SPECTRUM ENGINEERING

SPECTRUM MONITORING

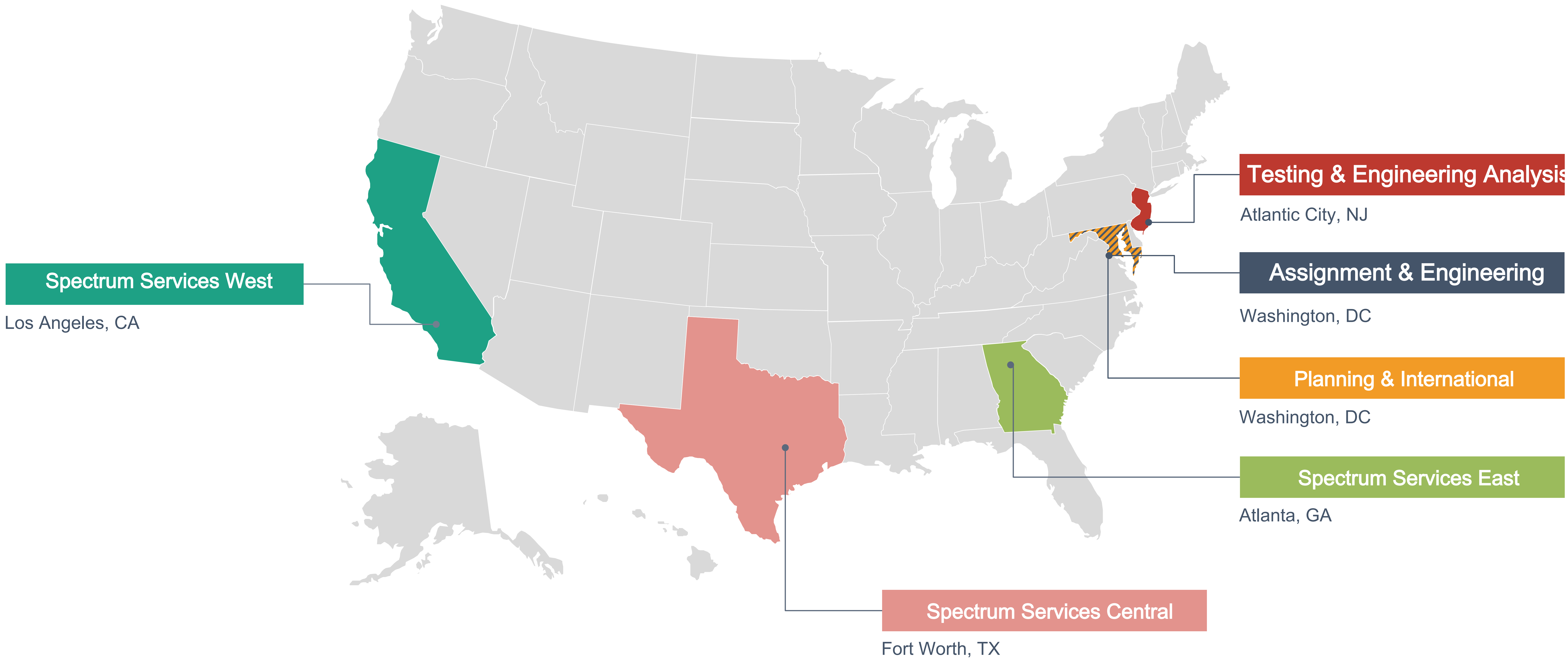
Michael Mankus | September 27, 2019

WHO WE ARE?

The safe transport of all individual flights between airports is based on radio frequencies being available and interference free so that all of the aviation systems function properly. The FAA's Spectrum Engineering Office provides these fundamental services by ensuring radio frequency assets are always clear and available, both now and in the future.

Spectrum Engineering Offices

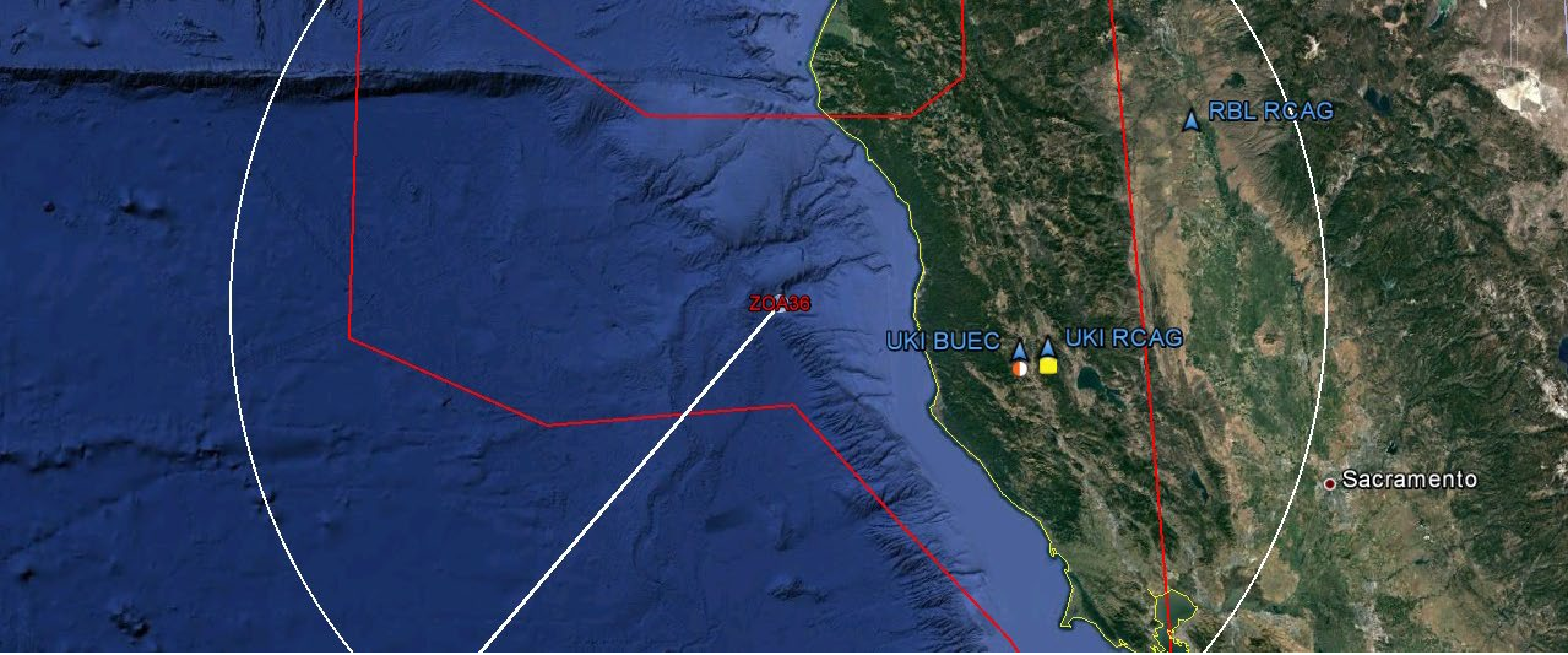
Management from Washington DC with field offices throughout the NAS



WHAT IS INTERFERENCE?

As our lives become filled with technology, the likelihood of electronic interference increases. Every lamp dimmer, garage door opener, or other new technical toy contributes to the electrical noise around us. NAS radio systems “listen” to that growing noise and can react unpredictably to their electronic neighbors.


Global Positioning System
Secondary Radar (x2)
VHF-2 Communications
Collision Avoidance
Direction Finder (x2)
ILS Localizer
VHF Omni Ranging
Satellite Comms
HF Communications (x2)
Weather Radar
ILS Glide Slope
VHF-1 Comms
Secondary Radar (x2)
Collision Avoidance
VHF-3 Communications
Radar Altimeter
Distance Measuring Equip
Marker Beacon
A380
A380 AIRBUS



RFI Case History Report #1

Sacramento, CA March 10 to March 21, 2017

Air Traffic personnel at the Oakland Air Route Traffic Control Center reported that the radio receiver equipment for sector ZOA36 (frequency **119.975 MHz**) was experiencing **signal reception issues** and was **unusable** in the eastern half of the sector. Air Traffic transitioned to the backup emergency (BUEC) equipment. Airway Transportation Systems Specialists contacted Spectrum Engineering for support.

This frequency is serviced from a **Remote Center Air Ground site** just outside of Sacramento, **hosting 5 voice communication frequencies** in the Air Traffic Control band of 118 MHz to 137 MHz. The site services flights from major nearby airports such as Sacramento International and San Francisco International.

The site is on a mountaintop at an elevation of 3500 feet (1050 meters)

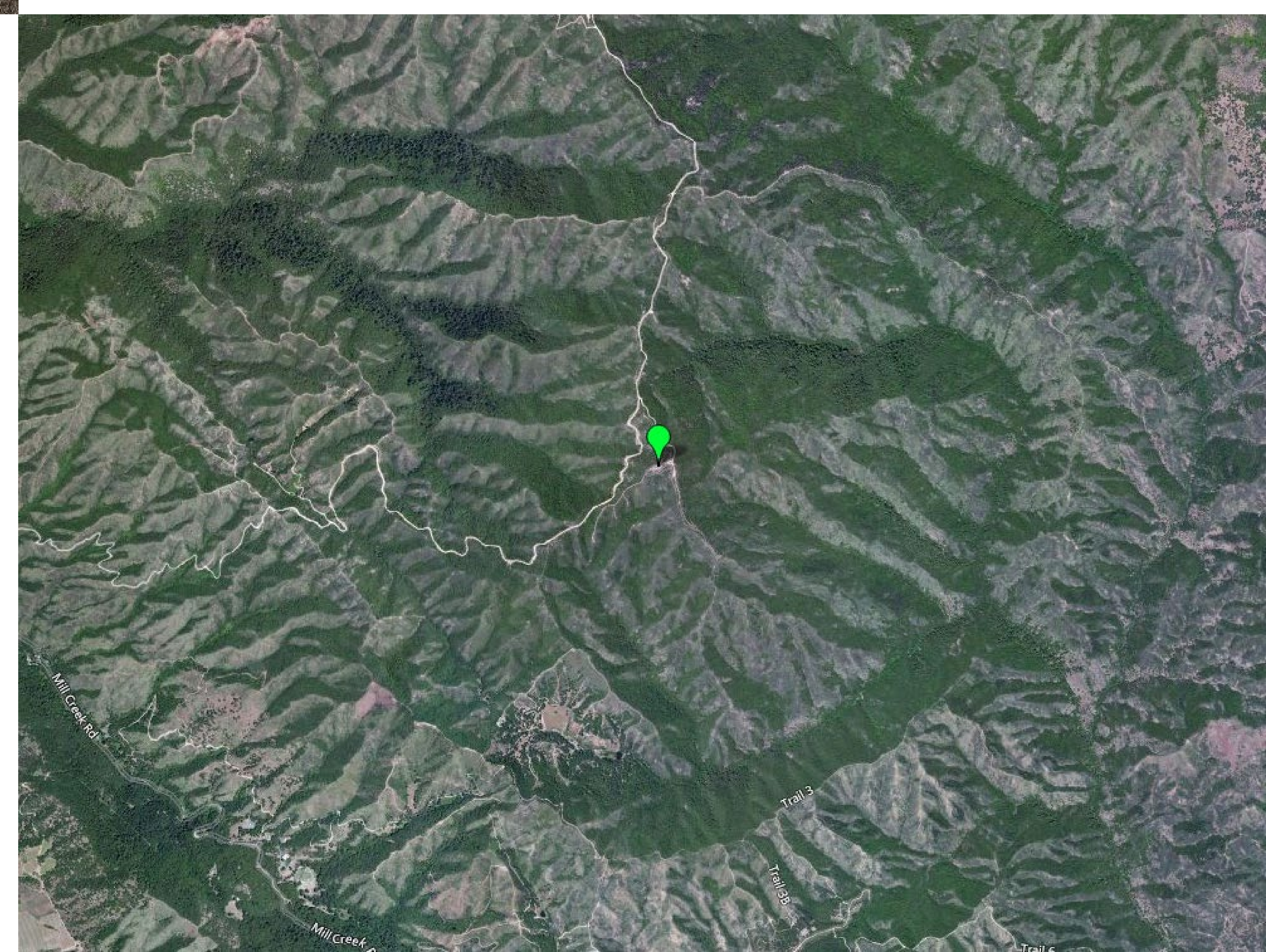
- Large radio-line-of-sight
- The interferer was potentially far away

This is a very remote section of California with very few populated areas surrounding it

It was discovered that 4 of the 5 frequencies at this site were all being interfered with

- Highly intermittent
- Appear for 30 to 60 minutes at a time
- Could go days without interference

The interference presented itself as heavy static across all the effected channels, making it highly difficult to communicate with aircraft



A survey was conducted by a Airway Transportation System Specialist with a Spectrum Analyzer

- A “dirty” RF transmitter was suspected

Directional antennas got a line-of-bearing to the source during one of the interference events

The source was traced to a communications shack on the mountain located 1.4 miles (2.3 km) away

The owner (AT&T) was identified and assisted in getting access

The source was identified as a Phillips T8 LED overhead light

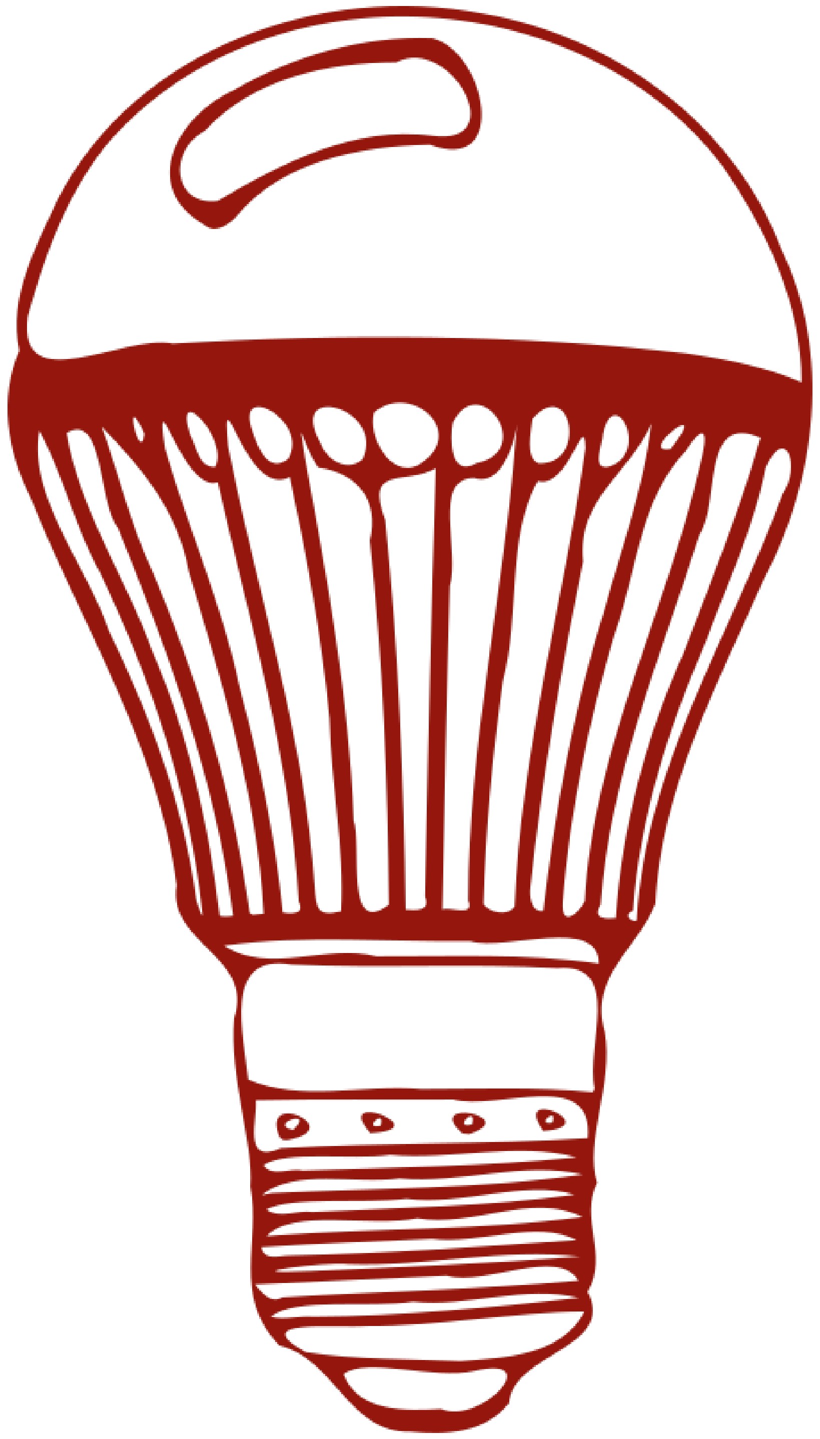
Case Summary

LED devices are noisy in the 30 MHz to 600 MHz band

LED technology is moving at a rapid pace with multiple vendors in the open market, some from the US, others from overseas A majority of the lighting units tested by Spectrum have failed to meet FCC CFR Title 47 Part 15 emission requirements.

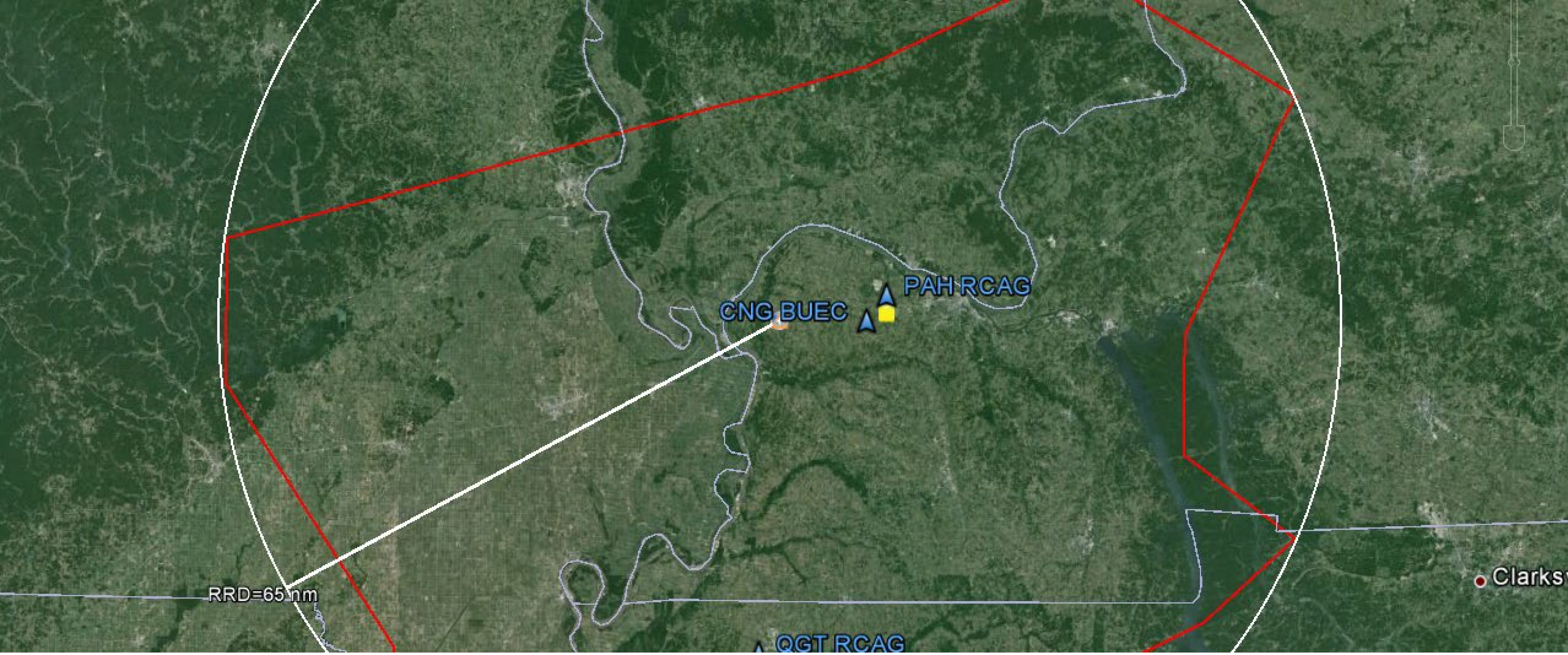
To keep the unit cost down, some manufacturers are using low-cost power supplies from overseas that have not been tested for FCC compliance. In June 2016 the FCC reiterated to manufacturers that LED devices are subject to the Part 15 rules for unintentional radiators.

In this case, the LED lighting had recently been installed as a retrofit to existing florescent lighting. The RFI occurred anytime an AT&T technician was on site for maintenance and had the lights turned on.



Source Credit:

Kevin Yazawa | Spectrum Engineering
Jason Shippen | Technical Services Operations Group



RFI Case History Report #2

Louisville, KY April 18 to May 16, 2017

Air Traffic personnel at the Memphis Air Route Traffic Control Center reported that **pilots flying** through sector ZME05 (**frequency 133.650 MHz**) were hearing **highly garbled country music** over their radios. The Memphis **Control Center was unable to hear** any illegal transmissions from their ground antenna and the interference was **only being reported by pilots** .

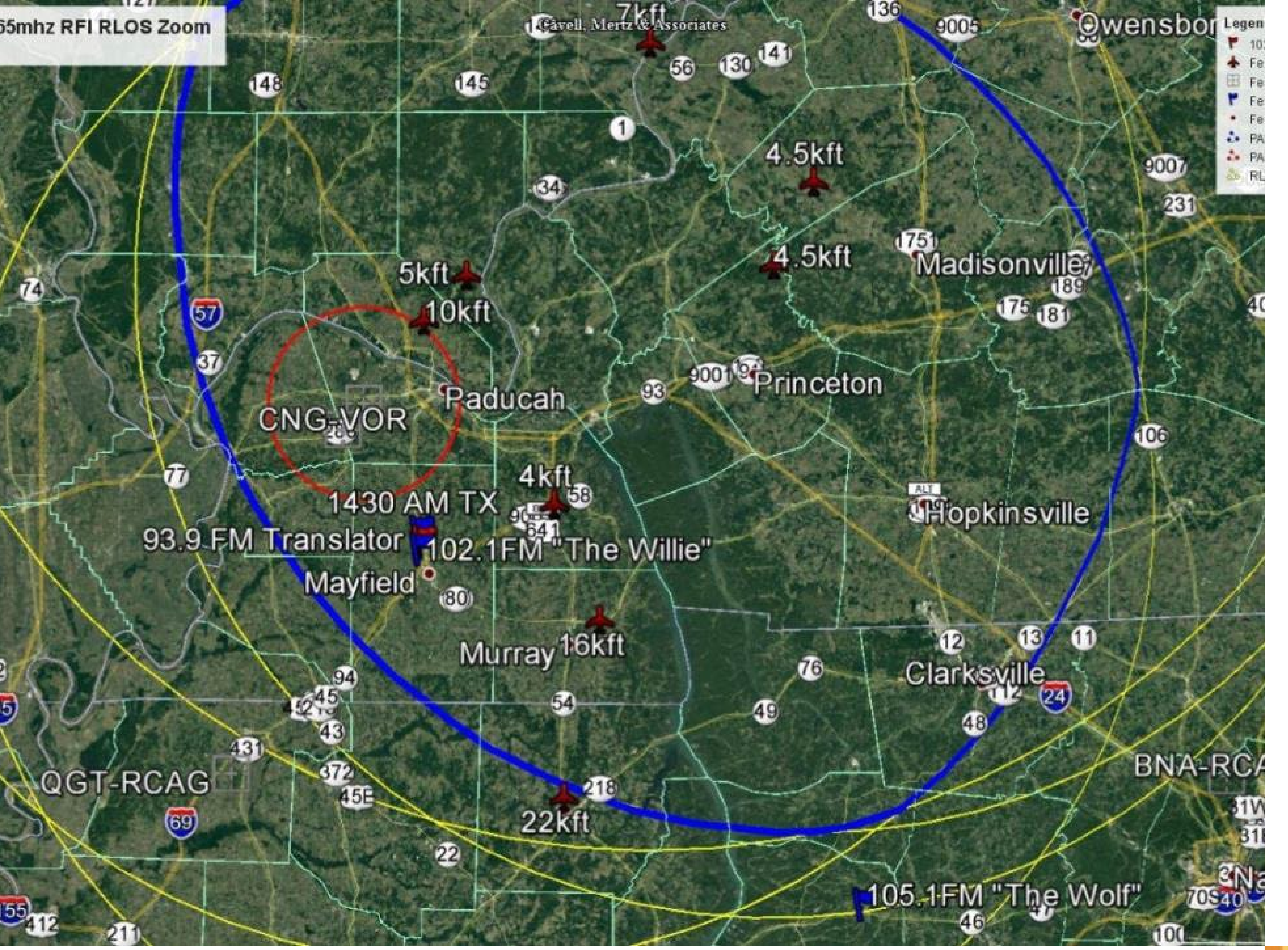
This frequency is serviced from a **Remote Center Air Ground site** just outside of Louisville, hosting just a **single voice communication frequency** in the Air Traffic Control band of 118 MHz to 137 MHz. The site services flights from major nearby airports in Illinois, Indiana, Kentucky, Tennessee, Arkansas and Missouri,

Assumption was made that the interferer was a commercial FM broadcast station - but where?

Traditional direction finding was not possible because the search area was large and the interference was intermittent

The interference was reported by pilots flying between 3,800 - 14,000 feet (1,200 – 4,300 meters)

Pilot reports were collected for two weeks and we performed a Venn-Diagram analysis utilizing the principles of radio-line-of-site



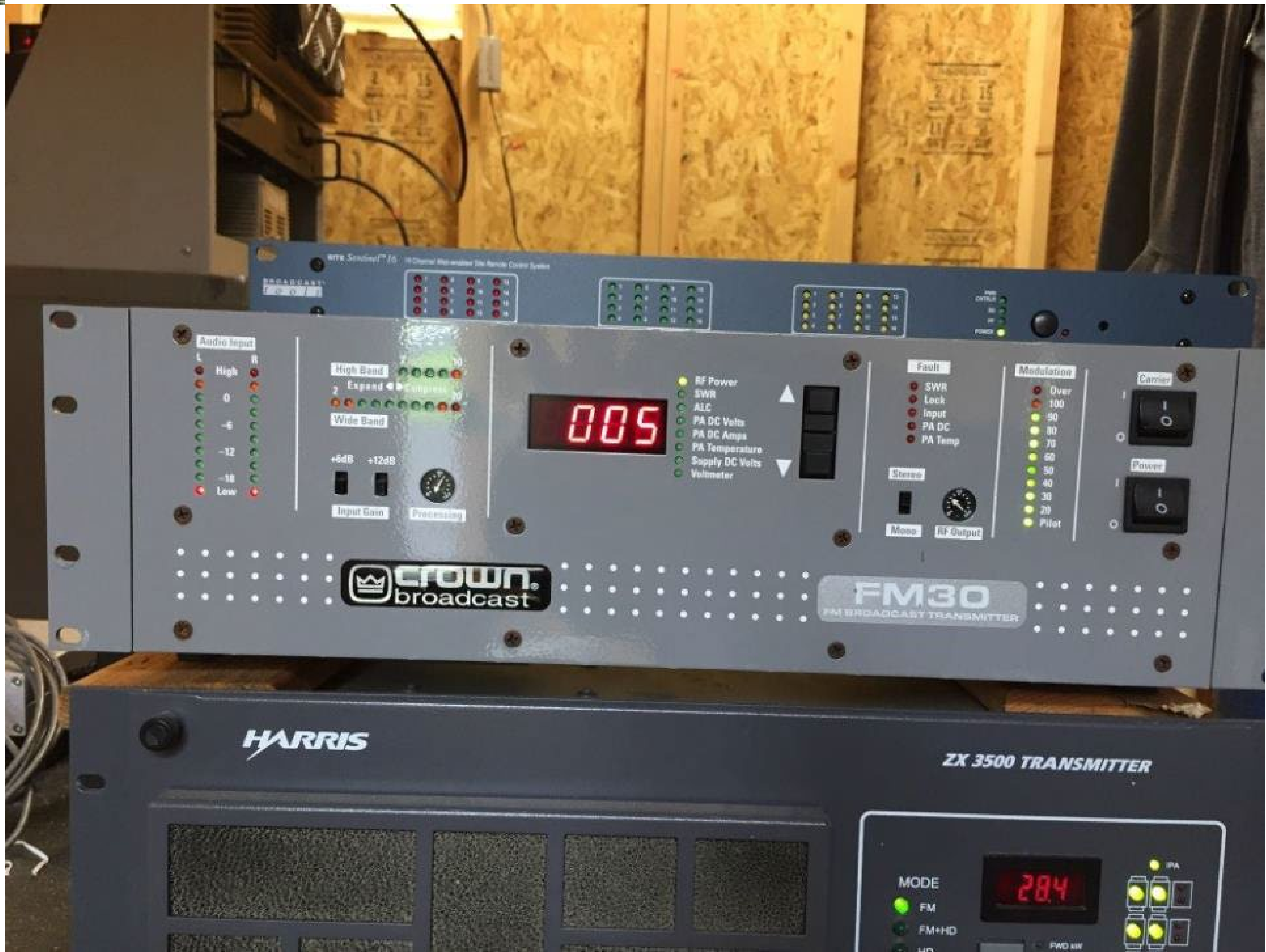
Spectrum Engineering used the results to begin searching frequency authorizations for FM broadcast stations

Both 93.9 FM and 102.1 FM were nearby and fit the search criteria

A site survey was conducted at both 93.9 FM and 102.1 FM

- Discovered drifting RF spurious signals from station 102.1 “The Willie”
- The Station Engineer stated they’d recently switched to a temporary transmitter due to problems with their main transmitter

Later that day, the radio station was able to get a replacement transmitter, solving the incident



Case Summary

Even commercially licensed transmitters can become faulty, broadcasting RF energy into aviation bands

Cases of airborne-only RFI can be difficult because the aircraft are at a high altitude with a large radio-line-of-site. This complicates the process of locating the source because the search-area is so large. Asking pilots to fly lower can help reduce the search-area.

This case was made more difficult due to the drifting-nature of the spurious signal. This meant that the signal was only on our FAA channel for short durations of time, making traditional DF techniques impractical.

In this case, there was no need to involve local law enforcement or an FCC enforcement officer. The ATSS and Spectrum Engineer were able to get great cooperation with the station engineer.

Source Credit:

Bruce V. Williams | Spectrum Engineering
Jeffery G. Cox | Technical Services Operations Group

Intentional Interference

Sometimes the interference is intentionally produced to disrupt air traffic

Intentional Jamming / Disrupting

Intentional disruptions to an aviation frequency such as CW signals, tones, broadband noise, etc.

Phantom Controlling

Intentionally attempting to affect the movement or positioning of an aircraft by issuing commands to aircraft.

Ongoing Case History

- March 2016 to present throughout the country
- The emergency voice frequency for aviation (121.5 MHz) has become a recurring target for unauthorized voice interference from an unknown individual conducting pranks.
- The interference is occurring country-wide and investigators believe the suspect may in-fact be a pilot or passenger who is transmitting at altitude from an aircraft.
- The suspect occasionally plays short recordings from pop media such as music, movies, and television. Sometimes he'll meow like a cat or laugh across the frequency.
- The FCC, FAA, and Nav Canada are all involved and working the case.
- If found, the suspect will likely be fined and charged with a federal crime.

Additional RFI Examples

In actuality, *anything* can produce RFI

Aviation
FAA to FAA, ARINC/ACARS, Aircraft, ELT, Heterodyne, Open Mic

Government
Border Patrol, Fire, Police, NTIA Sub-Agencies, All Military Branches, Canada, Mexico

Natural
Anomalous Propagation, Weather, Path Fade, Coverage

GPS
Jammers, Re Radiators, Military Exercises, Outages

Broadband
Power Line Noise, Power Systems, Poor Grounding, Unintentional EMI, Brute Force

Commercial
Broadcast Radio/TV, Cable TV, HAM/CB Radio, Cell Towers, Commercial Vehicles, Construction, Farming, Paging Systems, ISM Devices, Part 15 Devices

Toughest Cases

What problems cause our greatest headaches?

PILOT ONLY

When the interference can't be observed from the ground antenna, the engineer has a tough time knowing where to begin the search.

Venn-Diagram analysis is often used as well as dedicated flight tests using direction finding equipment (expensive).

INTERMITTENT

We can't get a fix on a signal that isn't broadcasting. Super intermittent signals create problems in terms of resource distribution – we can't dedicate a person to sit and wait for the RFI to occur.

BROADBAND OR SHIFTING

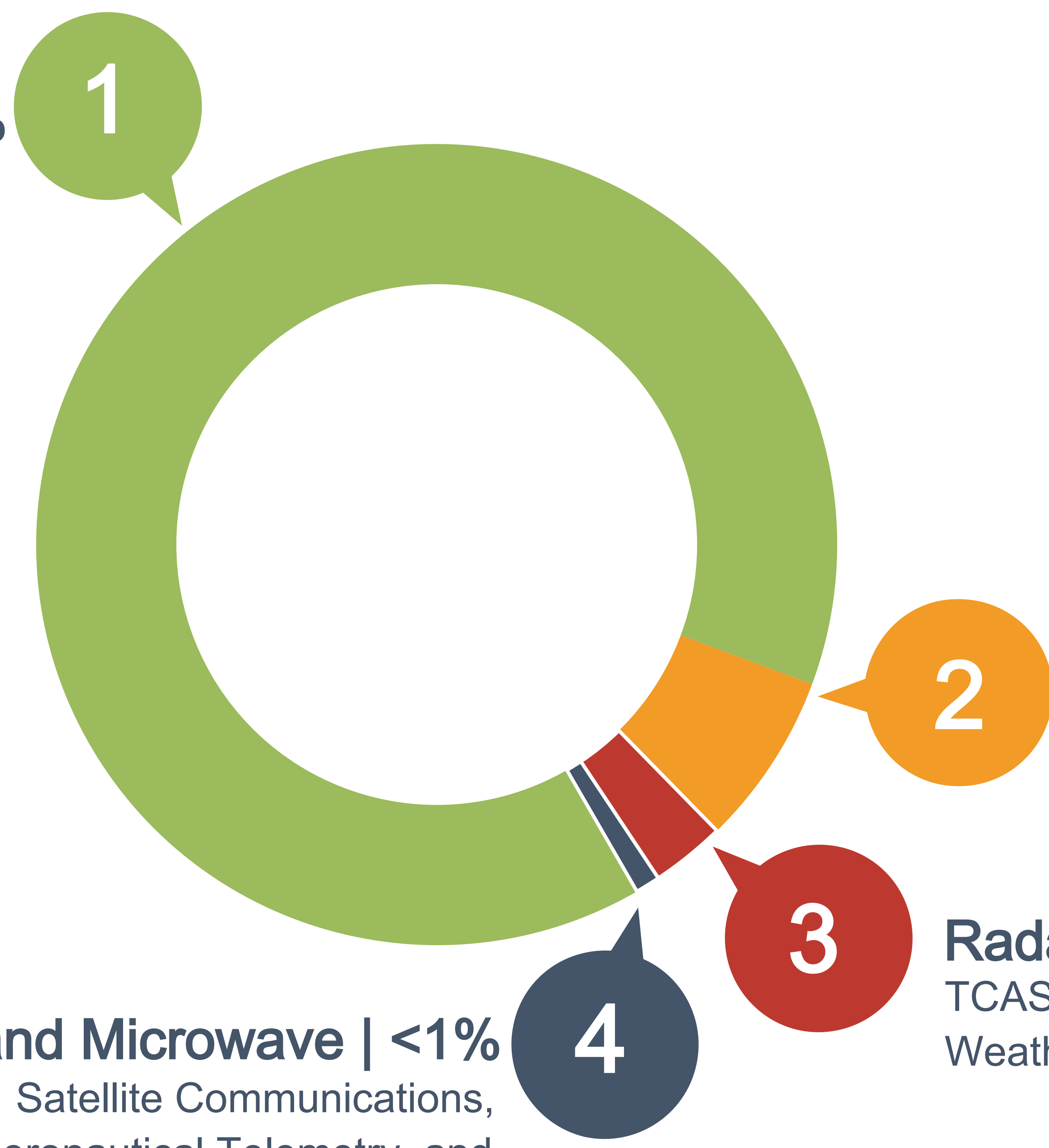
Most direction finding equipment is not suited for tracking broadband signals or signals that frequency shift.

This is made worse by the fact that broadband and shifting signals often affect more than a single frequency at a time.

Systems Effected

Between January 2018 and December 2018

Voice Communications | 89%
HF, VHF, UHF, and Land Mobile Communications



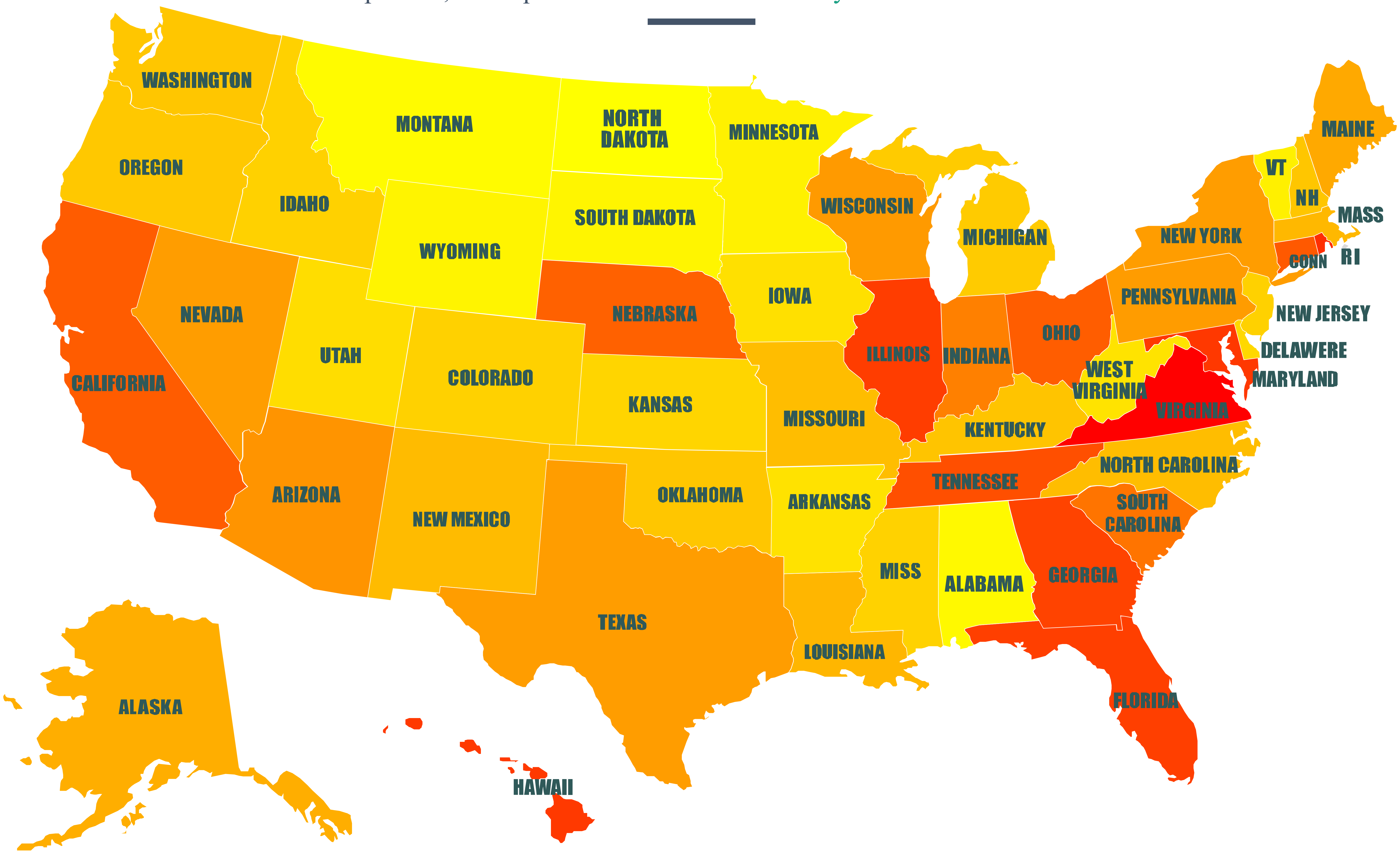
NAVAIDS | 8%
NDB, ILS, VOR, TACAN, DME, GPS, Altimeter

Radar | 3%
TCAS, Route Surveillance, Weather, Surface Detection

Satellite and Microwave | <1%
Satellite Communications, Aeronautical Telemetry, and Microwave Links

RFI Density

RFI events per 10,000 square feet between January 2018 and December 2018



HOW DO WE FIND RFI?

There are many different techniques for radio direction finding which are at the disposal of FAA personnel for tracking down sources of radio frequency interference.

RFI Task Force

Spectrum Engineering doesn't do it all: we get great help

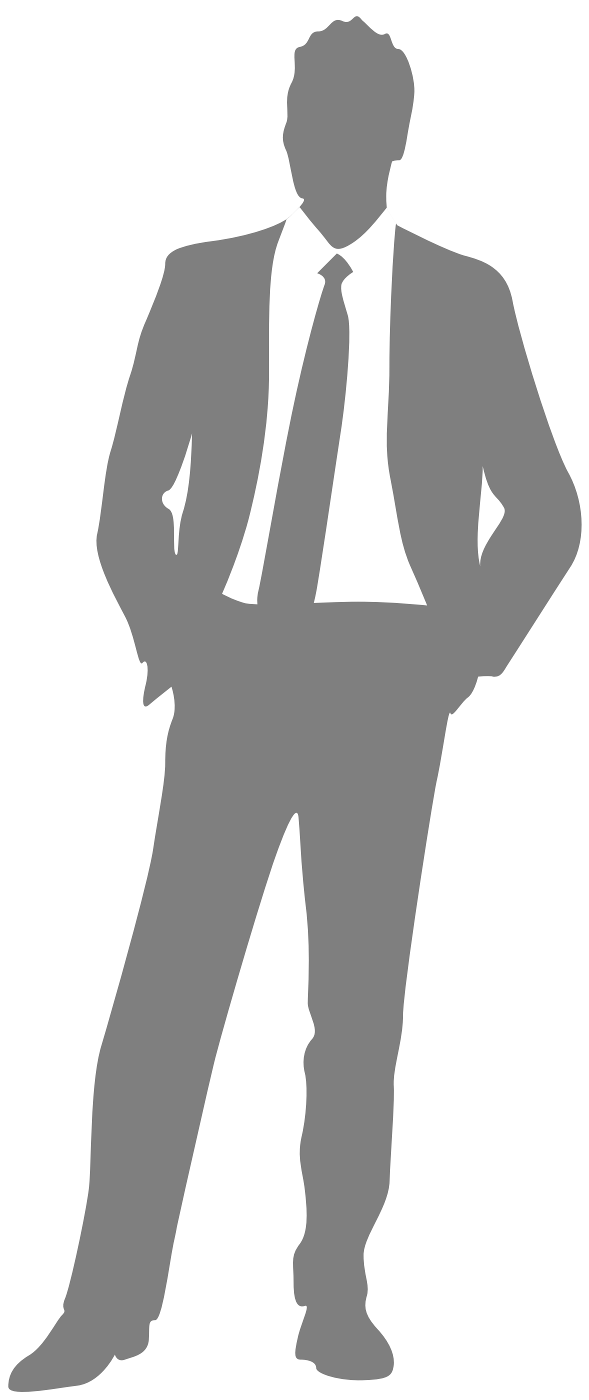
Airway Transportation System Specialist

Thousands of technicians tasked with systems support for each piece of airspace equipment

Although not part of Spectrum Engineering, Spectrum trains 60-75 ATSS a year in advanced techniques for RFI identification and tracking

Serve as the first line of defense against RFI, beginning to work RFI from the local level before requesting assistance from Spectrum Engineering

Spectrum Engineering provides dedicated direction finding equipment to assist in RFI mitigation



Spectrum Engineer

2 to 3 dedicated persons per Service Area who work the most difficult and severe cases of interference

Armed with state-of-the-art radio direction finding equipment that is capable of tracking down even the toughest instances of interference

Ultimately responsible for the resolution of each reported instance of radio frequency interference

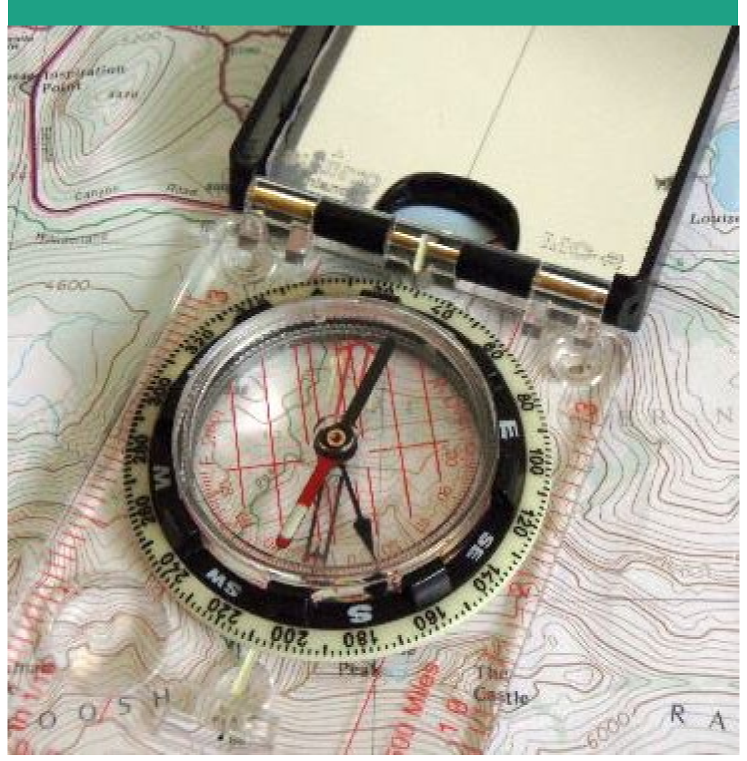
Travel the country working cases based on the impact of the interference to the NAS

ATSS Equipment (Historically)

Radio direction finding on the low-end

Receiver

Unlocked multi-band receiver with the ability to manually control RF gain and monitor signal strength



DF Antennas

A collection of directional antennas tuned for specific bands to assist in triangulation

$2,300

Spectrum Engineering Equipment

Radio direction finding on the high-end

Spectrum Analyzer

Used to monitor and capture spectrum usage as well as signal location via the "hot and cold" method

Automated Direction Finder

Utilizes the Watson-Watt technique to provide a line-of-bearing to the interferer

Adcock DF Antenna

Mobile and fixed antennas with circuitry to perform the Watson-Watt technique in conjunction with a direction finder

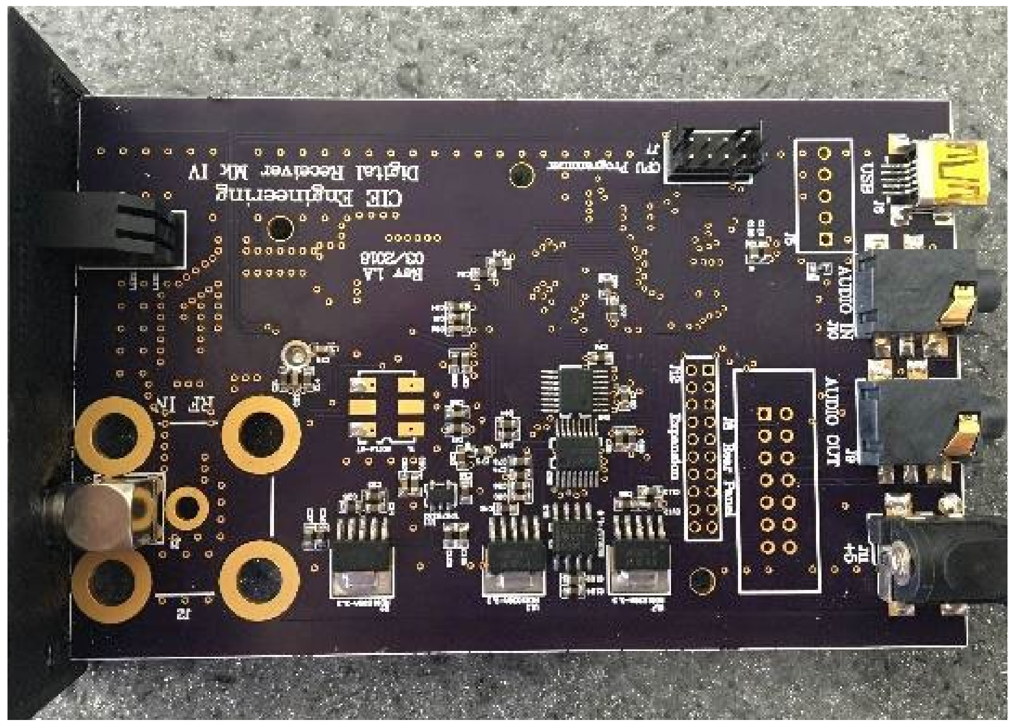
$15,500

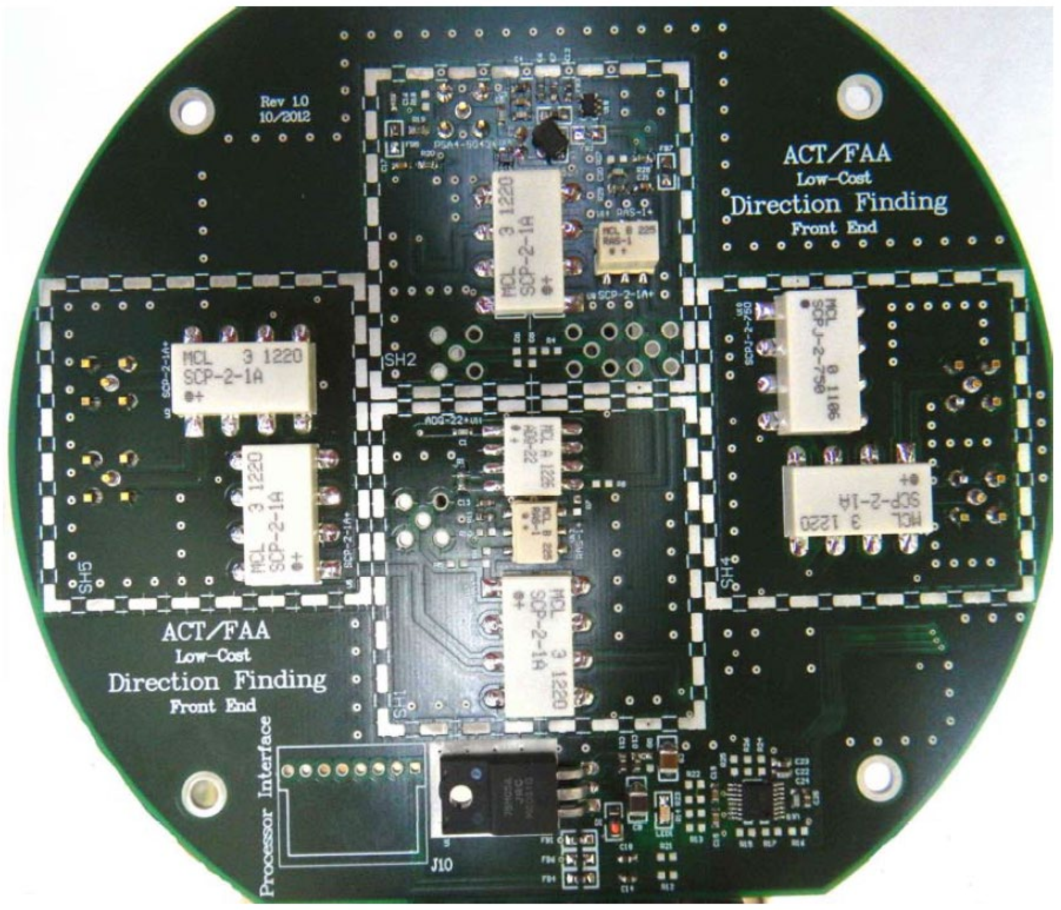
RFI Resolution Fleet


External Connections
Vehicle DF
External DF
AC Shore Power
SPECTRUM ENGINEERING
RF Ports
FEDERAL AVIATION ADMINISTRATION
belkin
EMERGENCY
Caps Lock
Shift
A/C
TEMP

Next Generation Equipment

Radio direction finding equipment developed purely in-house





Receiver, Direction Finder, and Spectrum Analyzer

Used to process the RF signal from the antenna to determine a line-of-bearing, measure spectrum power, and demodulate audio

Watson -Watt Front End

Implements the RF mixing required by the Watson-Watt technique to send modulated RF back to the direction finder

Completed VHF Mobile Variant

Finished product designed for mobile use between 50 MHz and 350 MHz

$2,300

Foxhunt Software

Purpose-built direction finding software designed in-house at the FAA

Development of a universal radio direction finding software suite was launched in 2011 within the FAA. The goal was to provide a single common interface to multiple pieces of similar RF equipment and to assist Spectrum Engineers by analyzing incoming data to provide real-time analysis of interference.

Listen

Listen to the channel to determine what is valid FAA Ops vs interference

Record

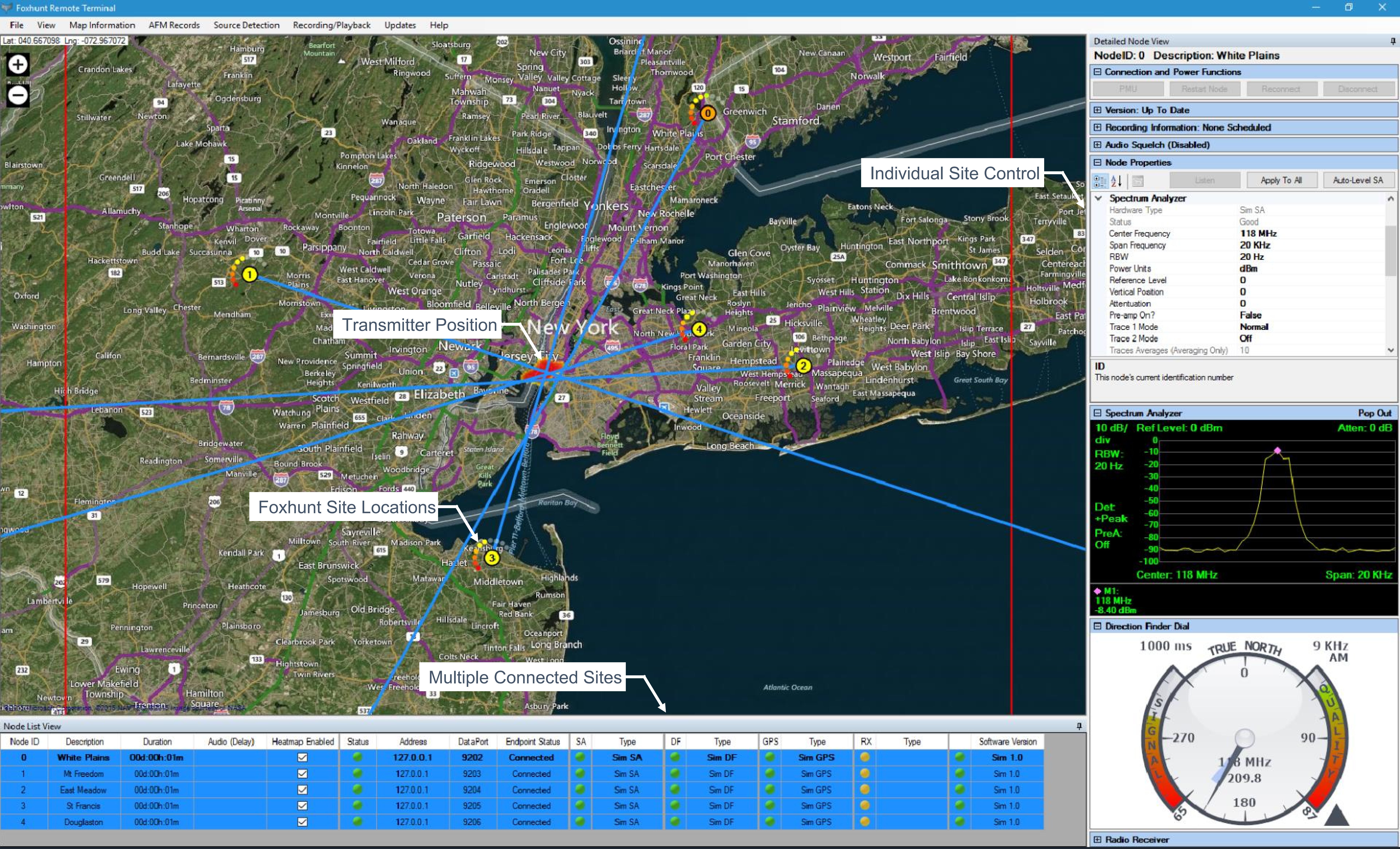
Record and playback data for assistance with intermittent cases

Analyze

Custom algorithm shows where the transmitter is most-likely located

Resolve

Generate reports and images for RFI resolution field reports



Connect
Remotely connect to multiple Foxhunt installations at once

Monitor
Monitor multiple locations from a single remote command center

Record
Record and playback data for assistance with intermittent cases

Resolve
Utilize bearings from multiple locations to quickly locate RFI

Ongoing RFI Elimination Efforts

Budget pressure is a primary driver for innovation

Weekly Teleconferences

Discuss any/all RFI related issues, share stories of recent cases, review changes in utilization, and handle distribution of resources

RFI Vehicles

Ten new Ford Explorer Interceptors being fully outfitted as mobile RFI elimination vehicles with the latest technology

In-House Low-Cost Equipment

Purpose-built and low-cost direction finder and antenna using the Watson-Watt techniques (final prototype testing scheduled for completion this year)

Foxhunt Sites

Rollout of additional Foxhunt fixed sites as well as mobile quick deployment transit cases

Ongoing Training

RFI Training Courses for FAA personnel (4 per year) and continued RFI training for Spectrum Engineers

THANK YOU

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