



Spectrum Forensics Tutorial

How the FCC Enforcement Bureau Field Does Spectrum Forensics

All views expressed are those of the speakers and do not necessarily represent the views of NTIA, ITS, or the FCC.

FCC Field - Spectrum Enforcement

- Overview and Goals of the Tutorial
- Introduction of Speakers
- Understanding the FCC's Jurisdiction and Regulation of Spectrum
- Analyzing Interference Complaints
- Interference Monitoring, Detection, and Location Tools
- Conducting Interference Investigations
- Identification, Measurement, and Verification of Interference
- Enforcement and Sanctions
- Case Studies
- Challenges in Spectrum Forensics
- Recommendations and Best Practices
- Applying Lessons Learned to Future Interference Scenarios



Spectrum Enforcement is Critical to Successful Spectrum Sharing

- 2010 Presidential Memo – 500 MHz for wireless broadband
- 2013 Presidential Memo – share spectrum where feasible
- NTIA's Commerce Spectrum Management Advisory Council
 - Enforcement Subcommittee Report (May 12, 2015)
- NITRD WSRD
 - Workshop on Enforcement Frameworks, Technology, and R&D (May 5, 2016)

FCC - Spectrum Sharing Enforcement Considerations

- FCC's Technological Advisory Counsel - Spectrum and Receiver Performance Working Group
 - Risk Informed Interference Assessment (2015)
 - Basic Principles for Assessing Compatibility of New Spectrum Allocations (December 11, 2015)
 - Next Generation Systems Architecture for Radio Spectrum Interference Resolution (March 9, 2016)
 - Noise Floor Technical Inquiry (June 15, 2016)
- FCC Spectrum Sharing Rules
 - Exclusion/coordination zones
 - Spectrum Access System/Environmental Sensing Capability
 - Spectrum Frontiers/5G
- FCC Modernization of the Field (July 16, 2015)

How to apply best practices from the FCC's experience in interference resolution to spectrum forensics in a dynamic spectrum sharing environment

- How to quickly identify the source of interference
- What are reasonable and timely corrective actions
- How to deal with unsophisticated unlicensed users
- What aspects of RF interference hunting can be automated
- How to leverage technology trends
- What types of mitigation techniques work
- How to use risk-informed interference assessment in the field
- What factors distinguish interference that is acceptable, degrading or harmful
- How to apportion responsibility

Tutorial Speakers and Moderator

- Margaret Egler
 - FCC Enforcement Bureau Western Region Counsel (Retired)
- Jim Higgins
 - Artic Slope Technical Services (NASA) Spectrum Management Engineer
 - FCC Enforcement Bureau Northeastern Deputy Regional Director (Retired)
- Greg Hermes
 - FCC Enforcement Bureau Equipment Development Group Director
- Rebecca Dorch
 - NTIA-ITS Senior Spectrum Policy Advisor
 - Former FCC Enforcement Bureau Western Region Director

Spectrum Forensics Case Studies

Legal Background –
Margaret Egler

FCC Enforcement Bureau Western Region Counsel
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History of the FCC

- The Radio Act of 1912
 - Enforced by the Department of Commerce, it began requiring licenses to operate any apparatus for radio communication as a means of commercial interaction particularly on vessels, priority to be given to distress signals.
- The Federal Radio Commission (FRC) established in 1927
 - “A wholly new Federal body was called into being to deal with a condition which had become almost hopelessly involved during the months following July 3, 1926, when it had become clear that the Department of Commerce had no authority under the 1912 radio law to allocate frequencies, withhold radio licenses, or regulate power or hours of transmission.” FRC 1927 Annual Report.

History of the FCC

- Communications Act of 1934
 - Established the Federal Communications Commission (FCC) as an independent U.S. government agency in 1934.
 - Gives FCC authority to regulate interstate and foreign commerce in communication by wire and radio.
 - Codified in Title 47 of the United States Code.
 - Rules promulgated by the FCC are found in Title 47 of the Code of Federal Regulations.

FCC – Field Inspectors

- Implementation of the 1912 Radio Act resulted in creation of nine Radio Inspection Districts across the country.
- Inspectors became part of the FRC in 1927.
- Then part of the FCC in 1934.

Who the FCC regulates (radio):

- FCC regulates “persons” – defined as:
 - An individual, partnership, association, joint-stock company, trust, or corporation. 47 U.S.C. 153(39)
- A license is required for any person who operates “any apparatus for the transmission of energy or communications or signals by radio”
 - From one place in any State, Territory, or possession of the United States or in the District of Columbia to another place in the same State, Territory, possession, or District; or
 - From any State, Territory, or possession of the United States, or from the District of Columbia to any other State, Territory, or possession of the United States; or
 - From any place in any State, Territory, or possession of the United States, or in the District of Columbia, to any place in any foreign country or to any vessel; or

Who the FCC regulates (radio):

- Within any State when the effects of such use extend beyond the borders of said State, or when interference is caused by such use or operation with the transmission of such energy, communications, or signals from within said State to any place beyond its borders, or from any place beyond its borders to any place within said State, or with the transmission or reception of such energy, communications, or signals from and/or to places beyond the borders of said State; or
- Upon any vessel or aircraft of the United States (except as provided in section 303(t) of this title); or
- Upon any other mobile stations within the jurisdiction of the United States.
- 47 U.S.C. 301

And doesn't regulate (radio):

- Radio stations belonging to and operated by the United States shall not be subject to the provisions of sections 301 and 303 of this title. All such Government stations shall use such frequencies as shall be assigned to each or to each class by the President. All such stations, except stations on board naval and other Government vessels while at sea or beyond the limits of the continental United States, when transmitting any radio communication or signal other than a communication or signal relating to Government business, shall conform to such rules and regulations designed to prevent interference with other radio stations and the rights of others as the Commission may prescribe. 47 U.S.C. 305(a).

How the FCC regulates spectrum users

- Primary Services.
- Secondary Service:
 - Shall not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date;
 - Cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned or may be assigned at a later date; and
 - Can claim protection, however, from harmful interference from stations of the same or other secondary service(s) to which frequencies may be assigned at a later date. 47 CFR 2.105

How the FCC regulates spectrum users

- Tertiary Services/Users
 - Licensed by rule:
 - The FCC may by rule authorize the operation of radio stations without individual licenses in the following radio services: (A) the citizens band radio service; (B) the radio control service; (C) the aviation radio service for aircraft stations operated on domestic flights when such aircraft are not otherwise required to carry a radio station; and (D) the maritime radio service for ship stations navigated on domestic voyages when such ships are not otherwise required to carry a radio station. 47 U.S.C. 307(b).
 - Operation does not require a license as long as the operator uses a certified device and complies with the rules for that radio service.

How the FCC regulates spectrum users

- Part 15 of the C.F.R. – Unlicensed Operation.
- An intentional, unintentional, or incidental radiator may be operated without an individual license provided:
 - The operation of the radiator is in accordance with the regulations; and
 - The radiator is in compliance with the administrative and technical provisions in this part, including prior Commission authorization or verification, as appropriate. 47 C.F.R. 15.1
 - Operation of an intentional, unintentional, or incidental radiator is subject to the conditions that no harmful interference is caused and that interference must be accepted that may be caused by the operation of an authorized radio station, by another intentional or unintentional radiator, by industrial, scientific and medical (ISM) equipment, or by an incidental radiator. 47 C.F.R. 15.5

Certification of Equipment

- No person shall manufacture, import, sell, offer for sale, or ship devices or home electronic equipment and systems, or use devices, which fail to comply with regulations promulgated pursuant to this section (which):
 - Govern[] the interference potential of devices which in their operation are capable of emitting radio frequency energy by radiation, conduction, or other means in sufficient degree to cause harmful interference to radio communications; and
 - Establish minimum performance standards for home electronic equipment and systems to reduce their susceptibility to interference from radio frequency energy.
- 47 U.S.C. 302a

Certification of Equipment

- Comprehensive rules found in Part 2 and Part 15 of the 47 CFR.
- Apply to devices used by licensed operators as well as devices approved for unlicensed use.
- Some devices are *per se* illegal (will not be certified), even though they can be purchased *e.g.*, cell phone jammers.
- These rules do not apply to U.S. Government systems and devices. 47 U.S.C. 302a(c).

FCC Monitoring and Interception

- The FCC can monitor, intercept, and disclose transmissions:
 - [Not unlawful for]an officer, employee, or agent of the Federal Communications Commission, in the normal course of his employment and in discharge of the monitoring responsibilities exercised by the Commission in the enforcement of chapter 5 of title 47 of the United States Code, to intercept a wire or electronic communication, or oral communication transmitted by radio, or to disclose or use the information thereby obtained. 18 U.S.C 2511 (Wiretap statute); *see also* 47 U.S.C. 605.

FCC Inspections

- The FCC can inspect:
 - Have authority to inspect all radio installations associated with stations required to be licensed by any Act, or which the Commission by rule has authorized to operate without a license under section 307(e)(1) of this title, or which are subject to the provisions of any Act, treaty, or convention binding on the United States, to ascertain whether in construction, installation, and operation they conform to the requirements of the rules and regulations of the Commission, the provisions of any Act, the terms of any treaty or convention binding on the United States, and the conditions of the license or other instrument of authorization under which they are constructed, installed, or operated.
 - 47 U.S.C 303(n).

FCC Inspections

- Part 15 Devices – additional requirements:
- Any equipment or device subject to the provisions of this part, together with any certificate, notice of registration or any technical data required to be kept on file by the operator, supplier or party responsible for compliance of the device shall be made available for inspection by a Commission representative upon reasonable request.
- The owner or operator of a radio frequency device subject to this part shall promptly furnish to the Commission or its representative such information as may be requested concerning the operation of the radio frequency device. 47 C.F.R. 15.29 (a) – (b).

Interference Complaints

- Receipt of complaint.
 - Timely?
- Identify the complainant.
 - What is their status?
 - Do they have standing?
- Contact the complainant.
 - Is the interference ongoing?
 - What are parameters?
 - What information can they provide?

Interference Complaints

- Identify the Act or Rule section being violated.
 - Is there a potential violation, or not?
 - Determine the elements of a violation.
 - Develop the evidence to establish each element.
 - Consider any exculpatory evidence.
- Is it harmful interference?

Interference Complaints

- Definition of Interference:
 - The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.
 - 47 C.F.R. 2.1.

Interference Complaints

- Definition of Harmful Interference:
 - Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations.
 - 47 C.F.R. 2.1.

Interference Complaints

- Identify the subject.
 - Could be licensed.
 - FCC databases.
 - A challenge if licensed by rule.
 - Could be unlicensed.
 - Must be identified by monitoring and direction finding.



Spectrum Forensics

Planning Investigations | 1 August, 2016

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Customer-Focused. Operationally Excellent.



Prioritizing, planning and conducting interference investigations

- How do field offices receive complaints for investigation?
- How are investigations prioritized?
- Planning an investigation
- Conducting the investigation
- Follow-up work

How do field offices receive complaints for investigation?

- FCC Consumer Center (Web and 888 number)
- Public Safety Interference web portal (new)
- FCC Operations Center (Urgent PS matters, by phone)
- Direct Contact to local Field Office
- Special web portals (CTIX, PIRPIX)
- Headquarters Referrals (e.g. Congressional referrals, Requests/info from other FCC bureaus, etc.)

How are investigations prioritized?

- Interference involving Safety-of-Life or Property
- Interference to public safety communications
- Interference to Critical Infrastructure/Key Resources
- Interference reported by licensees
- Interference from RF devices (Part 15/18 and illegal)
- General Interference complaints (including most complaints referred by Congressional staff offices)
- Investigations supporting FCC Strategic Goals
- Investigations and other activities based on requests of other FCC Bureaus and Offices

Planning an investigation

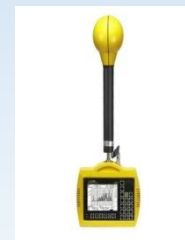
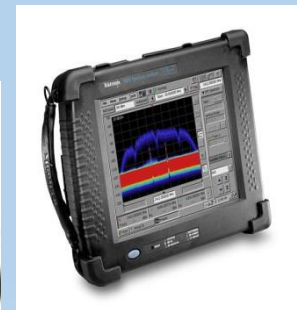
- Communicate with complainant (and subject, if known)
- Database research (licenses, nearby in-band/adjacent band transmitters, etc.)
- Assemble any necessary measurement equipment and do calibration checks, if applicable

EB Field Equipment Profile

- Technical investigative tools currently in use by EB's field
 - Includes both commercial off the shelf (COTS) and custom designed tools
 - Includes mission specific and general purpose spectrum enforcement tools
- The field equipping cycle
 - Identify challenges/needs, develop requirements, implement
- New hardware and software required to address equipment related challenges

Examples of Tools Currently in Use

- Z-Technology field strength meters VHF/UHF
- Potomac field strength meters for HF
- Tektronix and Agilent analyzers
- R&S PR100
- R&S DDF007 mobile locate
- Custom covert mobile direction finding (MDF) vehicles
- Fixed monitoring equipment located at field offices
- FCC Long range HF-DF network
- Mission specific and general purpose antennas, amplifiers, and filters
- Narda SRM3000
- WiFi analysis tools



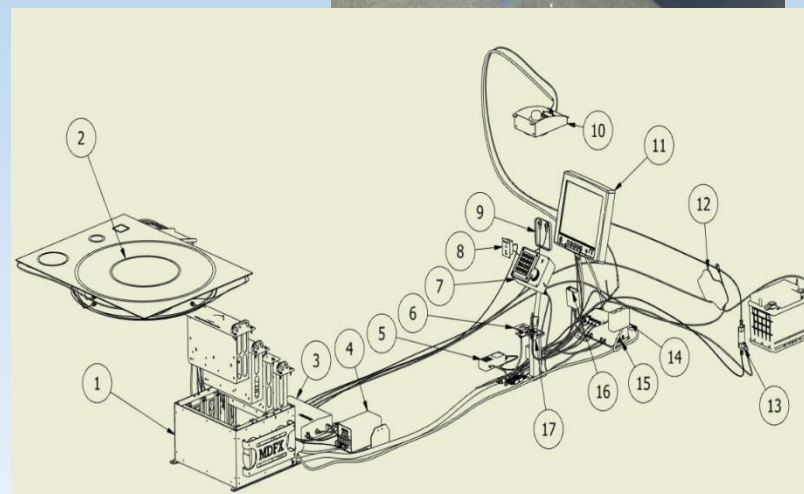
Equipment Development Group

- Located in Powder Springs, GA
- Manufactures and maintains EB's mobile direction finding fleet
- Maintains and upgrades Type-I HFDF remote site hardware and software
- Capabilities
 - Custom software development
 - Electronics design and assembly
 - Mechanicals design and assembly
 - Antenna testing
 - Small quantity production



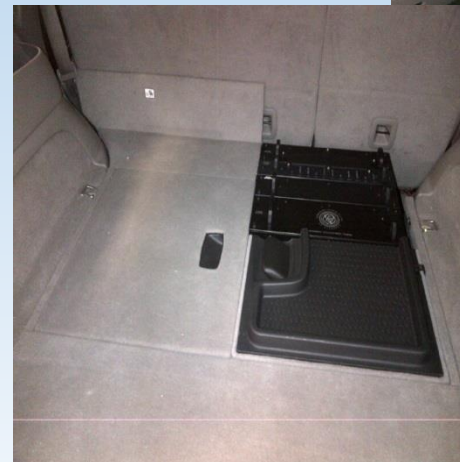
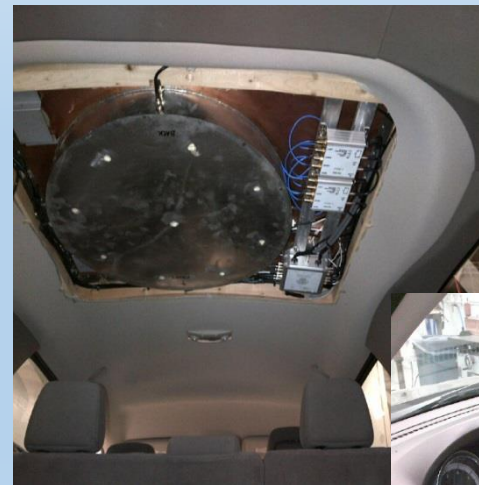
MDF System Overview

- Chevy Tahoe and Dodge Durango installations
- Switched amplitude angle of arrival (AOA) DF
- Homing style mobile DF system
- Covert cavity backed annular slot antennas
- 5 band automatic switching
- System designed and built at EB's EDG facility in Powder Springs, GA



MDF Hardware

- Antennas and modulators embedded in roof cavity
- Trunk mount control hardware includes SBC module, DF control module, receiver module, and power distribution module.
- All UI and controls accessible from front seats



MDF Software

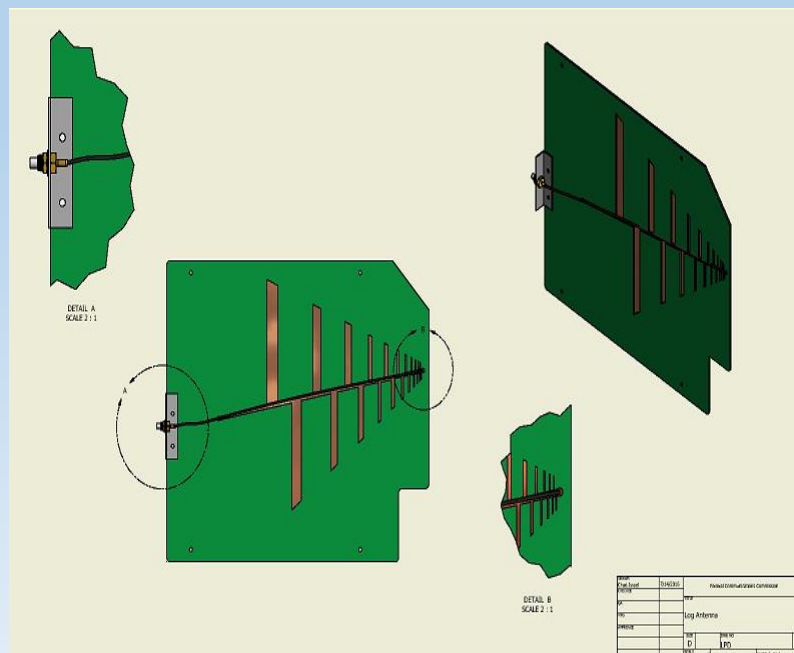
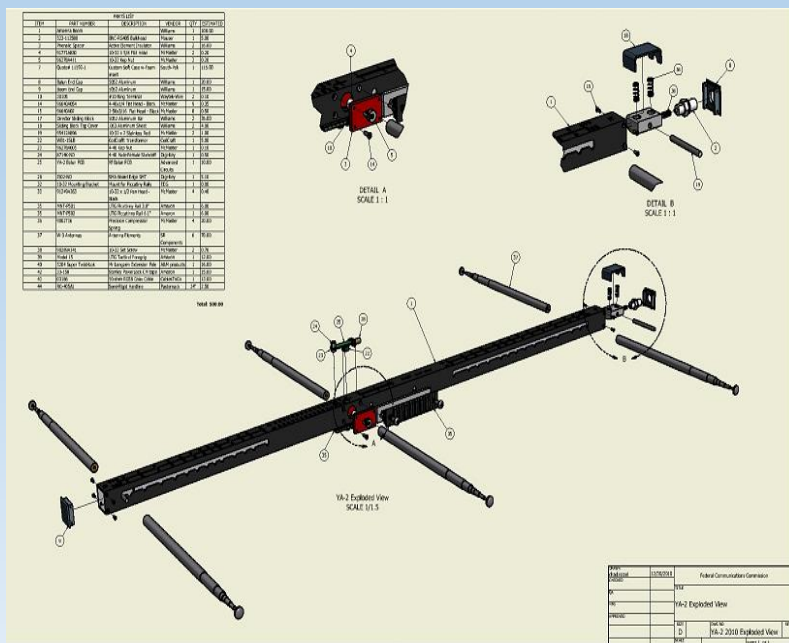
- Controls DF system from single dash mounted touch screen
- Compass Rose, SDU, Receiver control, Map
- LOB and audio recording
- In system licensee database support



Antennas

- Adjustable Yagi

- LPD





Spectrum Forensics

Conducting Investigations | 1 August, 2016

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Conducting the investigation

The “Four Step” process applies to most investigations:

- Monitor/Detect
- Characterize/Classify
- Identify
- Locate

Conducting the investigation

- Conduct remote monitoring if possible (if near an office or in HF band)
- On-site investigation – mobile DF vehicle, handheld portable equipment – spectrum analyzer, calibrated and/or directional antennas, portable receivers, wattmeter, etc.
- Document/confirm license parameters, measurements, site information, contact persons, etc.

Conducting the investigation

Investigating the interference source may involve:

- Connecting FCC receiver or analyzer to complainant system.
- Observing the interference on complainant's receiver.
- Acquiring the interfering signal in mobile DF vehicle, and DF/geo-locating.
- Locating a contact to access offending equipment.
- Making measurements to document the issue causing the problem.

Conducting the Investigation- Challenges

There are many permutations that influence the methods used in the investigation:

- i. Hi power vs. low power
- ii. Steady vs. intermittent
- iii. Stationary vs. mobile
- iv. Transmitter/emitter sources vs. external intermodulation or other environmental sources
- v. Part 15 and Part 18 emitters involved
- vi. Analog vs. digital signals
- vii. Line-of-sight vs. multipath
- viii. In-Band vs. Out of Band

Conducting the Investigation- Challenges

- Identifying/locating interference on frequencies with multiple signals is already a challenge
 - Existing FCC mobile DF technology responds to strongest signal
 - More than one signal requires DF system to do some moving around until the target signal is dominant

Conducting the Investigation- Challenges

Special equipment can help in some cases

- Some cases involve “operating practices” and not specifically errant RF energy
- Some DF capability is still usually needed to identify source of the offending emissions
- Demodulation of the signal can help to ensure that the DF is responding to the correct target

Closing the investigation

- Once identified, confirmation is needed of the interference source and mechanism causing it
- Measurements of output power and/or spurious emissions may be made on a transmitter output port
- Filtering may be temporarily inserted to confirm the elimination or reduction of interference
- For some types of sources, field strength measurements are needed to demonstrate that limits are exceeded

An “ON/OFF” test is usually the most efficient way to confirm the interference source

Follow-up work

- Case database input
- Case Report
- Re-contact complainant/subject on further status
- Spawning of new investigations
- Assessment of case for possible sanctions (warnings, violation notices, NALs, etc.)

FCC Sanctions – Monetary Forfeitures

- Monetary forfeitures:
- Any person who willfully or repeatedly failed to comply substantially with the terms and conditions of any license, permit, certificate, or other instrument or authorization issued by the Commission; or
- Willfully or repeatedly failed to comply with any of the provisions of this chapter or of any rule, regulation, or order issued by the Commission under this chapter or under any treaty, convention, or other agreement to which the United States is a party and which is binding upon the United States; . . .
- Shall be liable to the United States for a forfeiture penalty. A forfeiture penalty under this subsection shall be in addition to any other penalty provided for by this chapter; . . . 47 U.S.C. 503(b).

FCC Sanctions – Notice of Apparent Liability

- No forfeiture penalty shall be imposed under this subsection against any person unless and until—
- The Commission issues a notice of apparent liability, in writing, with respect to such person;
- Such notice has been received by such person, or until the Commission has sent such notice to the last known address of such person, by registered or certified mail; and
- Such person is granted an opportunity to show, in writing, within such reasonable period of time as the Commission prescribes by rule or regulation, why no such forfeiture penalty should be imposed.

FCC Sanctions – Notice of Apparent Liability

- Such a notice shall (i) identify each specific provision, term, and condition of any Act, rule, regulation, order, treaty, convention, or other agreement, license, permit, certificate, instrument, or authorization which such person apparently violated or with which such person apparently failed to comply;
- (ii) set forth the nature of the act or omission charged against such person and the facts upon which such charge is based; and
- (iii) state the date on which such conduct occurred. Any forfeiture penalty determined under this paragraph shall be recoverable pursuant to section 504(a) of this title. 47 U.S.C. 503(b).

FCC Sanctions – Notice of Apparent Liability

- ***Forfeiture order.*** If the proposed forfeiture penalty is not paid in full in response to the notice of apparent liability, the Commission, upon considering all relevant information available to it, will issue an order canceling or reducing the proposed forfeiture or requiring that it be paid in full and stating the date by which the forfeiture must be paid.
- ***Judicial enforcement of forfeiture order.*** If the forfeiture is not paid, the case will be referred to the Department of Justice for collection under section 504(a) of the Communications Act (47 U.S.C. 504(a)).
- 47 C.F.R. 1.80(f).

FCC Sanctions – Citation Exception

- **Exception:**
- No forfeiture liability shall be determined under this subsection against any person, if such person does not hold a license, permit, certificate, or other authorization issued by the Commission, and if such person is not an applicant for a license, permit, certificate, or other authorization issued by the Commission, unless, prior to the notice required by paragraph (3) of this subsection or the notice of apparent liability required by paragraph (4) of this subsection, such person (A) is sent a citation of the violation charged; (B) is given a reasonable opportunity for a personal interview with an official of the Commission, at the field office of the Commission which is nearest to such person's place of residence; and (C) subsequently engages in conduct of the type described in such citation. 47 U.S.C. 503(b)(5).

FCC Sanctions – Citation Exception

- Exception to the exception:
- The provisions of this paragraph shall not apply, however, if the person involved is engaging in activities for which a license, permit, certificate, or other authorization is required, or is a cable television system operator, if the person involved is transmitting on frequencies assigned for use in a service in which individual station operation is authorized by rule pursuant to section 307(e) of this title, or in the case of violations of section 303(q) of this title, if the person involved is a nonlicensee tower owner who has previously received notice of the obligations imposed by section 303(q) of this title from the Commission or the permittee or licensee who uses that tower.
- 47 U.S.C. 503(b)(5).

FCC Sanctions – Notice of Violation

- Except in cases of willfulness or those in which public health, interest, or safety requires otherwise, any person who holds a license, permit or other authorization appearing to have violated any provision of the Communications Act or any provision of this chapter will, before revocation, suspension, or cease and desist proceedings are instituted, be served with a written notice calling these facts to his or her attention and requesting a statement concerning the matter.
 - 47 C.F.R. 1.89

FCC Sanctions - Warnings

- Warnings are typically more informal notices cautioning the operator about issues, usually involving interference or unauthorized operation.
- For interference caused by Part 15 Devices:
 - The operator of a radio frequency device shall be required to cease operating the device upon notification by a Commission representative that the device is causing harmful interference. Operation shall not resume until the condition causing the harmful interference has been corrected. 47 C.F.R. 15.5(c).

FCC Sanctions – *In Rem* Seizures

- Any electronic, electromagnetic, radio frequency, or similar device, or component thereof, used, sent, carried, manufactured, assembled, possessed, offered for sale, sold, or advertised with willful and knowing intent to violate section 301 or 302a of this title, or rules prescribed by the Commission under such sections, may be seized and forfeited to the United States.
- DOJ has the authority, FCC works with DOJ on equipment seizures.
 - 47 U.S.C. 510.

FCC – Shut Down Orders

- Cease and Desist Orders/Revocation Order
 - Where any person (1) has failed to operate substantially as set forth in a license, (2) has violated or failed to observe any of the provisions of this chapter, or section 1304, 1343, or 1464 of title 18, or (3) has violated or failed to observe any rule or regulation of the Commission authorized by this chapter or by a treaty ratified by the United States, the Commission may order such person to cease and desist from such action. (Typically issued to licensees or permittees, and involves a hearing, *see* 47 C.F.R. 1.91).
- Part 15 operation:
 - The operator of a radio frequency device shall be required to cease operating the device upon notification by a Commission representative that the device is causing harmful interference. Operation shall not resume until the condition causing the harmful interference has been corrected. 47 C.F.R. 15.15(c).

FCC – Shut Down Orders

- Many “shut downs” occur voluntarily when an inspection reveals violations or unauthorized use or harmful interference and the operator is willing to immediately correct the interference or violations.
- The FCC cannot seize equipment without assistance from DOJ using the appropriate seizure procedure.

FCC – Criminal prosecution

- General Authority:
 - Any person who willfully and knowingly does or causes or suffers to be done any act, matter, or thing, in this chapter prohibited or declared to be unlawful, or who willfully and knowingly omits or fails to do any act, matter, or thing in this chapter required to be done, or willfully and knowingly causes or suffers such omission or failure, shall, upon conviction thereof, be punished for such offense, for which no penalty (other than a forfeiture) is provided in this chapter, by a fine of not more than \$10,000 or by imprisonment for a term not exceeding one year, or both; except that any person, having been once convicted of an offense punishable under this section, who is subsequently convicted of violating any provision of this chapter punishable under this section, shall be punished by a fine of not more than \$10,000 or by imprisonment for a term not exceeding two years, or both. 47 U.S.C. 501.

FCC – Criminal Prosecutions

- Criminal prosecutions are rare.
 - FCC must refer matter to Department of Justice and DOJ must agree to prosecute.
 - Typically, concerning spectrum, will involve some type of willful interference:
 - 47 U.S.C 333 = No person shall willfully or maliciously interfere with or cause interference to any radio communications of any station licensed or authorized by or under this chapter or operated by the United States Government.

FCC – Criminal Prosecutions

- 18 U.S.C. 1362 = Whoever willfully or maliciously injures or destroys any of the works, property, or material of any radio, telegraph, telephone or cable, line, station, or system, or other means of communication, operated or controlled by the United States, or used or intended to be used for military or civil defense functions of the United States, whether constructed or in process of construction, or willfully or maliciously interferes in any way with the working or use of any such line, or system, or willfully or maliciously obstructs, hinders, or delays the transmission of any communication over any such line, or system, or attempts or conspires to do such an act, shall be fined under this title or imprisoned not more than ten years, or both.

FCC – Criminal Prosecutions

- 18 U.S.C. 1367 = Whoever, without the authority of the satellite operator, intentionally or maliciously interferes with the authorized operation of a communications or weather satellite or obstructs or hinders any satellite transmission shall be fined in accordance with this title or imprisoned not more than ten years or both.
- These violations will all typically involve a 47 U.S.C. 301 charge as well.

Case Studies

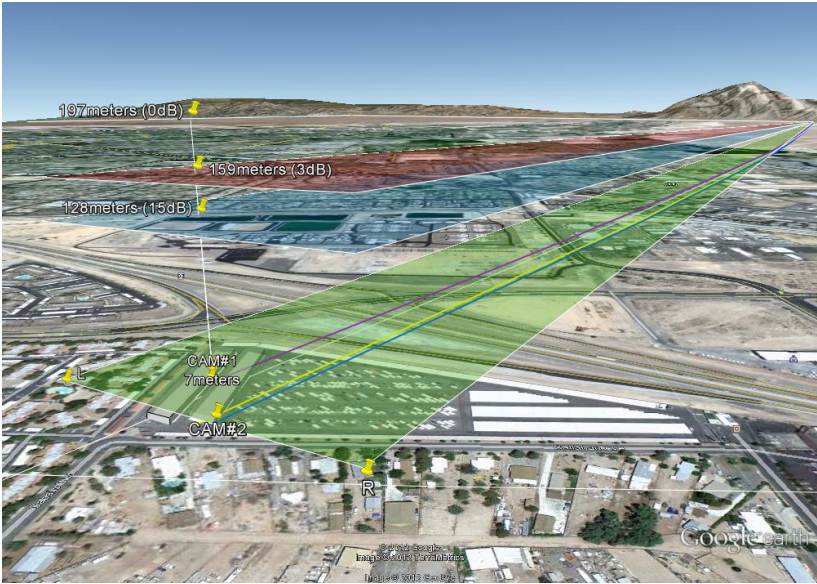
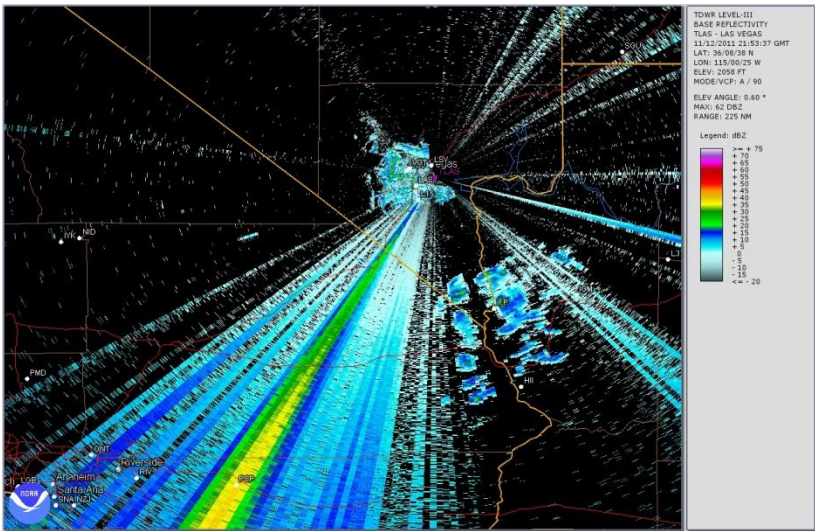
- U-NII Interference to Terminal Doppler Weather Radar
- Low Power Device Interference to Commercial Wireless LTE
- Malicious, Intentional, and Disruptive Interference
- Interference to Satellite-Based Passive Sensing Services



U-NII Interference to Terminal Doppler Weather Radar

- Interference in the 5600 -5650 MHz band
 - TDWR primary
 - Unlicensed National Information Infrastructure (U-NII) – Part 15
 - U-NII devices must be certified
- Dynamic Frequency Selection certification requirement
- “Interference” manifests as a strobe line on the TDWR display
 - Impairs detection of wind sheer along a (usually) narrow azimuth
- FCC OET/EB Memo (July 27, 2010) Elimination of Interference to TDWR
 - Beyond 35 km or line of sight
 - 30 MHz away from the TDWR operation center frequency
- Joint FCC/FAA Interference Resolution Group

Interference to TDWR



Low Power Device Interference to LTE

- Low power devices operating under Part 15 and Part 18
 - Lighting ballasts – Part 18
- Certified vs uncertified
- Malfunctioning or degrading equipment
- Aggregate interference

Malicious, Intentional, and Disruptive Interference

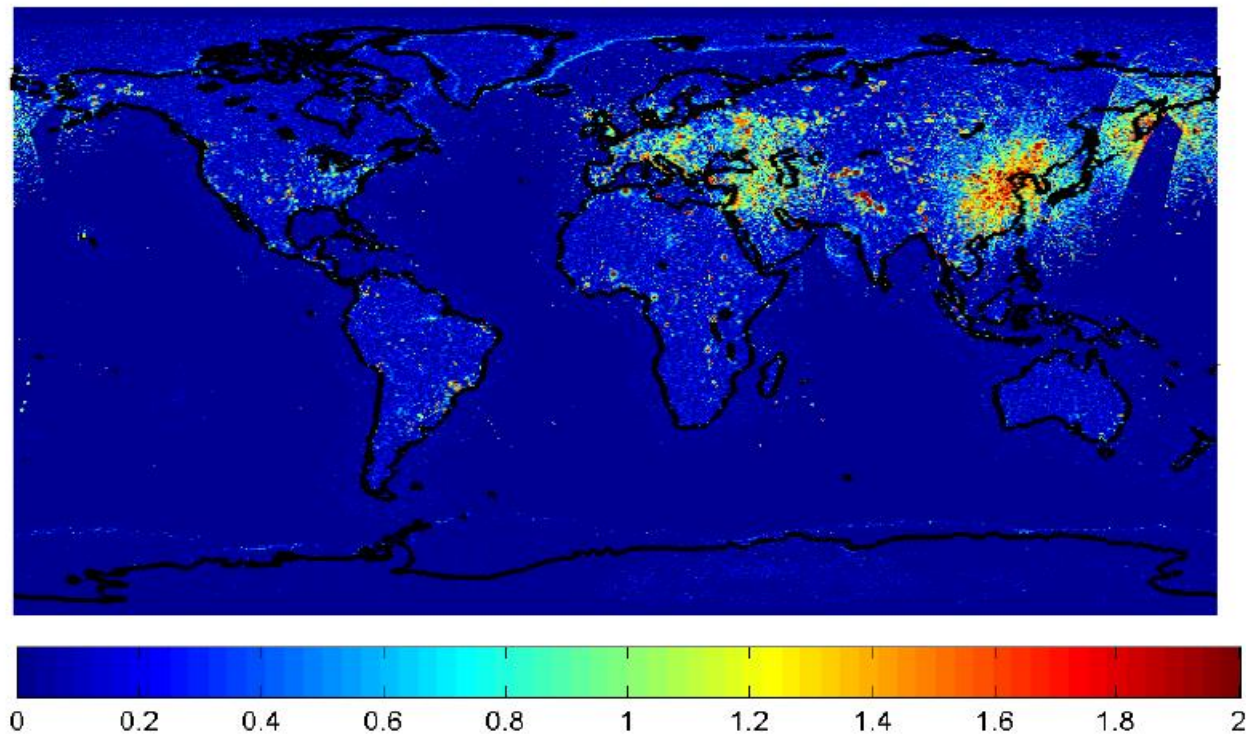
- Malicious ix to public safety frequencies
 - criminal
- Intentional ix
 - False distress
 - Disgruntled former employees
 - Deauthentication
- Disruptive

Interference to Satellite-Based Passive Sensing Services

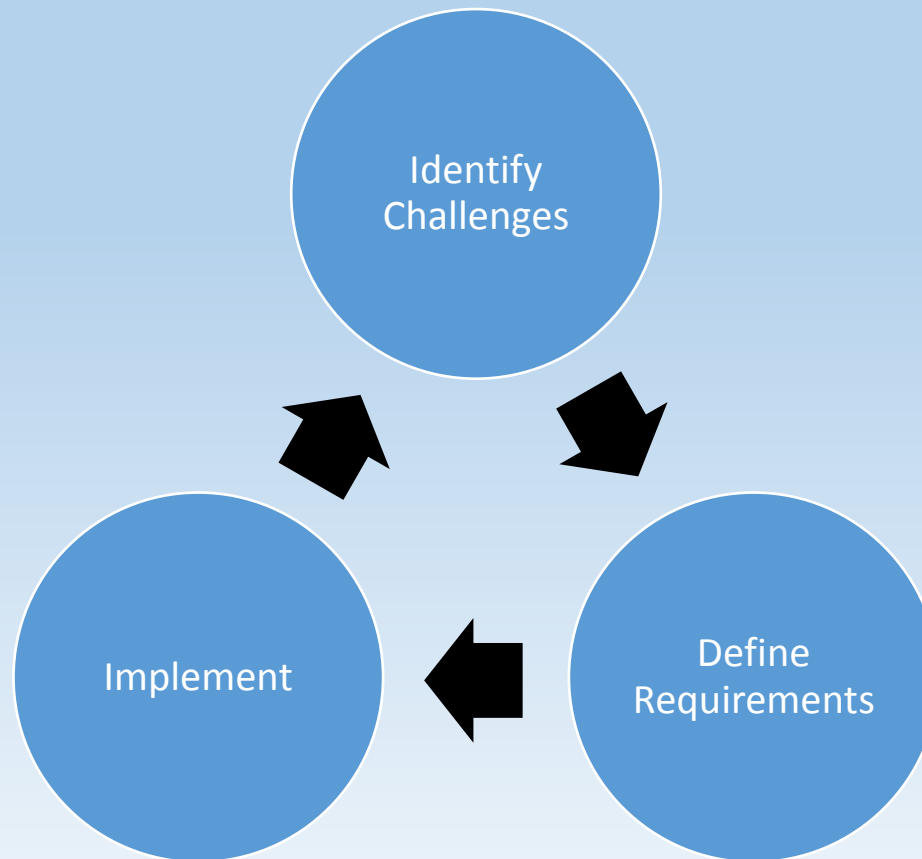
- Interference to 1400 – 1427 MHz
 - Polar orbiting
 - Global concern
 - Passive sensing band, i.e., no transmission
- Emissions from in-band and out-of-band sources
 - Sources can be relatively weak
 - Field search can be complex
- Geolocation estimates derived from satellite orbital parameters

Interference to 1400-1427 MHz (NASA SMAP)

Max-Hold Log₁₀(H pol RFI) 5/1-5/8



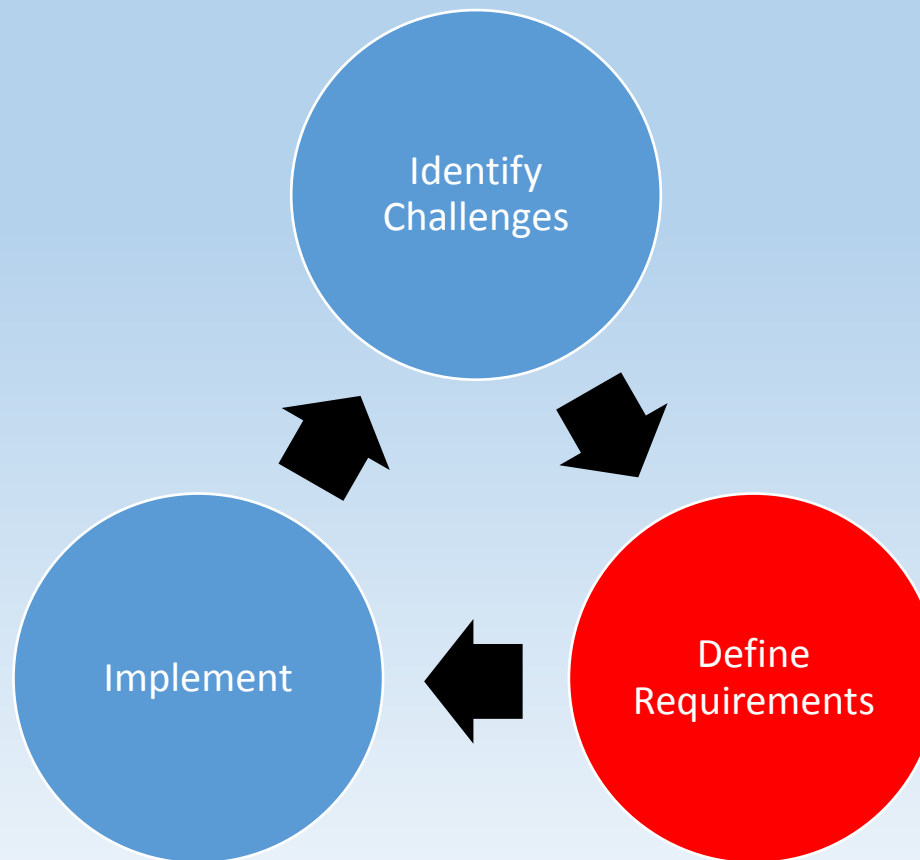
The Field Equipping Cycle



Identifying Equipping Challenges

- Agents must cover entire spectrum and work within the limitations of their equipment
 - Frequency range limitations
 - Multipath
 - Sensitivity limitations
- Agents cover a very large area of responsibility, and cope with investigations involving many different technologies
- Shared spectrum related interference on the rise
- Intermittent emitters
- Mobile emitters present challenges

The Field Equipping Cycle



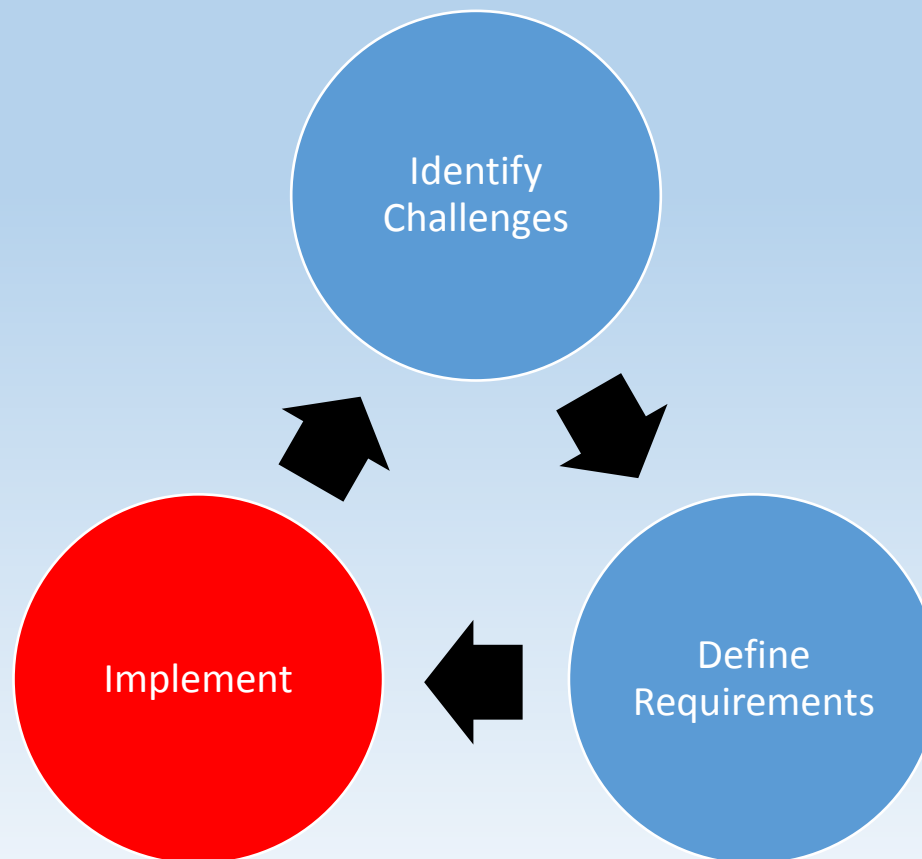
Define Equipment Requirements

- Solutions more specialized to IX in shared spectrum
- Improved foot based interference hunting tools
- Improved solutions for detecting, classifying, and locating higher frequency, lower power emitters.
- Solutions specialized for hunting jamming equipment
- Solutions to ease in locating mobile emitters causing interference
- Increased probability of intercept (POI)

Automation

- Spectrum sensors that can notify agents of events
 - Signal breaking a spectrum mask
 - Loss of signal
 - Change in signal characteristics
- Automatic signal classification
- Automated report generation

The Field Equipping Cycle



FTAC Working Group

- Formed to investigate the use of COTS portable, remote controlled spectrum sensors and geo-location systems.
- Desirable features
 - Wide frequency range (20 MHz to 6 GHz)
 - Single system for temporary fixed, and mobile operation
 - Ability to be programmed/controlled locally or remotely
 - Ability to operate autonomously for long periods of time
 - Data recording and report generation
- RFI Issued May 2016
- FTAC is in the process of evaluating vendor solutions

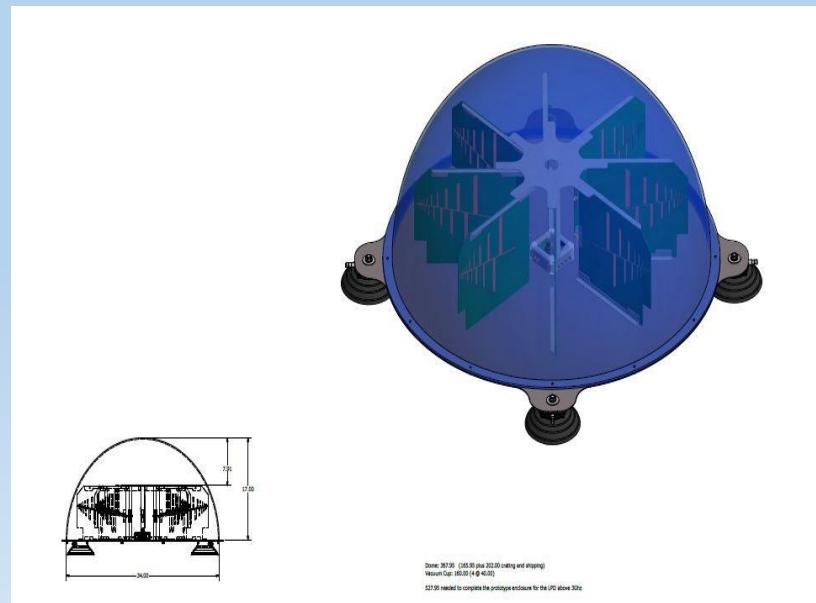
Equipping for the Future

- Add real time analyzers/SDR's to the equipment compliment to allow for greater POI of fast acting intermittent emitters
- Increase range of spectrum analyzers to 50 GHz
- Combination of fixed and mobile direction finding/monitoring systems
 - Approx. 20 covert systems placed throughout the US
 - High sensitivity systems
 - Shippable systems
 - Immunity to electronic warfare threats
- Network of fixed and mobile spectrum sensors.

New Hardware Approaches

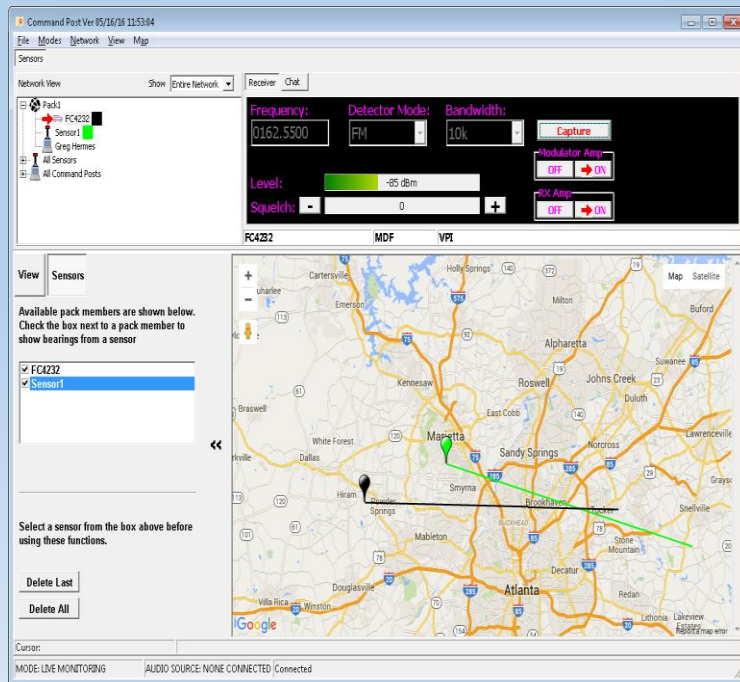


enclosures and mountings
for swappable mission
specific filters and amplifiers

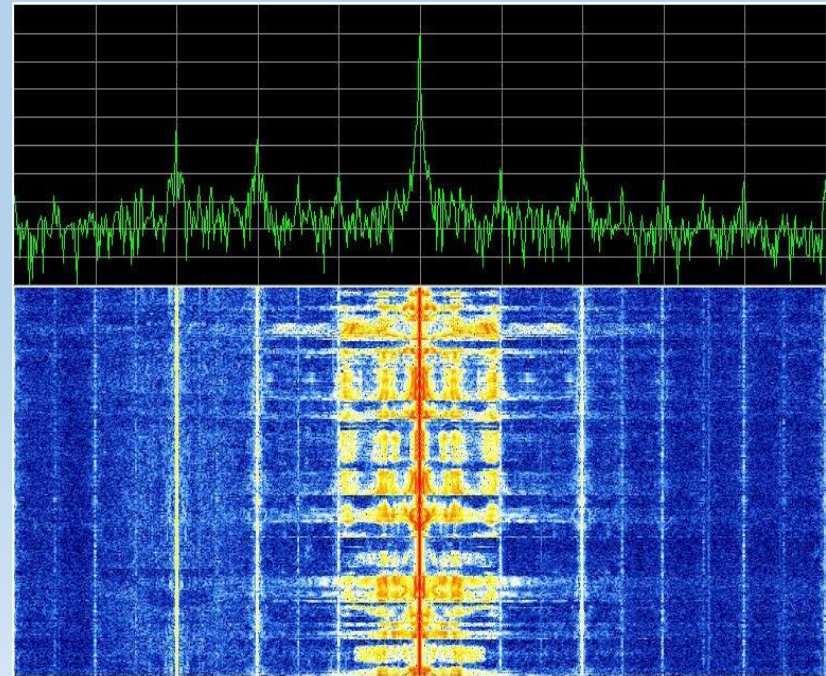


High gain DF head for FCC
systems

New Software Approaches

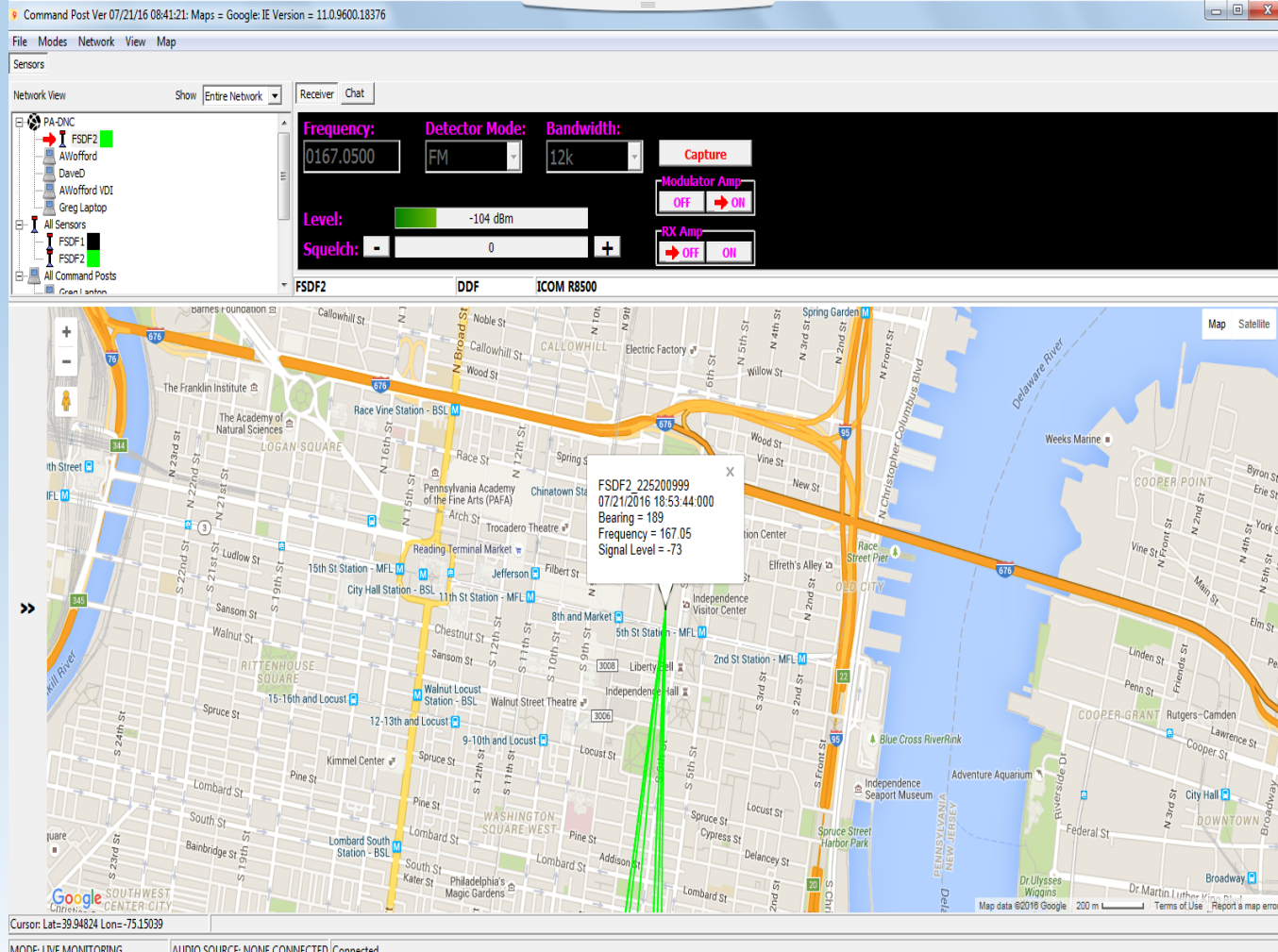


Networked system of fixed and mobile sensors allow agents to collaborate, or call on unmanned sensors from remote locations.



Spectrum investigation automation software in conjunction with SDR's or spectrum analyzers already owned by FCC can be deployed and notify agents when certain events occur

Fixed DF/Sensor Deployed at DNC



Lessons Learned

- Value of accurate databases
- Transparency of mechanisms in protocol stack
- Value of self-calibration checks on equipment
- “Art” to direction finding, especially with reflections
- Importance of filters in receivers
- Continual training and learning new technologies
- Spot verification of equipment certifications
- Inadvertent \neq intentional

Recommendations

- Ex Ante
 - Require signal characteristics for transmitters
 - Compiled into an open database
 - Require identification embedded into transmission
 - Call signs, MAC address, embedded IDs, GPS coordinates, etc.
 - Equipment certification requirements
 - Functionality to remotely control/disable
 - Receiver certification as RFI resistant
- Ex Post
 - Searchable database of cases of harmful interference
 - Identification of equipment that fails to sense, detect and avoid
 - Centralized complaint intake with ability to analyze trends
 - Database of unauthorized, illegal devices
 - Self-sensing/self-aware devices
 - Advanced demodulation and signal analysis tools



Applying Lessons Learned and Best Practices to Future Sharing Scenarios

- NOAA GOES/POES ground stations
- Citizens Broadband Radio Service
- Dedicated Short Range Communications Systems/Intelligent Transportation Service
- IoT environment
 - How to quickly identify the source of interference
 - What are reasonable and timely corrective actions
 - How to deal with unsophisticated unlicensed users
 - What aspects of RF interference hunting can be automated
 - How to leverage technology trends
 - What types of mitigation techniques work
 - How to use risk-informed interference assessment in the field
 - What factors distinguish interference that is acceptable, degrading or harmful
 - How to apportion responsibility