INTERFERENCE DETECTION AND MITIGATION TECHNIQUES FOR WIRELESS SYSTEMS

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MOTOROLA SOLUTIONS

Interference Is As Old As Radio Itself

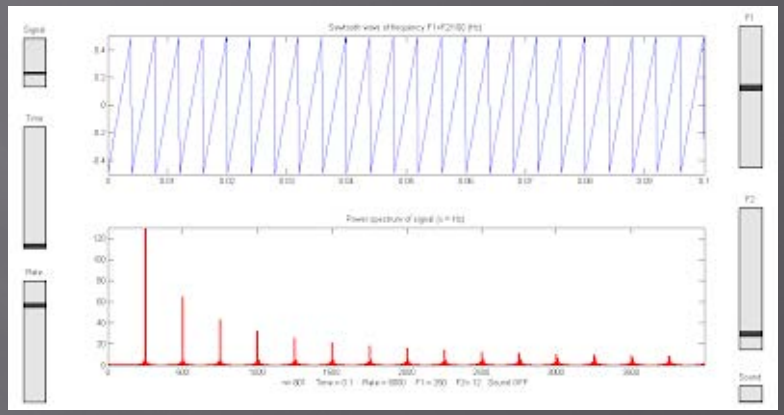
- April 15th, 1912 (hint: Not Income Tax filing deadline in US)
  - "what is the matter with u." Two hours after collision; sent from "MV Frankfort"
  - "you fool, stdbi and keep out!" Response from MV Titanic
- April 14th, 1912
  - "In lat 42N to 41.25N long 49W to long 50.30W saw much heavy pack ice and great number of large icebergs..." Sent from MV Mesaba
  - "Keep out, I'm working Cape Race!" MV Titanic response as passenger messages were being sent home using the 500kHz channel
- Most ships had only 2 frequencies to use including 500kHz
- Rotary spark / damped waveform signals occupied large amounts of spectrum; caused tremendous interference.
- No enforceable rules back then…..

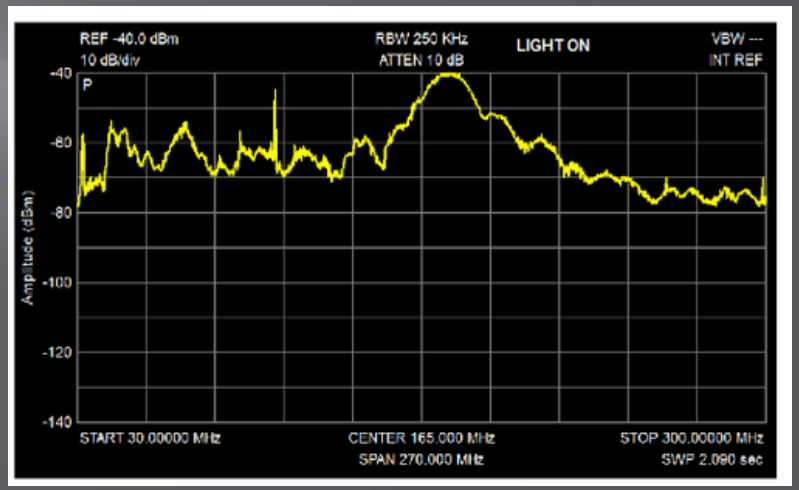
What Is Interference?

- Keynote speech yesterday:
  - Noise of any form could be construed as "Interference"
    - kTB noise
    - Galactic Noise
    - Natural electromagnetic phenomenon (weather, etc)
  - Let's narrow it down…
  - Define interference as "interference" when it is:
    - Of, or from, a manmade source; …..is
    - Extraneous to desired intelligence being conveyed;… and it
    - Impacts communications within the protected or desired service area of the information source transmitter.
    - Many, if not most, systems operate "Interference Limited" vs. "Noise Limited" today. Herein, we have limited further the definition of "interference" to set aside acceptable or allowed interference and interference sources.
- For purposes of discussion today, Interference will be defined as undesired RF signals that are disruptive to communications circuits within defined service limits.

Interference In Many Forms Throughout History

- AM Radio ~1950-present
  - $F_{h:}$ Multiples of 15,750 / 15,734kHz from horizontal yoke deflection circuits
  - CFL lighting
  - LED lighting
  - Switching power supplies
  - Engine electronics
  - Cable modems
  - Flat panel TV/Monitors
- Not just limited to the .5-30MHz allocations anymore
  - FM radio (88-108): LED traffic lighting; cigarette lighter smart phone chargers
  - Plasma television –VHF/UHF noise (2000-2010 time frame)
  - Lighting; high efficiency DC supplies
- Does it stop at 100MHz?
  - Absolutely Not!



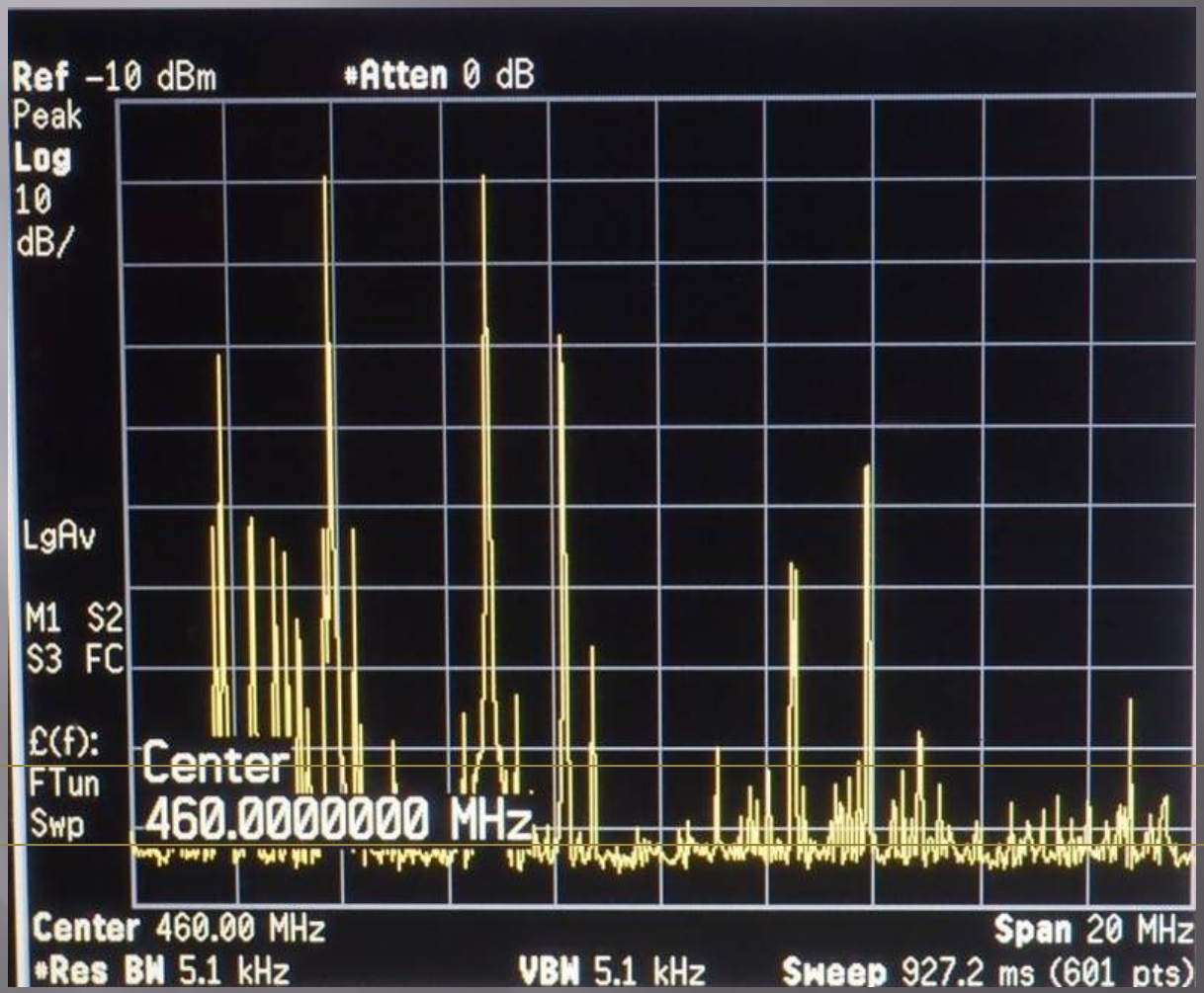


Numerous Reports of RF Interference

Survey Respondent	Interference Cause	Band(s) Affected	How Affected	Impact Area
Government of Quebec, Canada	Found 15 locations in City with interference cause by lighting.	VHF	Loss of coverage, noise and garbled transmissions on portables and mobiles	Within 250 meters but distance varies
Tenafly Fire Dept. (New York)	High efficiency interior lighting; also some new FAA tower lighting	VHF Lowband; 700/800 MHz	20 dB increase in noise floor	Not specified
Oregon DOT	LED traffic lights; an LED flashlight next to portable radio	VHF	Loss of coverage to mobiles and portables; also to consumer FM car radios	Within 50-75 feet of LED traffic lights. Within about 14 inches of LED flashlight
Industry Canada	Electronic ballasts for florescent lights in nearby store	800 MHz cellular band	Broadband noise 20 MHz wide caused loss of coverage/dropped cellular calls	Within 2 km
P3 Communications	LED billboards. Have performed many interference investigations for cellular carriers	700 MHz cellular band	Increased noise for cellular base stations	Within a few hundred yards
US Coast Guard Auxiliary	LED and Florescent lighting inside and outside building	VHF; UHF; 700/800 MHz	Locks up radio systems in scan or trunked mode; impact to portable, mobile and base stations.	Since it locks down system in scan or trunked mode, impact is to wide area.

https://ecfsapi.fcc.gov/file/1081108971898/RF_Interference_from_Energy_Efficient_Lighting_Report_Final_20150630.pdf

Noise Floor – Instrumentation Limits
UHF Part 90 / 74 Spectrum



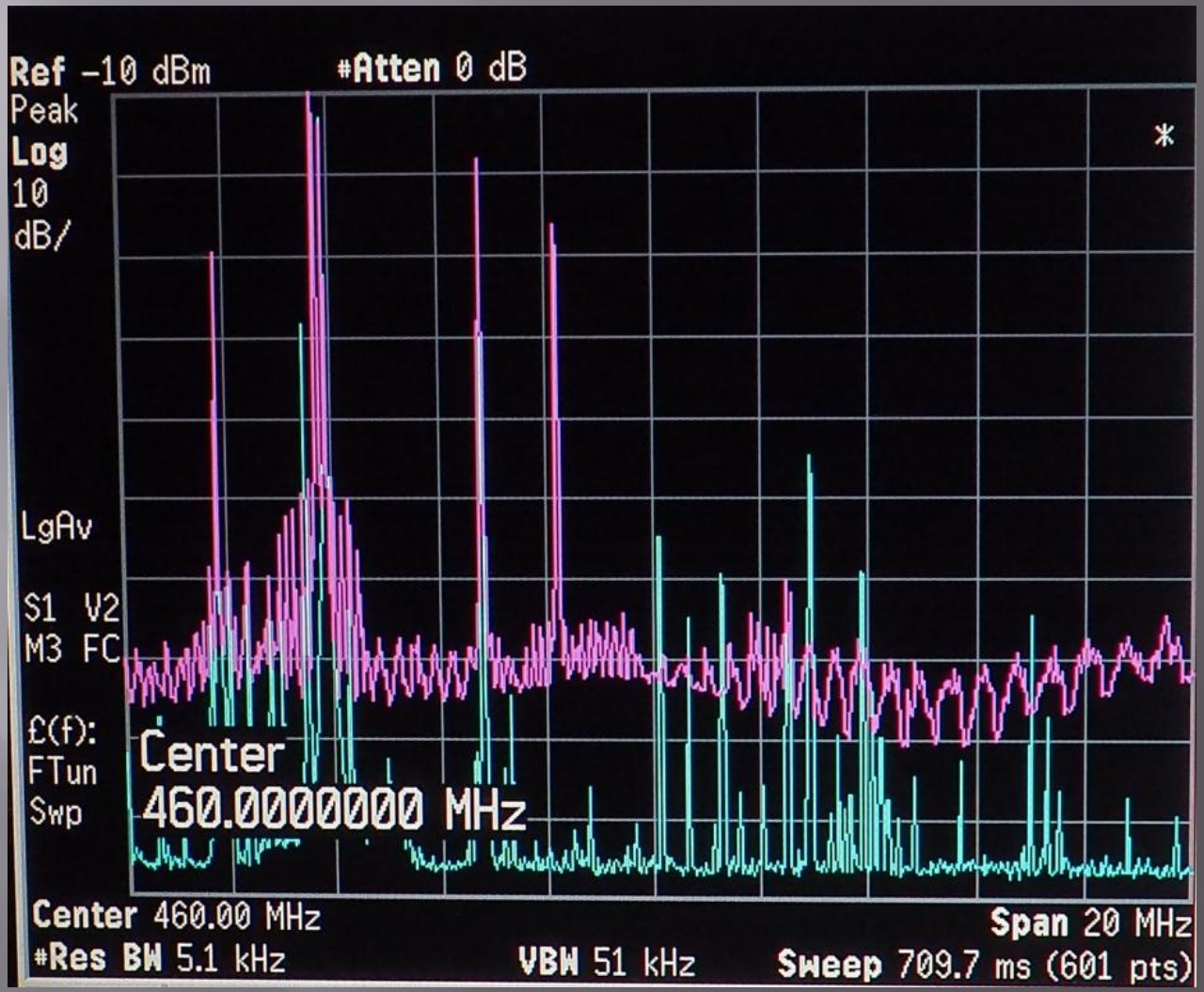
-10dBm

-20dBm

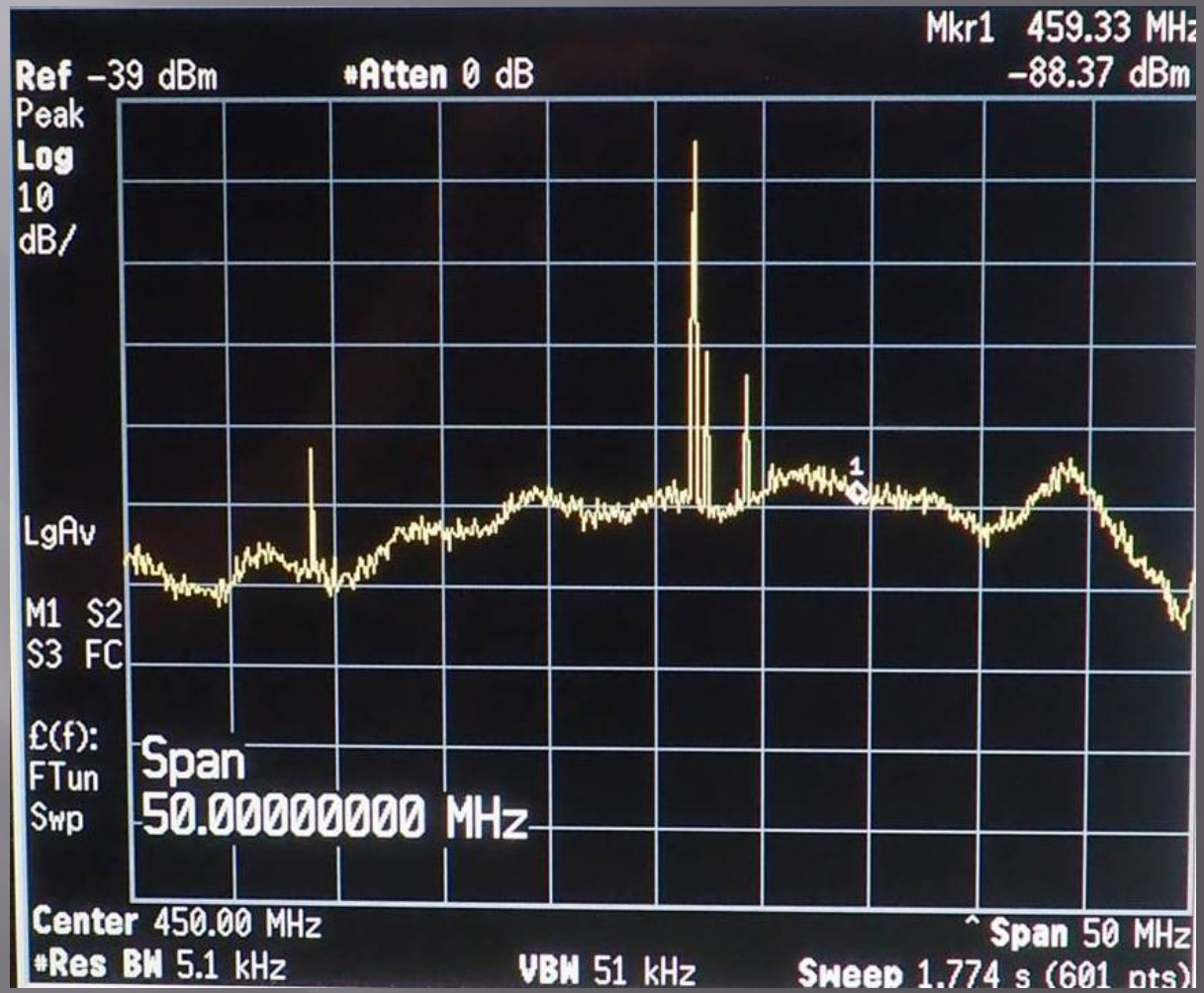
-72dBc

-105dBm

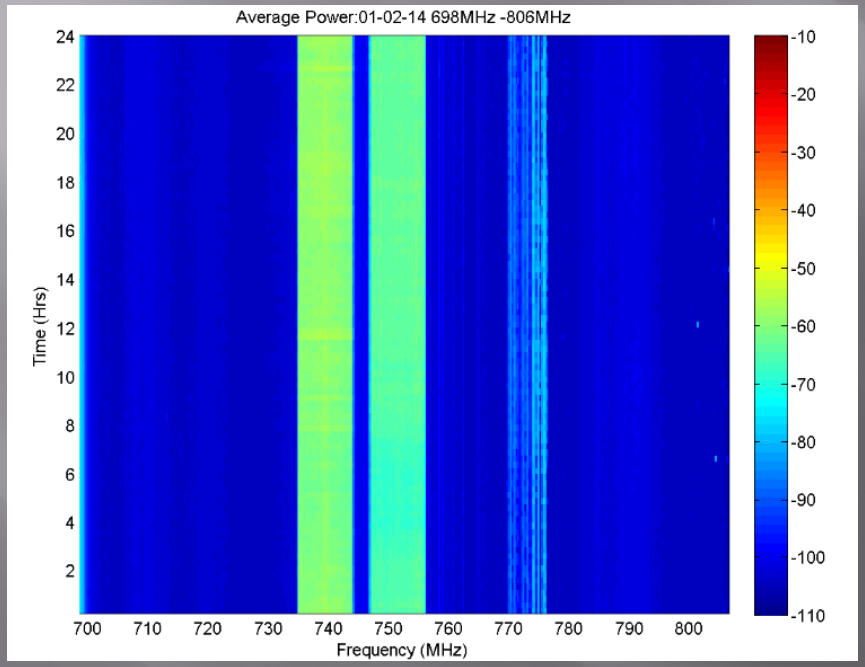
Spectrum Overlay w/Interference

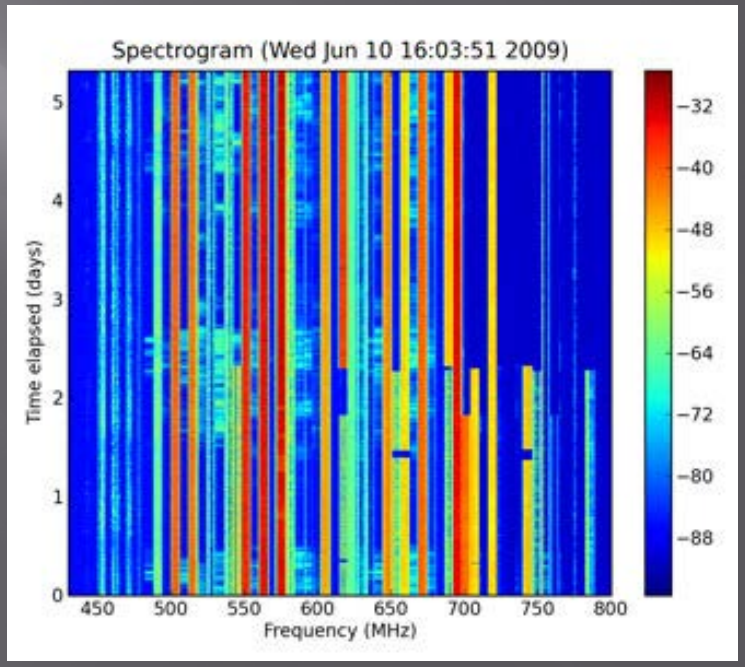


Peak-Hold Spectrum Capture: Still Lacking in Detail



Visual Chart Limitations

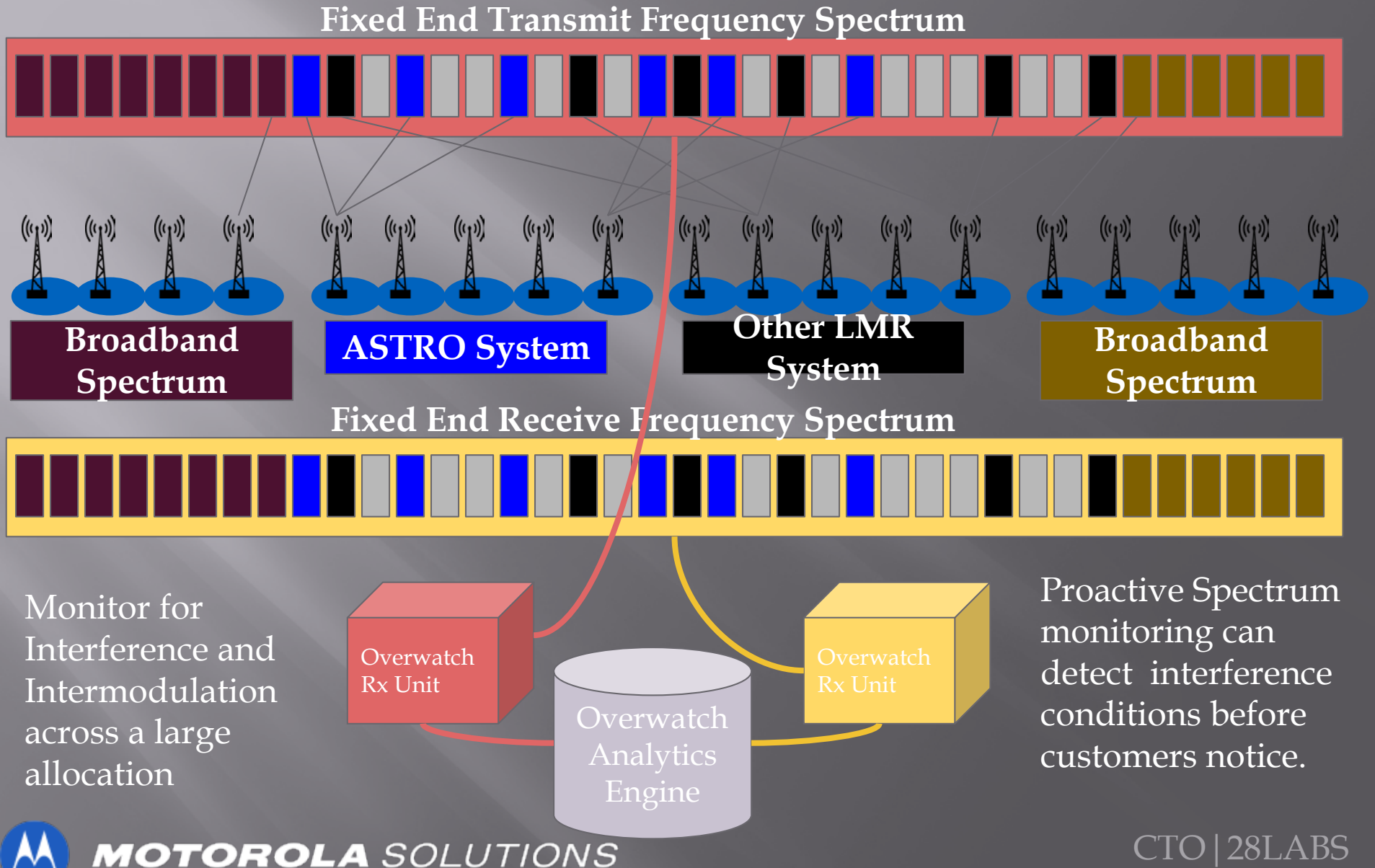




Detailed Data Collection and Analysis

- Exploit large pool of equipment already deployed
  - Further leverage currently deployed equipment base
  - Augment with additional, low cost equipment
  - Distributed Data processing
    - Raw data pre-processed on edge /on-site; reduce backhaul load
    - Cloud processing; analytics of data
  - Goals:
    - Identify underutilized and opportunistic use spectrum
    - Early detection of system degradation and pending failure modes
    - Detection of interference and jamming
  - Minimal cost approach; yet achieve highest resolution

Spectrum Analytics (Overwatch) Concept

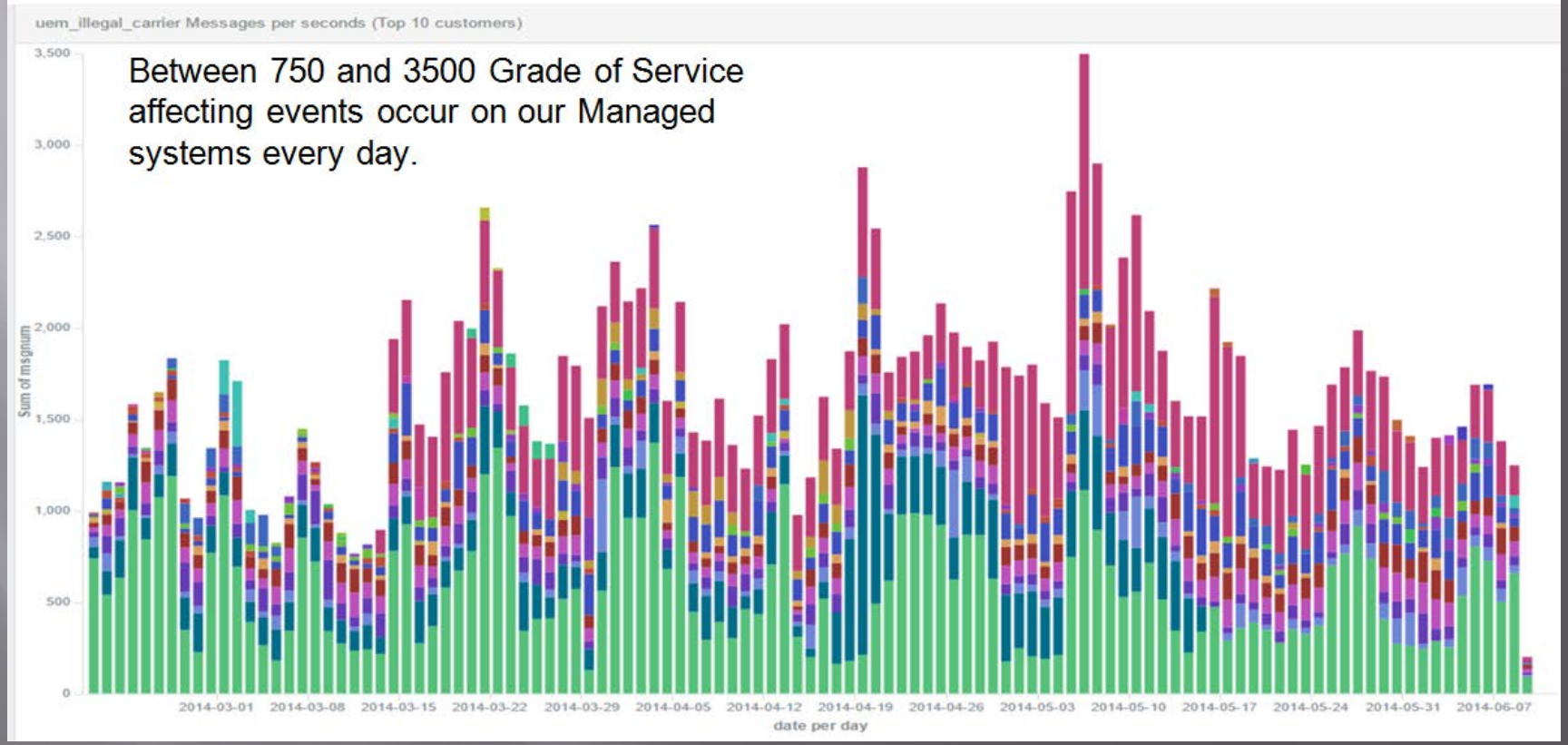


Monitor for Interference and Intermodulation across a large allocation

Proactive Spectrum monitoring can detect interference conditions before customers notice.

Interference is Common – Even in Licensed Spectrum

ILLEGAL CARRIER – MULTIPLE CUSTOMER VIEW OVER 3 MONTHS



Deployed Experimental System Example

Make use of dwell time when system experiences low demand

Runs in background

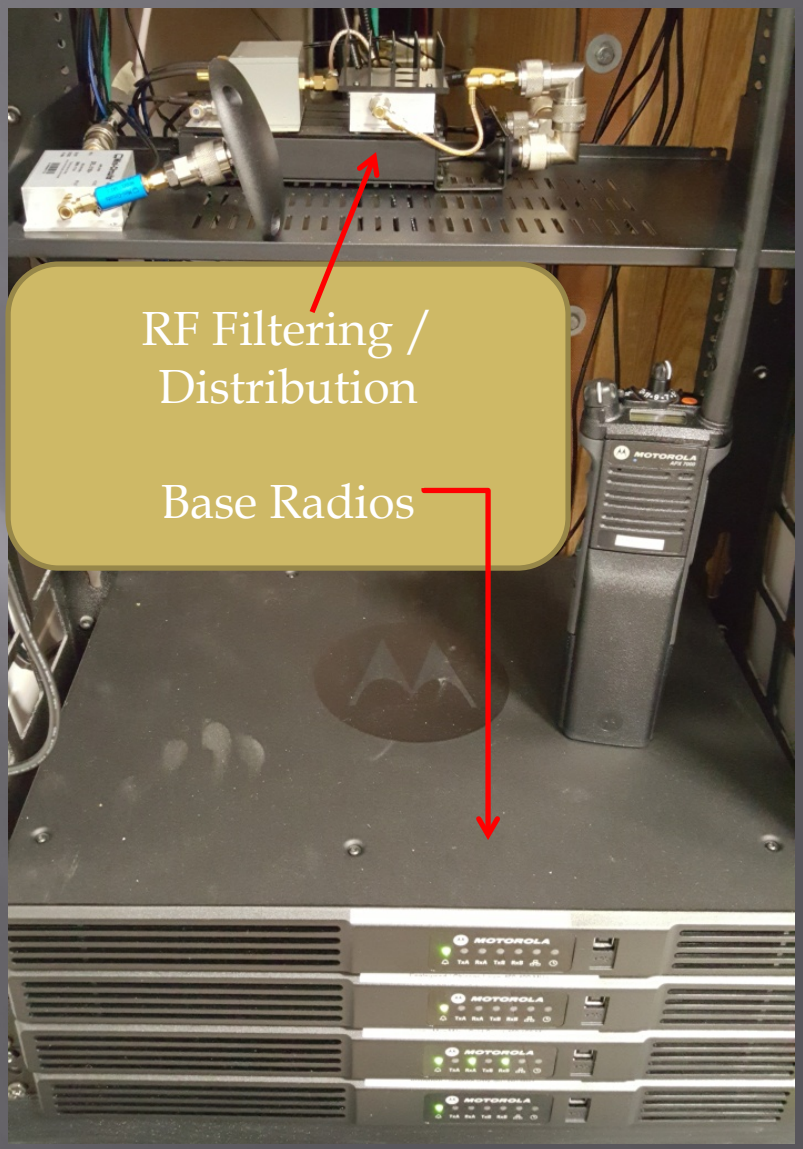
Uses a-priori knowledge of active transmit channels

Currently utilizes a supervisory PC; intent is to eliminate it

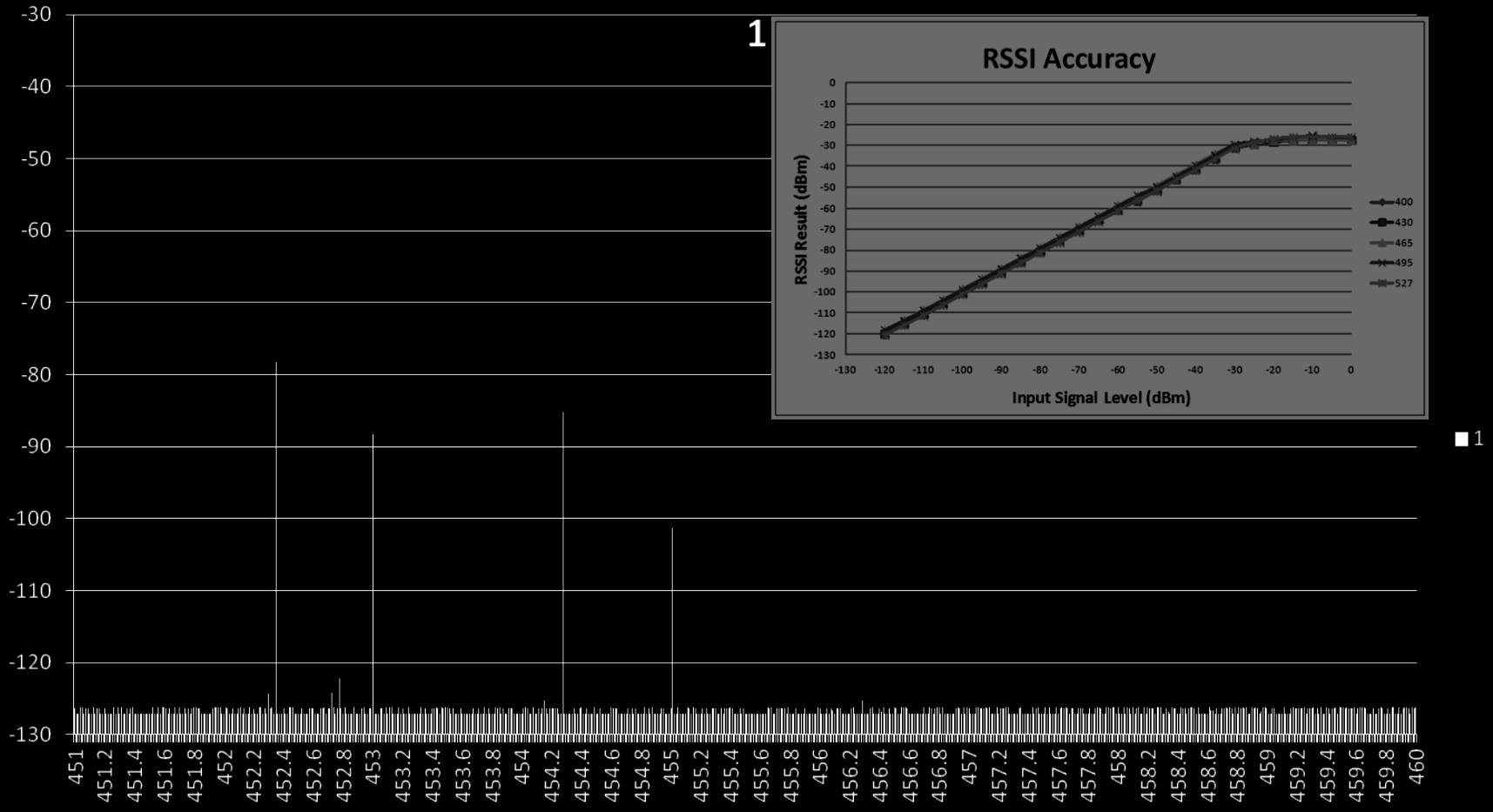
Signal is pre-processed within the base radio; backhauled to cloud

Multi-site approach enhances illegal carrier and interference detection

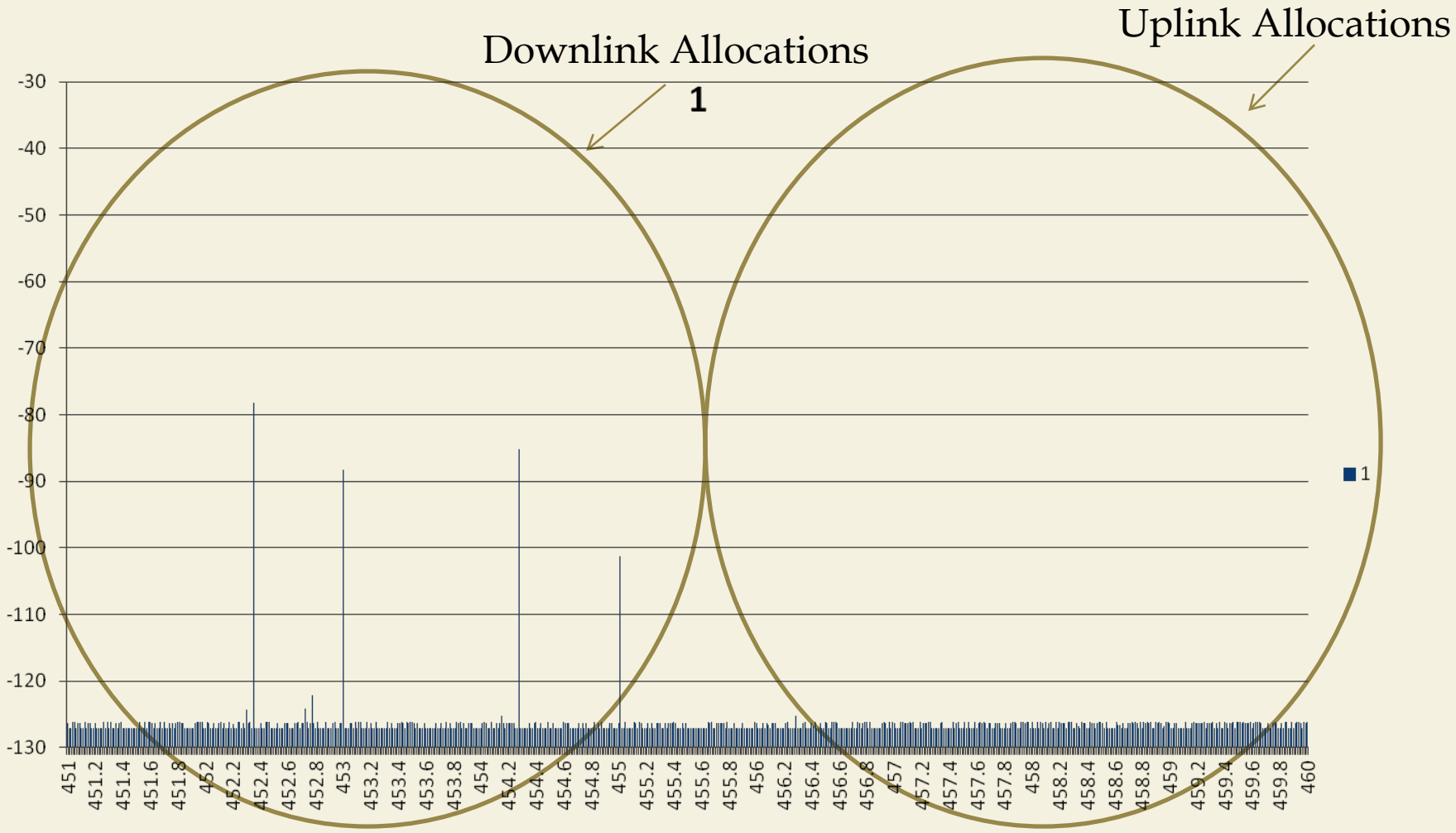
Investigating methods to expand to subscriber devices



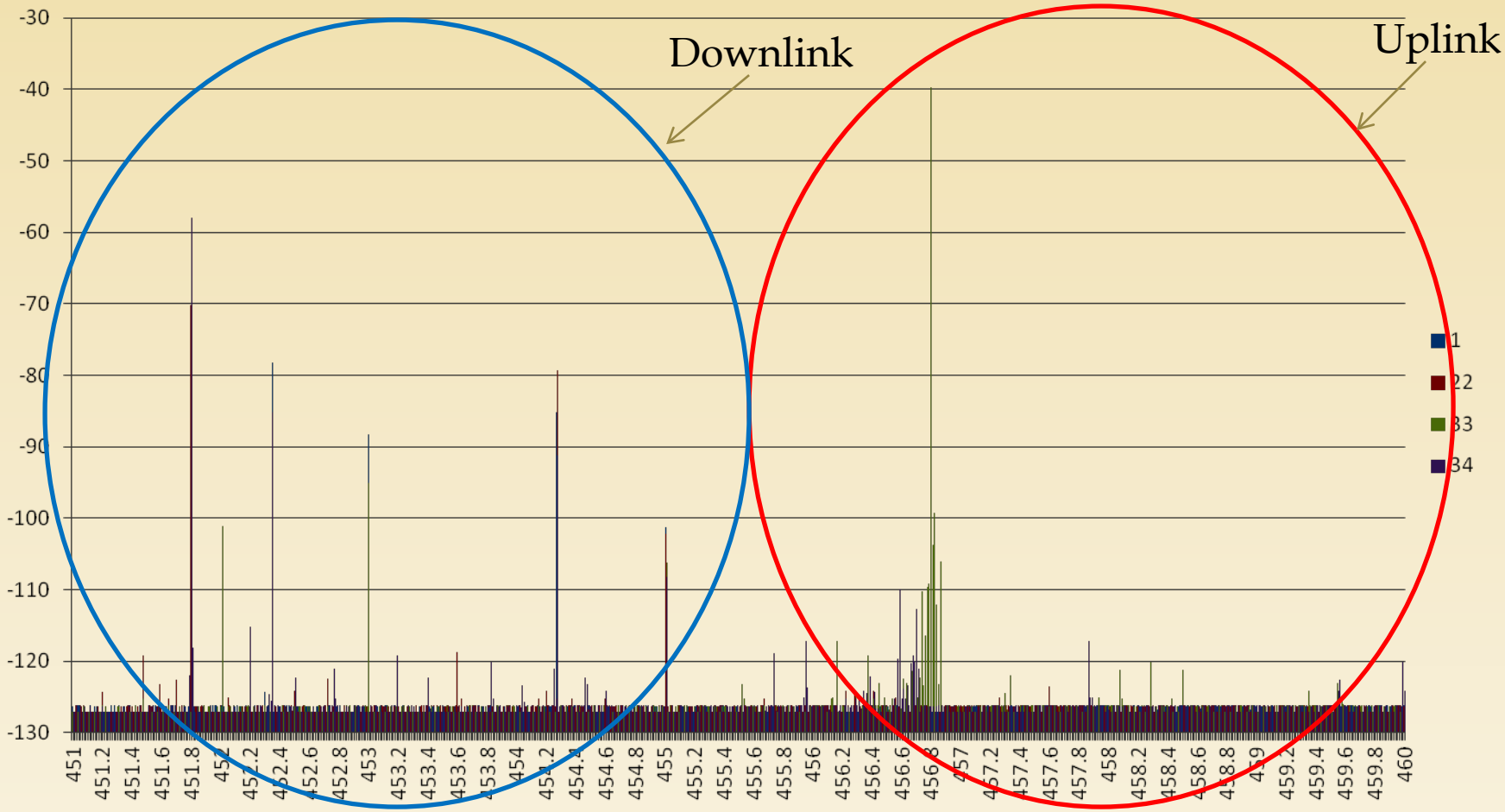
Reference UHF Noise Floor



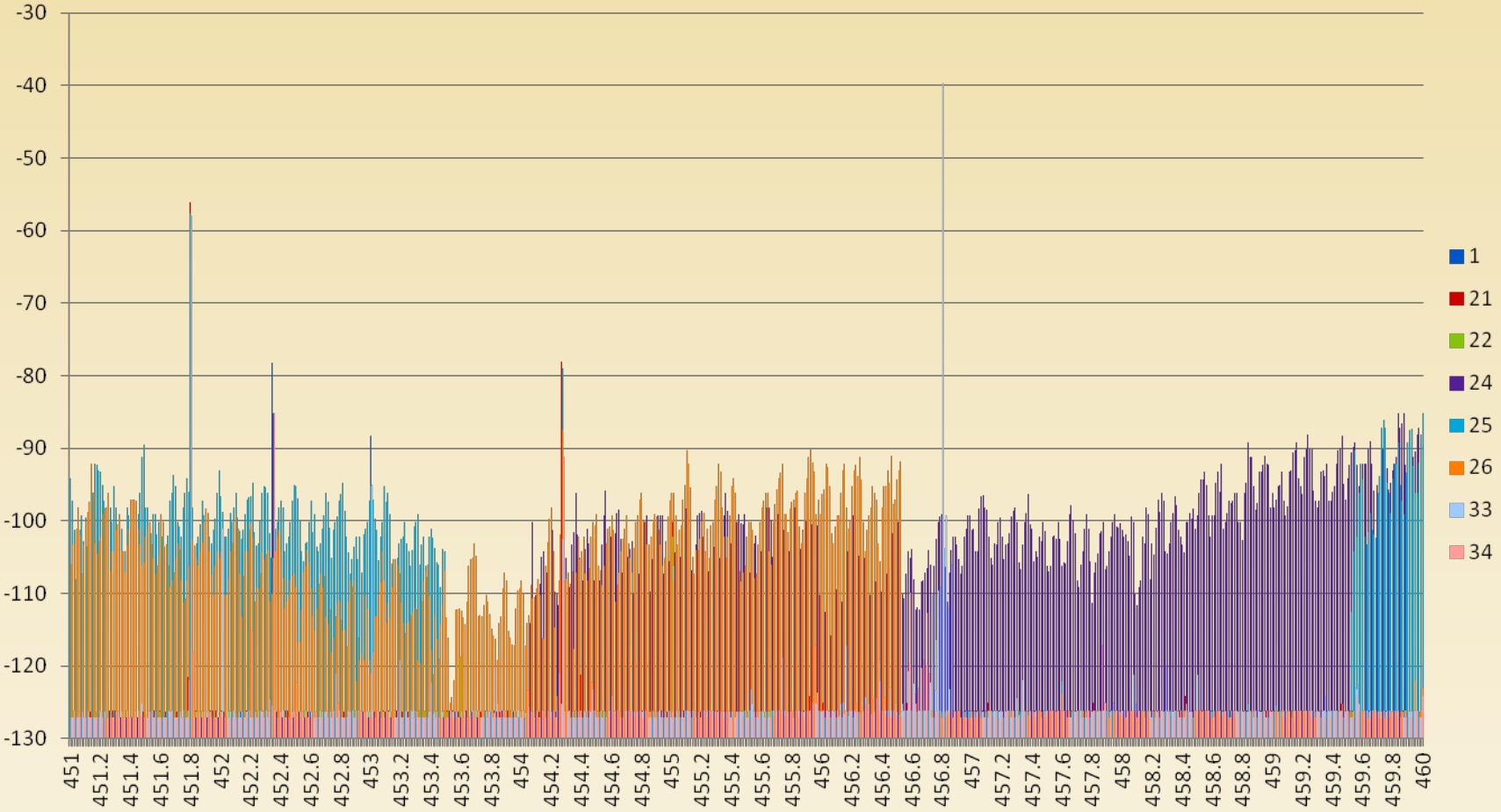
Reference Noise Floor HDR Spectrum Sampling
UHF Part 90; 74 Allocations



UHF Part 90; 74 Allocations
High Dynamic Range Spectrum Monitoring

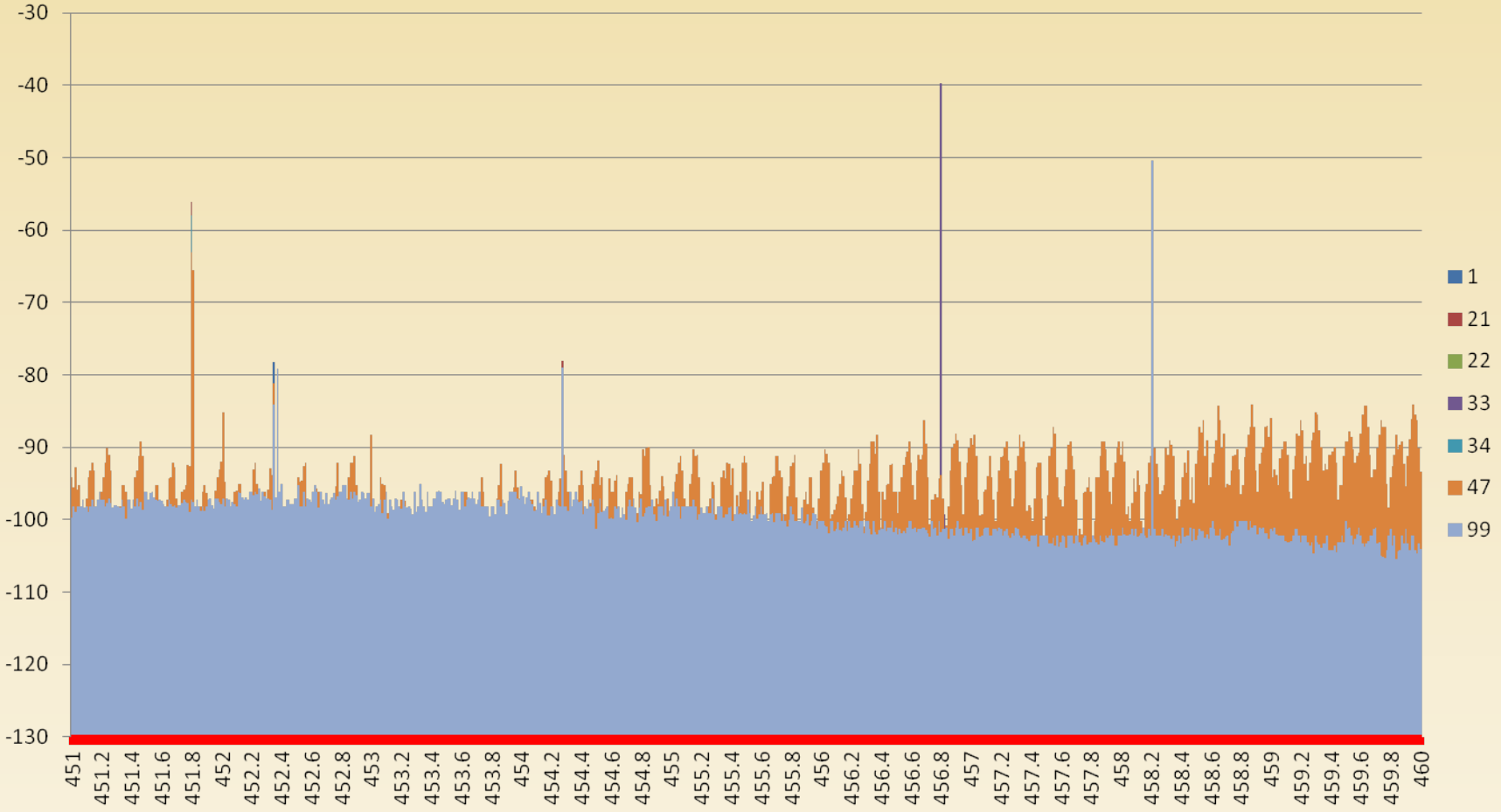


Local Interference RF Signature Multiple Sweeps

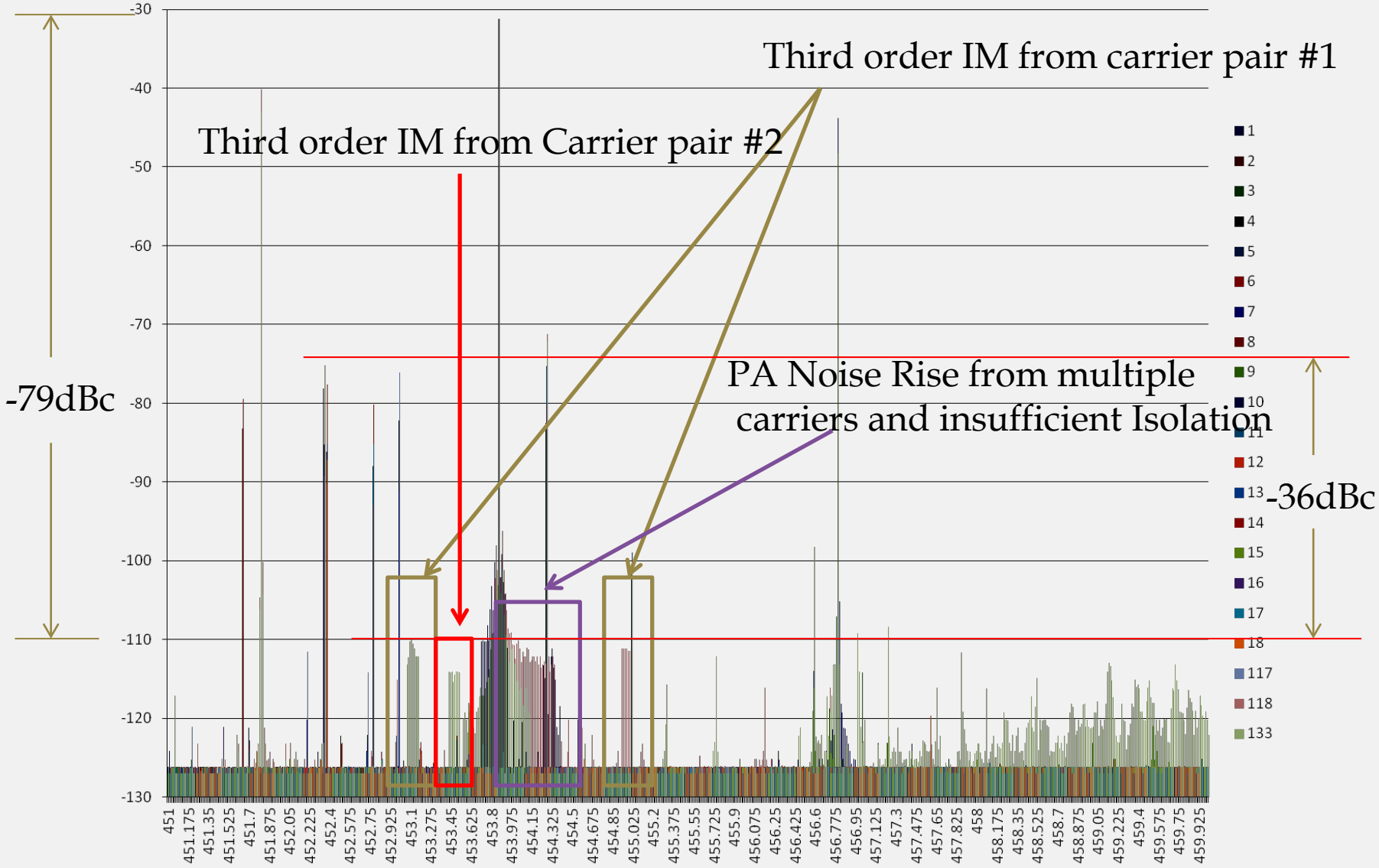


Aggregate Spectrum of Multiple Noise Sources

True Broadband Generator; Switch-mode Power Supply



IM Detection OverWatch



Increased Awareness and Emphasis on Interference and Jamming / Avoidance

FCC NEWS from the Federal Communications Commission

Media Contact:
Will Wiquist, (202) 418-0509
will.wiquist@fcc.gov

For Immediate Release

FCC FINES FLORIDA DRIVER $48,000 FOR JAMMING CELLULAR & PUBLIC SAFETY COMMUNICATIONS DURING WORK COMMUTE

WASHINGTON, May 25, 2016 – The Federal Communications Commission today issued a $48,000 fine against [redacted] for using a cell phone jamming device in his car during his daily work commute to and from Tampa, Florida. [redacted] illegal operation of the jammer continued for up to two years, caused interference to cellular service along Interstate 4,

Reactionary vs. Anticipatory Systems

- Reactionary
  - Wait until it happens
    - Recognize the effects of interference and jamming
  - Try evasive measures; find one that works
    - Requires training and experience; not always conducive to stressful conditions
  - Have back-up plans for communications needs; manually alter systems
    - Not always possible. Ex: SFN. LTE.
- Anticipatory
  - Observe systems degrading over time; use a-priori knowledge available
    - Minimize self-interference and catch new sources early
  - Cooperatively detect interference
    - Many technical papers discuss the advantages of and gains associated with cooperative sensing.
  - Plan alternatives in advance; proactive back-ups. Ex: Unlinked NB systems.
    - Anticipate solutions; have solutions at the ready at all times. Automate.
  - Active anti-interference / anti-jamming measures
    - An area where research and development investment needs to be made
  - (Demo of active avoidance system – audio clip)

 75 Second Audio Demo

 Short A/B Demo

In Conclusion….

- Interference is as old as radio itself
- Interference, even at low levels, is generally adversarial towards communications systems but is increasing in prevalence every day.
- Spectrally efficient systems , in general, have increased vulnerability towards service denial – especially directed attacks.
  - We are rapidly moving from individualized, licensed allocations to single frequency per entity deployments. A-priori information handed to the bad players.
- Often times, the cost of building robust systems is difficult to justify; therefore,
  - Research into interference detection, avoidance and suppression will continue to grow in importance.
  - We must become anticipatory, vs. reactionary, in how we deal with interference and jamming.
- WInnForum Top 10 Innovations List…
  - **Innovation #8**: Interference Mitigation Techniques – all through:

- Driving towards kTB and increasing dynamic range of sensors, identifying waveforms and sources, rethinking how we define interference, make the data easier to visualize, and further developing techniques to mitigate interference. Creatively, yet economically build a sensing network using existing infrastructure when possible.