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Spectrum Clearing and Geo-Locating Legacy Signals

Introduction

To meet demand for additional bandwidth for cellular and broadcast operations, national regulators are reallocating spectrum previously used for other applications. Before a new network can be rolled out within these frequencies, it is critical for the new license owner to confirm that all legacy users have terminated their transmissions. A typical example is the repurposing of the 600 MHz frequency band in the U.S. for LTE and 5G networks, which had previously been allocated for broadcast television.

Once unwanted legacy signals are detected, new license owners must locate the interference signal source. Remedial actions can then be taken with the operator of that signal source to remove the transmission. This application note highlights the process and techniques used to perform a spectrum clearing sweep and signal geo-location with the Anritsu Mobile InterferenceHunter™ MX280007A (MIH) system and Field Master Pro™ MS2090A real-time spectrum analyzer. The clearance process for the cellular 600 MHz band in the U.S. is used as an example.

Scope of Spectrum Clearance Operation – 600 MHz Band

In order to deploy cellular service, over one thousand TV stations are required to relocate or cease operations in Band 71 (see Figure 1).

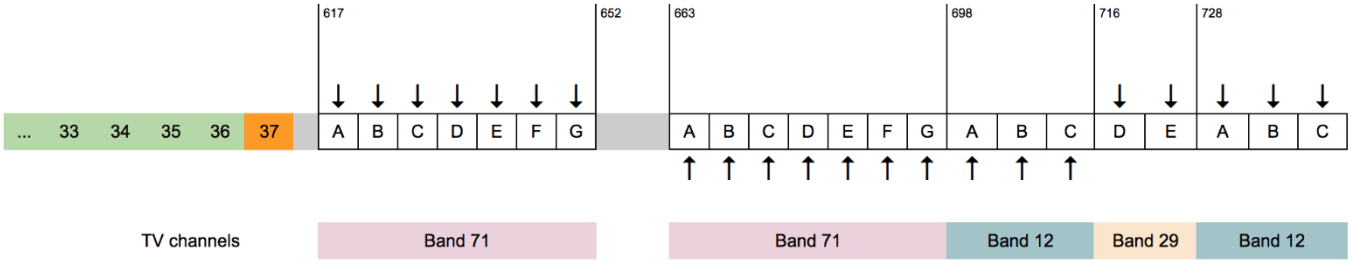

Figure 1. Spectrum for 600 MHz Deployments [1]

The uplink cellular band is the 35 MHz range of spectrum located between 663-698 MHz, while the downlink is 35 MHz wide and located in the 617-652 MHz range. Each band is logically divided into seven 5 MHz blocks A through G. TV stations will remain on channels 36 and below. Channel 37 and the gap between uplink and downlink bands will be used for other applications.

This map (Figure 2) shows the areas where the first 10,000 cell sites are deployed in the 600 MHz band.

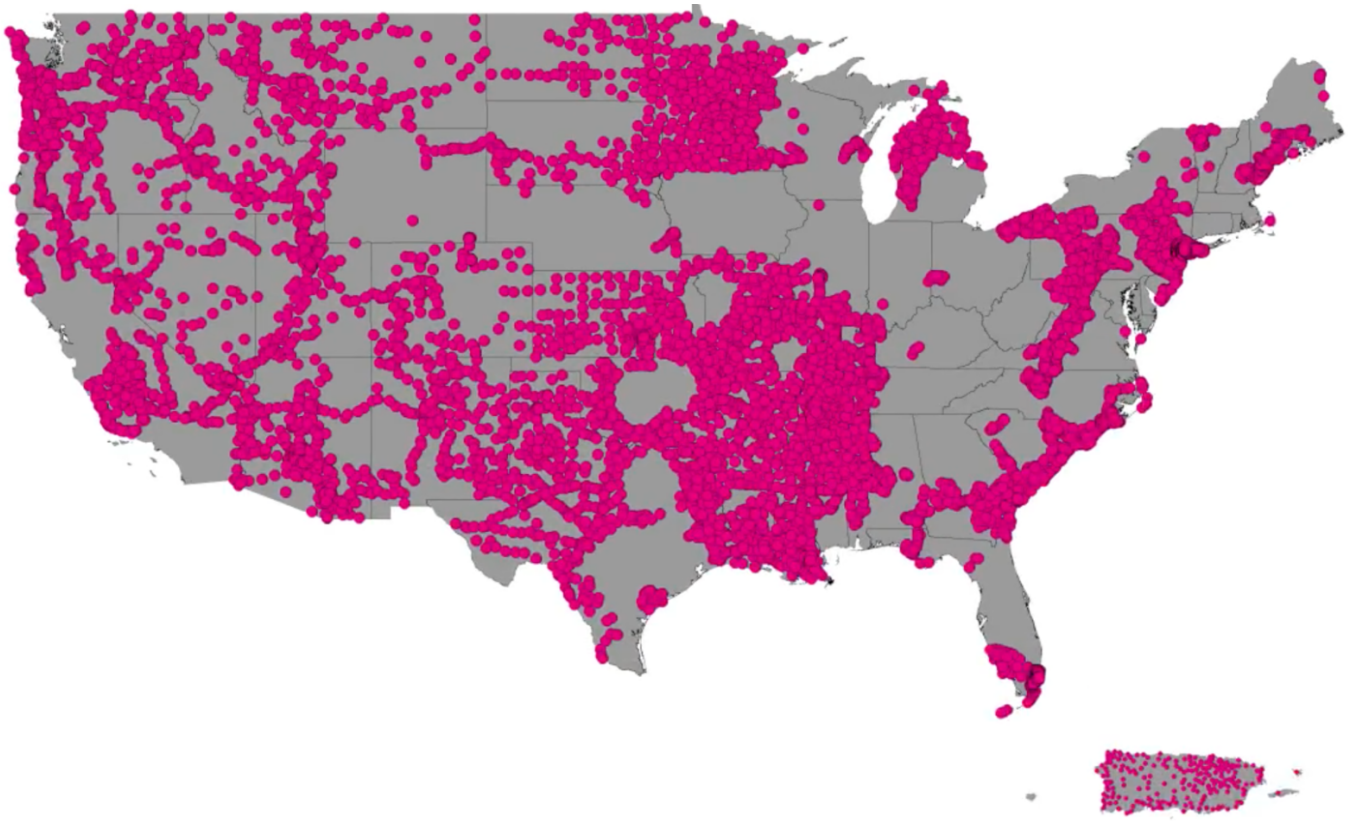

Figure 2. 600 MHz Cellular Deployment Map (first 10,000 sites) [2]

Carriers include the following providers.

- T-Mobile
- Speculators
- US Cellular
- Dish
- Comcast
- Regional Carriers

Anritsu Mobile InterferenceHunter MX280007A

Anritsu's Mobile InterferenceHunter MX280007A (MIH) is designed to meet both requirements for performing spectrum clearing sweeps and geo-locating sources of interference.

1. Spectrum Clearing - Scan the spectrum of interest to determine presence of legacy and illegal/ unwanted signals
2. Interference Signal Hunting – Identify the location (geo-locate) of those sources of interference.

[1] [2] Maps and charts available at www.spectrumgateway.com

Figure 3 illustrates the different components that form a typical MIH system.

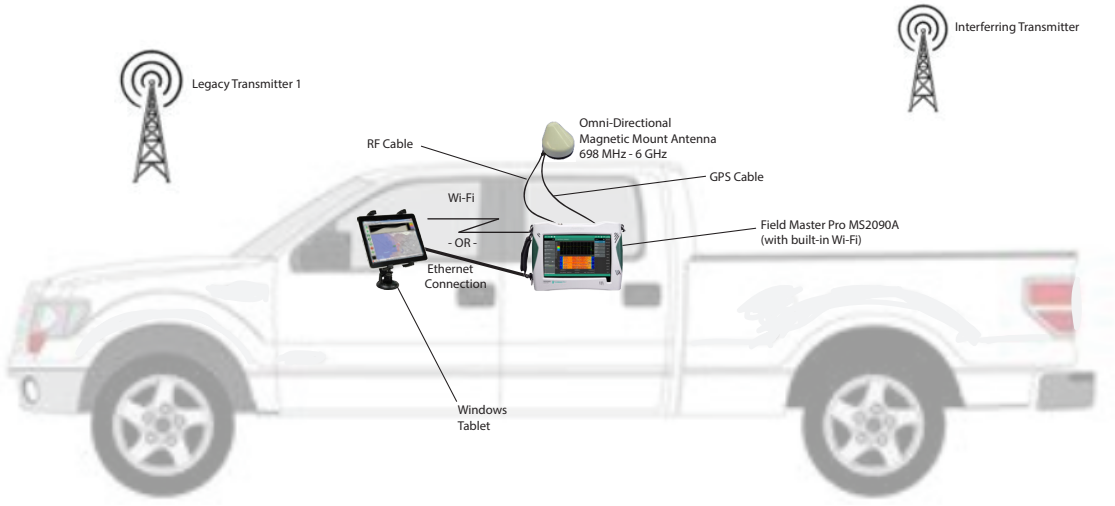

Figure 3: Spectrum Clearance and Interference Hunting Components

The MIH application runs on a tablet or laptop using the Windows® operating system. The PC/tablet connects to the Field Master Pro MS2090A spectrum analyzer by Ethernet cable or Wi-Fi® link[3]. On the roof of the vehicle is a magnetic mounted, omni-directional antenna that also has a built-in GPS antenna. Separate RF cables run from the antenna to the Field Master Pro MS2090A RF input, as well as from the GPS antenna to the Field Master Pro MS2090A GPS receiver input.

As the vehicle is driven around the geographic area of interest, the MIH application can pull RF measurements, such as channel power and GPS location, from the Field Master Pro MS2090A spectrum analyzer. These measurements are plotted on a digital map to create an overview of unwanted RF signals in the area.

Spectrum Clearance Simplified

The first step in conducting a spectrum clearance operation is the set-up of the Field Master Pro MS2090A spectrum analyzer for the frequency channel to be analyzed. Other parameters of interest include RBW/VBW settings, reference levels, and whether the use of a preamp is required. MIH works by measuring the channel power of the frequency band set by the spectrum analyzer.

To begin, from the Mode dropdown menu on the Mobile InterferenceHunter software, select the Spectrum Clearing option (Figure 4).

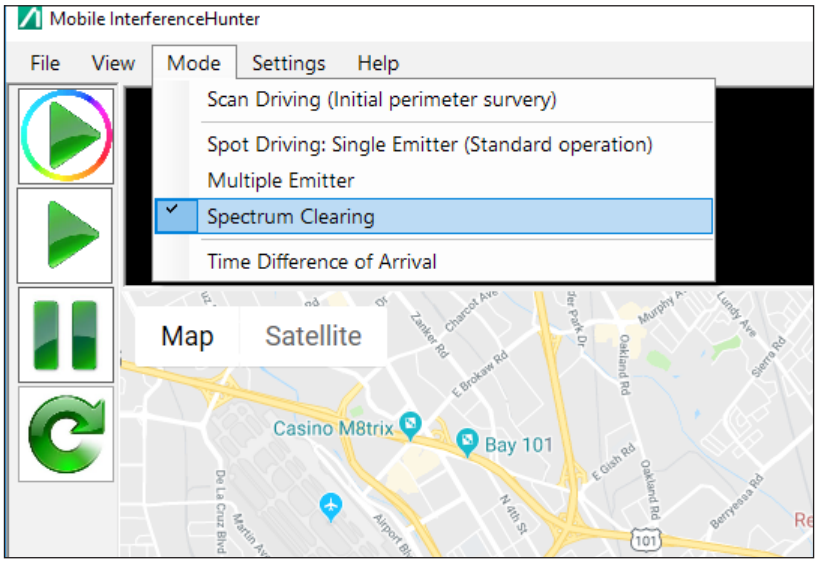

Figure 4. Select Spectrum Clearing Setting in MIH Application

[3] If using a wireless connection between the Field Master Pro MS2090A spectrum analyzer and PC/tablet, care must be taken that the wireless frequencies (ISM bands) do not interfere with the signals being surveyed.

A pop-up window is then displayed (Figure 5) where the threshold power can be set to a level where a signal would start to be considered a problem. By setting the threshold limit appropriately, signals below the threshold do not trigger alarms and are ignored during the data collection process. This value is typically a few dB above the instrument noise floor (measured with channel power for the current setup). Spectrum traces can also be saved each time a signal is measured above the threshold setting.

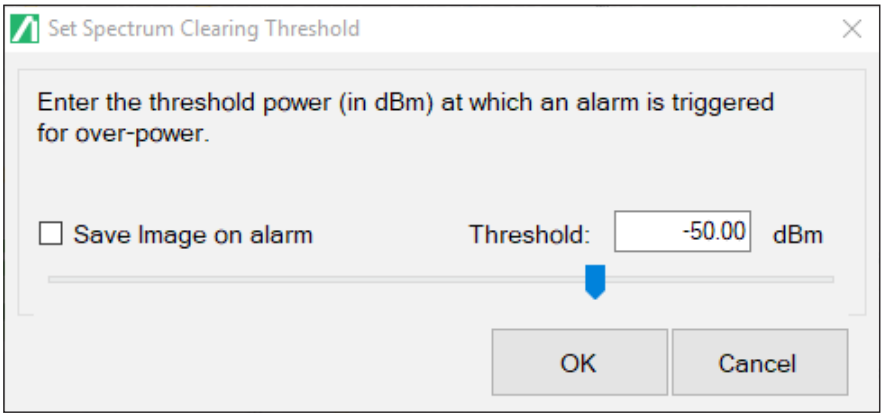

Figure 5. Spectrum Clearing Threshold Setting

If needed, the threshold setting can be changed after collecting measurements in the spectrum clearance drive operation. This is a post-processing capability useful for locating unwanted signals at unanticipated power levels.

In Spectrum Clearing mode, MIH allows users to set this go/no-go threshold based on the Field Master Pro MS2090A spectrum analyzer's channel power measurements. Other spectrum analyzer options, such as min and max hold, can be used for the drive.

- Min hold is generally used for measuring signals that appear underneath larger fluctuating signals, such as seen in LTE uplink bands.
- Max hold can be used to find intermittent or bursty signals, such as those encountered in radar applications.

In the example shown in Figure 6, a clearance drive is conducted near San Jose, California. Measurements were made in the 600 MHz band. One can easily see areas where signals are present (shown in red) and where the spectrum is clear (shown in green). The top of the screen shows power measurements as a function of position.

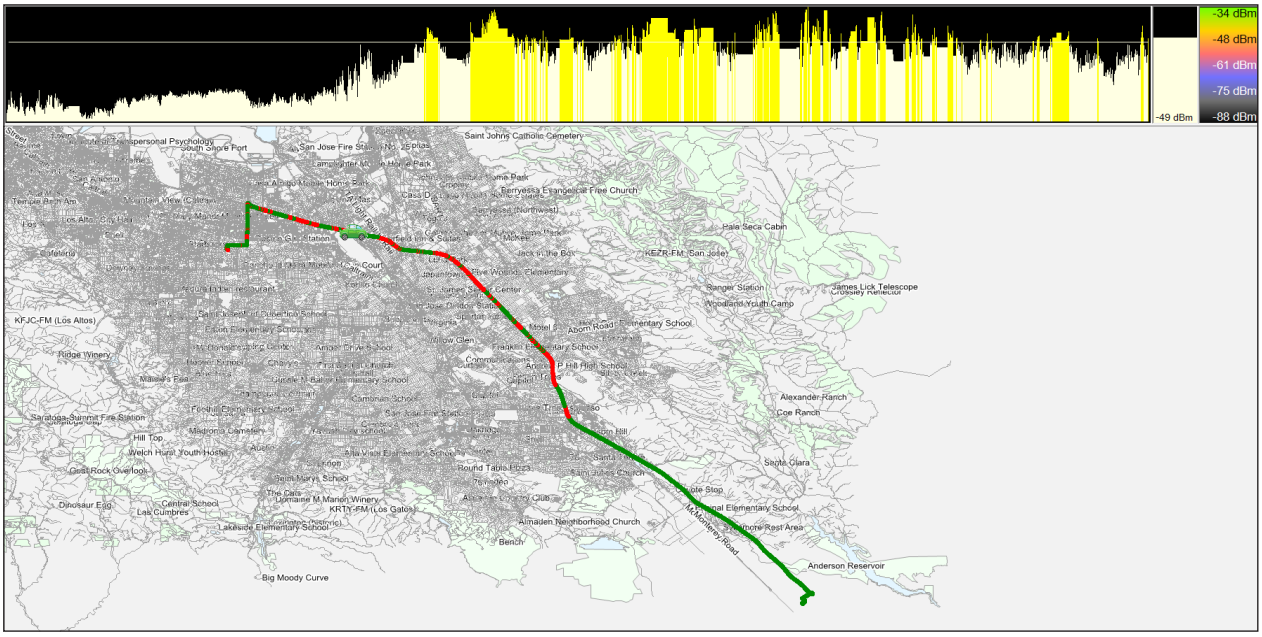

Figure 6. Spectrum Clearance Drive Example

Users may also save spectrum traces for each measurement point where unwanted or interfering signals are present. This facilitates discovery of the type of signal(s) present by viewing spectrum profile, center frequency, and bandwidth. For example, the 600 MHz spectrum was previously occupied by broadcast TV transmitters. If the spectrum shape captured and recorded at the point of interference has the characteristics of a broadcast TV transmitter, it is likely that the incumbent user is still active and has not shut down their transmitter. In addition to discovering whether certain previously authorized signals were removed, users will also record any other signals in the band. This can be caused by intermodulation products mixing at out-of-band frequencies or by illegal signals. Additionally, faulty or degraded cable TV networks can leak radiation into both the UHF and VHF bands.

Figure 7 shows an example of a signal present in the 600 MHz band. Such signals can disrupt the cellular signals to be deployed in the area.

Figure 7. Spectrum Showing Signals in Frequency Band of Interest

In most cases, the uplink channels for the 600 MHz band (663-698 MHz) are surveyed for unwanted signals. Power levels of uplink signals are lower than the downlink and more susceptible to interference problems. In areas where time domain duplexed (TDD) signals are used, downlink and uplink signals share the same frequency spectrum and are separated only in time. Spectrum clearance becomes essential in these bands. Even low levels of interference can result in degradation of key performance indicators (KPIs) for the new operator. This results in poor cellular performance, especially data throughput.

Interference Hunting

Once the spectrum clearing operation is complete, it is important to geo-locate all detected signals. The interference hunting capability of MIH can then be utilized. MIH continuously measures the signal(s) of interest, guiding the user to the position where the transmission(s) originate. This is done by providing signal position estimates on a map and voice prompts to guide the user to the signal source.

Key features for the Mobile InterferenceHunter solution include:

- Fast geo-location of signals by driving around the interference zone in a vehicle
- Location of continuous broadcast and intermittent signals
- Capability to find signals hidden by LTE transmissions in the uplink bands
- Constant automated measurements to minimize multi-path effects
- Post-drive analysis tools
- Quick setup
- Heat maps to facilitate signal positioning
- Use of either online (GoogleMaps) or off-line maps if internet connection not available

Figure 8 shows an example for a signal hunting application.

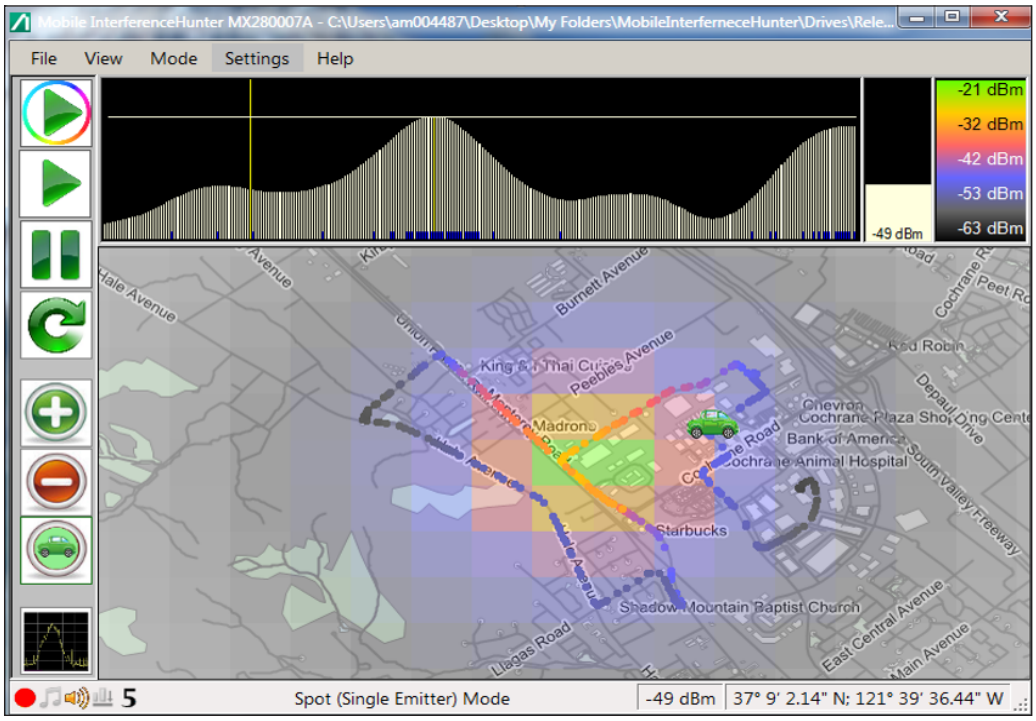

Figure 8. Interference Hunt Results

For real-time analysis of interference, a car icon is placed on the map showing the user's current position. Breadcrumbs (colored dots) are also left on the map whose colors are proportional to signal strength. This facilitates the signal hunting process, making it adaptable for different types of signals.

Figure 9 shows the various modes available with MIH. In addition to spectrum clearing, MIH provides the ability to quickly locate single emitters as well as multiple emitters. The channel power measurement capabilities in MIH also allow users to track and locate signals that fluctuate in frequency, such as amplifiers and repeaters driven into oscillation.

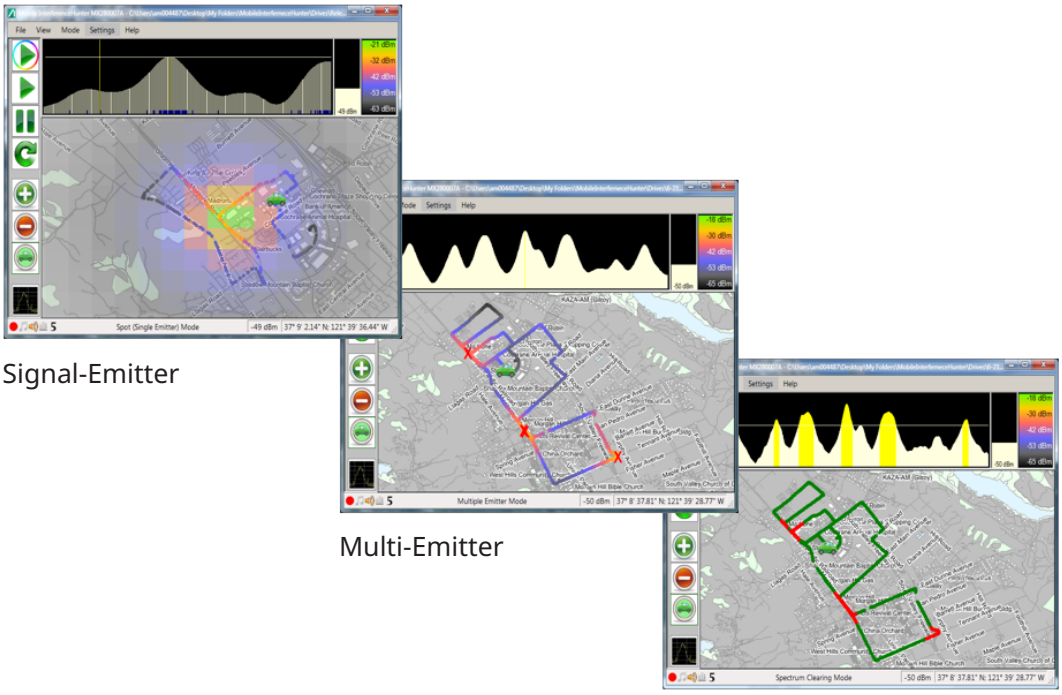

Figure 9. Multi-Mode Capabilities for Mobile InterferenceHunter

Pinpointing the Interference Source

The Mobile InterferenceHunter solution is designed to get the user close to the interference source. In some cases, the mobile unit will not be able to locate the exact signal position. For example, an interference source may be located in an office building, roof top, or in a location inaccessible to the mobile unit. At this point, the user will need to walk to the interferer position using a Yagi or other directional antenna connected to the Field Master Pro MS2090A spectrum analyzer. For this final step, the Field Master Pro MS2090A can be configured to emit an audio tone that changes in pitch and volume as the power of the interfering signal changes. By connecting a Yagi antenna to the MS2090A, sweeping it in a systematic pattern in the direction of the interfering signal, then noting the antenna direction when the tone is at a maximum, it is possible to quickly identify the precise direction that the signal is coming from. Figure 10 shows a technician pinpointing the interference source using the MA2700A Handheld InterferenceHunter, a Field Master Pro, a Yagi antenna, and an Anritsu spectrum analyzer.

Figure 10. Final Step in Geo-Locating Interference Source

Spectrum Clearing for Intermittent Signals

A spectrum clearance drive provides a snapshot of possible signal activity during the test process. In some cases, unwanted signals may be present intermittently or only during certain times of the day/week/month. In such situations, a semi-permanent spectrum monitor may be required to constantly monitor spectrum.

Anritsu offers a line of Remote Spectrum Monitors (RSMs) suitable for this application. Models are available for both indoor and outdoor applications. Together with Anritsu's Vision™ software, automated monitoring of multiple frequency bands can be conducted twenty-four hours per day, seven days a week. Measurements are saved and made available for analysis and post-processing activity. Figure 11 illustrates the various RSM models available.

MS27101A (Half-Rack) **MS27102A (IP67 Rated)**

Figure 11. Remote Spectrum Monitors for Constant Interference Monitoring

Vision Software MX280001A

Vision software is used to automate the process of remote spectrum monitoring. Measurements can be updated continuously to create a spectrum history of the RF environment over extended periods of time. Backhaul to a central server can be done by using wireless modems, Ethernet, or fiber. In this way a spectrum profile can be created to ensure the RF frequency channels of interest are clear over extended time periods. Figure 12 shows various capabilities provided by Vision software.

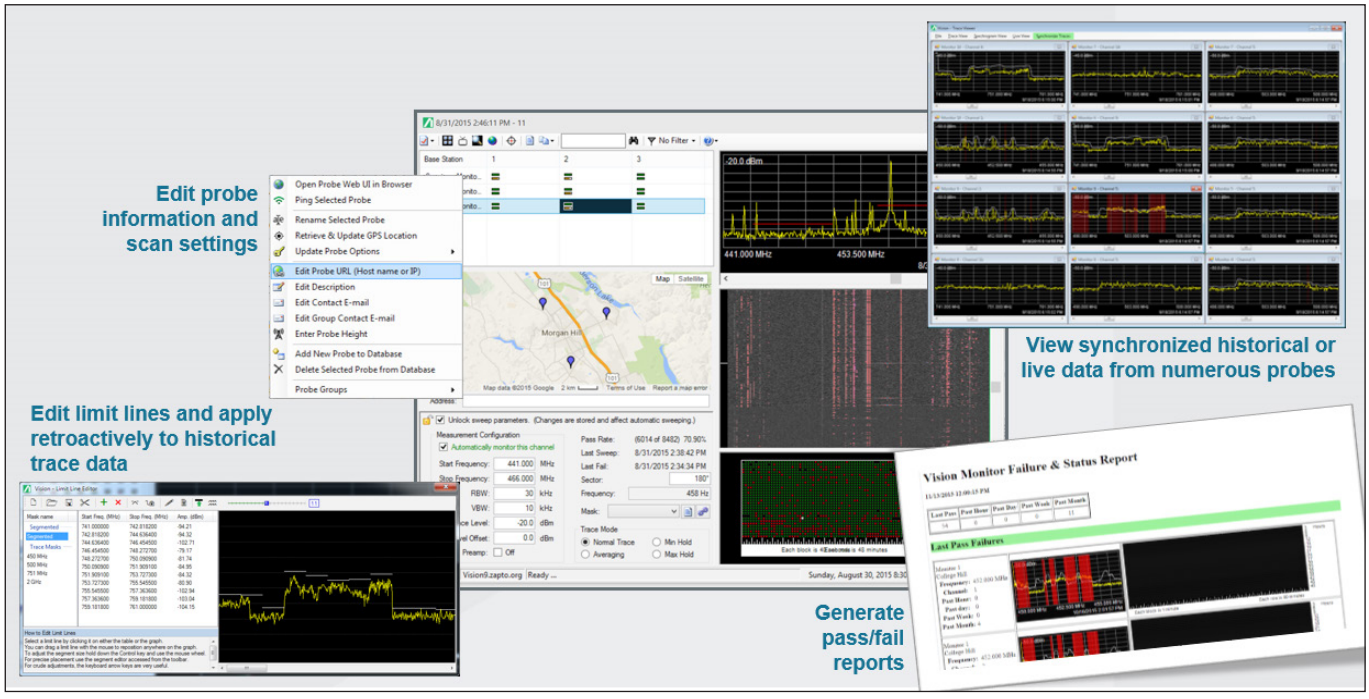

Figure 12. Vision Software Capabilities

Conclusion

Anritsu's Mobile InterferenceHunter MX280007A is a quick and reliable way to find multiple or single emitters even in difficult reception conditions. The ability to work with multiple signal sources, reflections, RF shadows, and multi-path distinguish the Mobile InterferenceHunter MX280007A from conventional systems that depend solely on directional antennas. The ability to work with signals that are intermittent, bursty, or drift rapidly in frequency separate this solution from more expensive ones targeted at a single, fixed-frequency interferer.

The Mobile InterferenceHunter MX280007A's post-capture analysis capability allows users to modify search parameters without re-driving the route. This enables the re-analysis of the captured data and the opportunity to consult with experts when needed, providing interference hunting and spectrum clearing capability over the frequency bands of interest. The Mobile InterferenceHunter MX280007A is a quick, reliable, and multi-emitter enabled solution for interference hunting and spectrum clearing needs.

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