine the exact cost of monitoring and managing your radio system well ahead of budget planning deadlines	Guess that your calibration and alignment expenses will not exceed the annual projected costs
Expand the solution to monitor coverage at multiple sites automatically	Haul your testing equipment out to each site to measure signal health

Evaluating the Next Steps

While radio frequency drift is only one of the many risks our nation's first responders face every day, it should not take a tragedy to provoke action. Technology has given us the power to protect our responders from the dangers of failing communications equipment.

As public safety agencies move further into the spotlight, it's becoming increasingly important for government leaders and department officials to shield their agency from negative media exposure, public scrutiny, and potential liability claims.

Though budget constraints have forced this industry to adjust tactics and adopt reactive maintenance schedules, this practice poses a significant danger to our first responders and our communities. We must remember that communication is the lifeblood of every emergency operation. Leaving our first responders susceptible to known equipment failures is not a viable option.

Over-the-air waveform analyzers provide agencies an affordable solution to two expensive problems: protecting both responders and the community from the rising costs of maintenance and the elevated risk of a communication breakdown.

Before deciding on your agency's next mission-critical purchase, it's imperative to evaluate the priorities. No matter where the future of technology leads us, clear and reliable communication will always be a non-negotiable necessity.

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, long-range over-the-air in real-time without user intervention. LocusUSA supports government customers across the United States and Canada on the local, state, and federal levels with this first-of-its-kind, proactive tool, 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.

Follow LocusUSA on :

DiagnostX in the Field

"During an emergency situation, radios have to perform. There's no time to fix them. We can avoid problems in the field by not having failures during a major incident. It also keeps people in the field by identifying problem radios, replacing them and are keeping the team in the field while they being worked on."

John Daly
Telecommunications Manager
Collier County, Florida

"Our department would spend a great deal of time chasing down specific issues with the radio system that were not valid. DiagnostX revealed the problem was not with the system but with individual radios."

Tracy Roberts
Former Radio System Manager
Cobb County, Georgia

"We support 2,500 radios across many agencies. In the past we have spent up to a year checking the alignment on all of the radios. With the DiagnostX unit we can print off the list of the radios that need to be aligned and call them in at will. This is a great cost savings to our organization. Add in Aeroflex's auto-tune feature on their 8800 service monitor and I have reduced preventative maintenance from a 2 technician / 1 year project to 1 technician / 1 month project."

Jake Thompson
Radio System Manager
Anoka County, Minnesota

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