The Engineering Behind 800 MHz Interference

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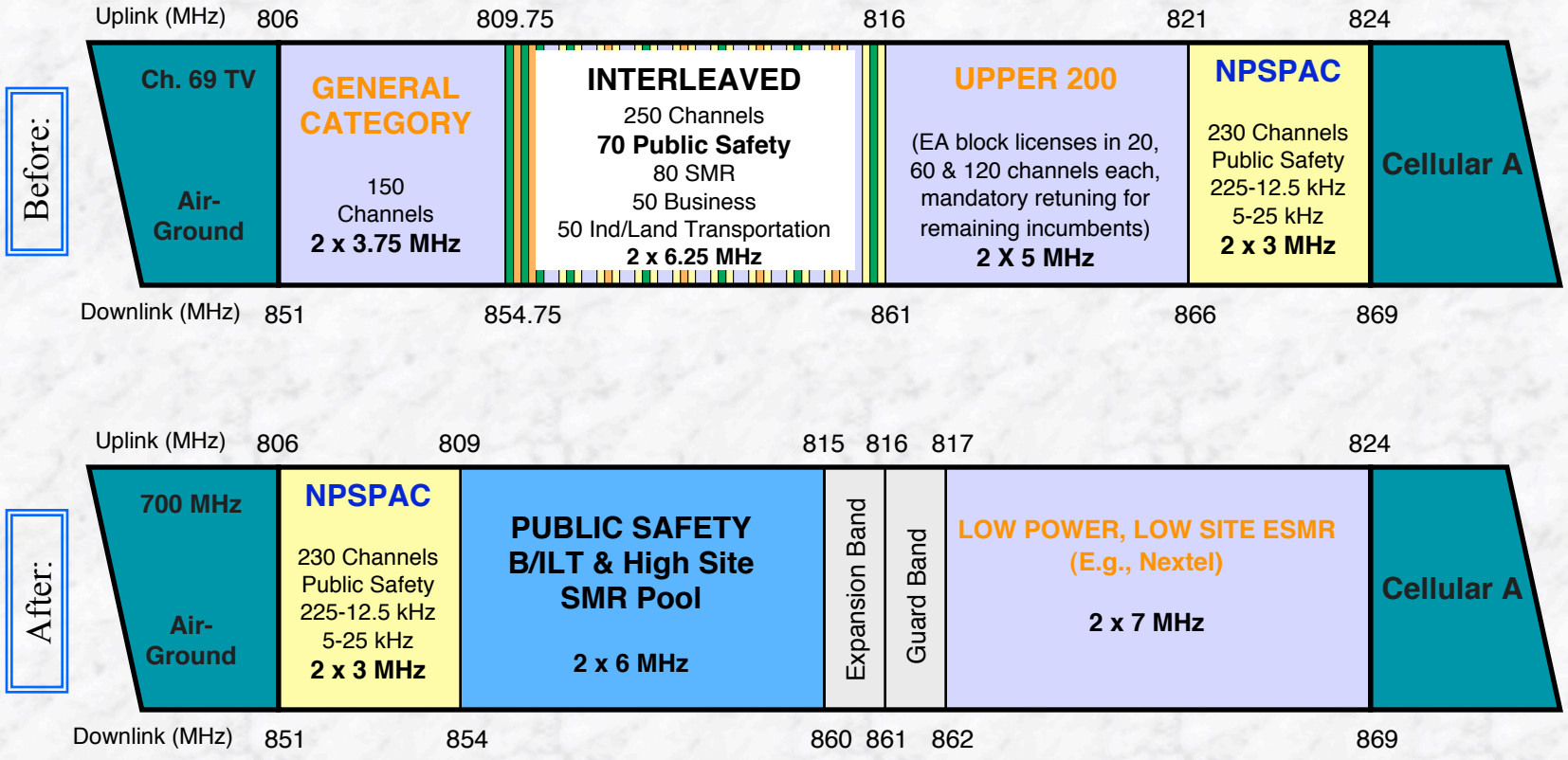
Spectrum Map



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The Near-Far Problem

- Weak public safety signal from distant tower site cannot overcome strong signals from nearby cell site
- Notwithstanding the cell site fully complies with FCC emission rules
- Problem is usually in the public safety receiver, caused indirectly by the cellular operator

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Sources of Interference

- **ESMR operator, 862-869 MHz band**
  - Primarily Sprint Nextel
  - Originally iDEN, but iDEN shut down June 30, 2013
  - Being replaced by CDMA and LTE (by mid-2014)

- **Cellular A operator, 869-880, 890-891.5 MHz**
  - Usually AT&T Mobility or Verizon Wireless in urban areas
  - AT&T primarily employs GSM (200 kHz), UMTS (5 MHz)
  - Verizon primarily employs CDMA, EV-DO (1.25 MHz)
  - Both operators building LTE in 700 MHz band
  - Forward link power control makes problem intermittent

- **Cellular B operator, 880-890, 891.5-894 MHz**
  - To a much lesser extent, practically non-existent

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Types of Interference

- **Out-of-Band Emissions**
  - Generated at Nextel or A-Band operator cell site
  - Falls in the RF and IF passband of receiver
- **Receiver Intermodulation**
  - Non-linear mixing of external carriers in receiver front end
  - Interference is created inside the receiver
  - Can be operator-only mixes or Sprint Nextel/A/B cross products
- **Receiver Overload**
  - Only one frequency required to cause problem
- **OOBE Tends Not to be the Problem**
  - Filtering at base station is effective post-rebanding

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Protection Criteria (FCC 90.672)*

- **Minimum Median Signal Level at Location**
  - Mobile -104 dBm
  - Portable -101 dBm
- **Minimum Sensitivity**
  - Mobile or Portable, -116 dBm
- **Minimum Adjacent Channel Rejection**
  - Assumed to be analog, measured per TIA-603-D
  - Mobile 75 dB
  - Portable 70 dB
- **Minimum IM Rejection**
  - Assumed to be analog, two-tone, measured per TIA-603-D
  - Mobile 75 dB
  - Portable 70 dB

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*Also Part 22.970.

Shortfalls of Existing Standards

- **And TIA-603-D tests do not tell whole story**
  - Maximum interferer level during test is -48 dBm (for portable with -118 dBm sensitivity and 70 dB ACR)
  - Interferers are often at -10 dBm on the street
- **Other tests are needed to characterize radio**
  - Strong signal IM rejection
  - Overload rejection, Image rejection
- **Are broadband cellular signals different?**
  - Yes, but overall peak power and IM power are most important.
  - For same ERP, broadband has lower power density which helps the problem with regard to RX IM.
  - High peak-to-average ratio: receiver will respond to the peak power in the signal, so interference specs should be referenced to and tested with peak power.

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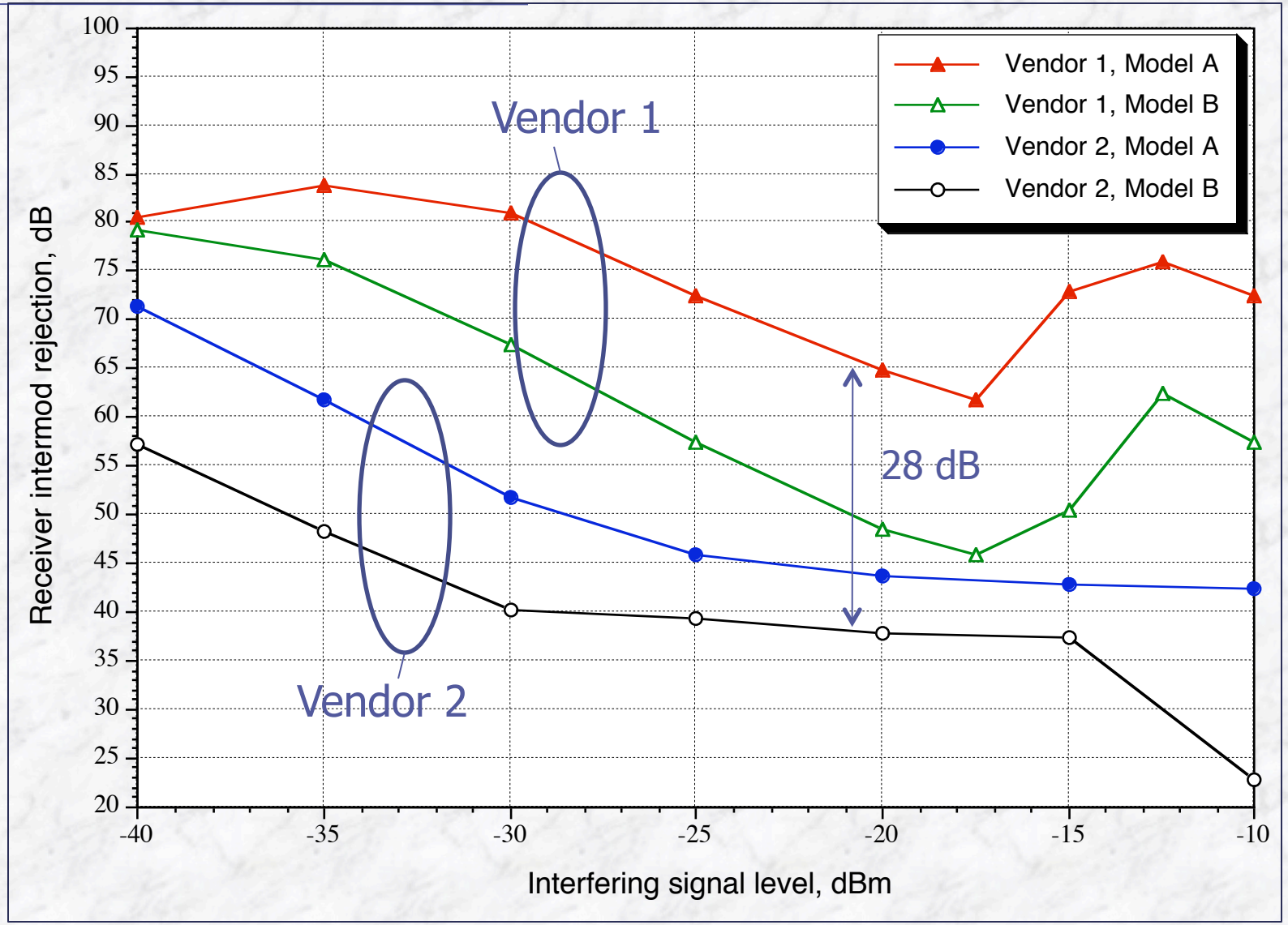
Strong Signal IM Examples



Mitigation Techniques

- **Work with Cellular Operator(s)**
  - Identify the offending site
  - Perform on/off testing to isolate problem
  - Be aware it may be Sprint Nextel *and* A band operator

- **Possible Short Term Solutions**
  - Retune for IM (hard to do with broadband signals)
  - Reduce output power (works, but operator will object)
  - Move antennas away from roof edge
  - Replace cell site antennas with no-null fill type
  - Change beamtilt of cell site antennas (mixed results)
  - Install bandpass filters on mobiles (easy, but not free)
  - Insert bandpass filter in portable antenna radome (problematic)
  - Replace public safety radios with better performers

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Is This a Widespread Problem?

- **Must Be**
  - Nothing unique about Oakland or Charleston County
- **Characteristics of Problem Cities**
  - Urban area with low cellular antenna heights
  - Public safety signal adequate, but not super strong (< -60 dBm)
  - Modern, but perhaps not best performing public safety radios
- **Given the limitations of typical public safety radios and the strong interfering signals on the street, we expect this to be a widespread problem.**

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Long Term – Better RX Stds.

- **The main problem is the portable bandpass filter**
  - Until recently it had to pass 851-869 MHz
  - Practical filters typically pass 845-875 MHz
  - Little motivation to unilaterally change filters due to added cost and logistics of managing a US-only product line (and lingering issues in border regions).

- **Need a 851-861 MHz filter for public safety band**
  - Should it be mandated like Part 90.672?
  - If so, what is the transition period?
  - Filter is not foolproof and poorly designed receivers might still see problems. Should minimum strong signal IM performance also be specified in Part 90.672?

- **Part of a bigger FCC initiative**
  - See ET Docket 13-101

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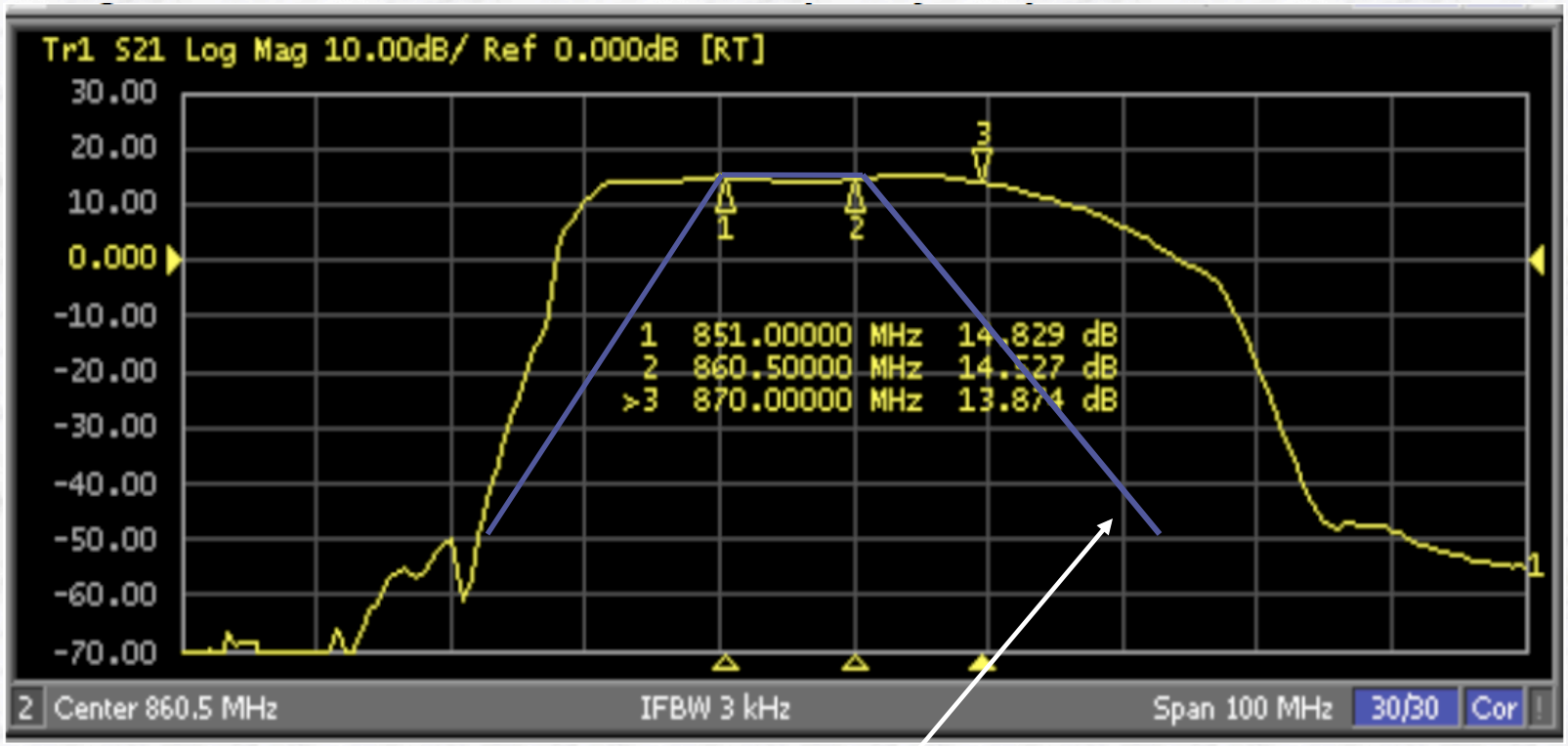
Typical Portable Band Pass Filter



Desired Post-Reband Filter
850-860 MHz

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Conclusions

- **Rebanding alone does not solve whole problem**
  - Bandpass filters and/or better receivers are needed now
- **Sprint Nextel conversion to LTE is a problem**
  - Broadband, high peak-to-average signal
  - Cell site “tuning” no longer possible for RX IM
  - Mitigated by lower power density for RX IM
- **Receiver performance varies dramatically**
  - Between models of the same vendor
  - Between different vendors
- **RFP requirements not adequate**
  - Strong signal IM performance is not specified or required in RFPs, but should be

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