Public Safety 800MHz Interference

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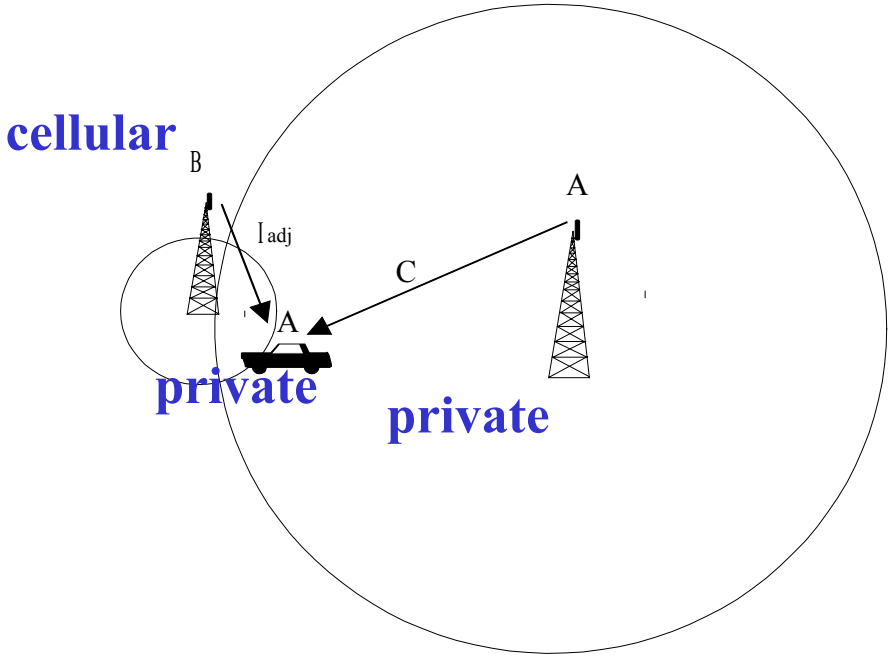
Agenda

- Summarize Factors that Contribute to Interference
- Viability of Adding “Fill-In” Sites
- Public Safety Receivers

Near - Far Scenario is a major cause of interference

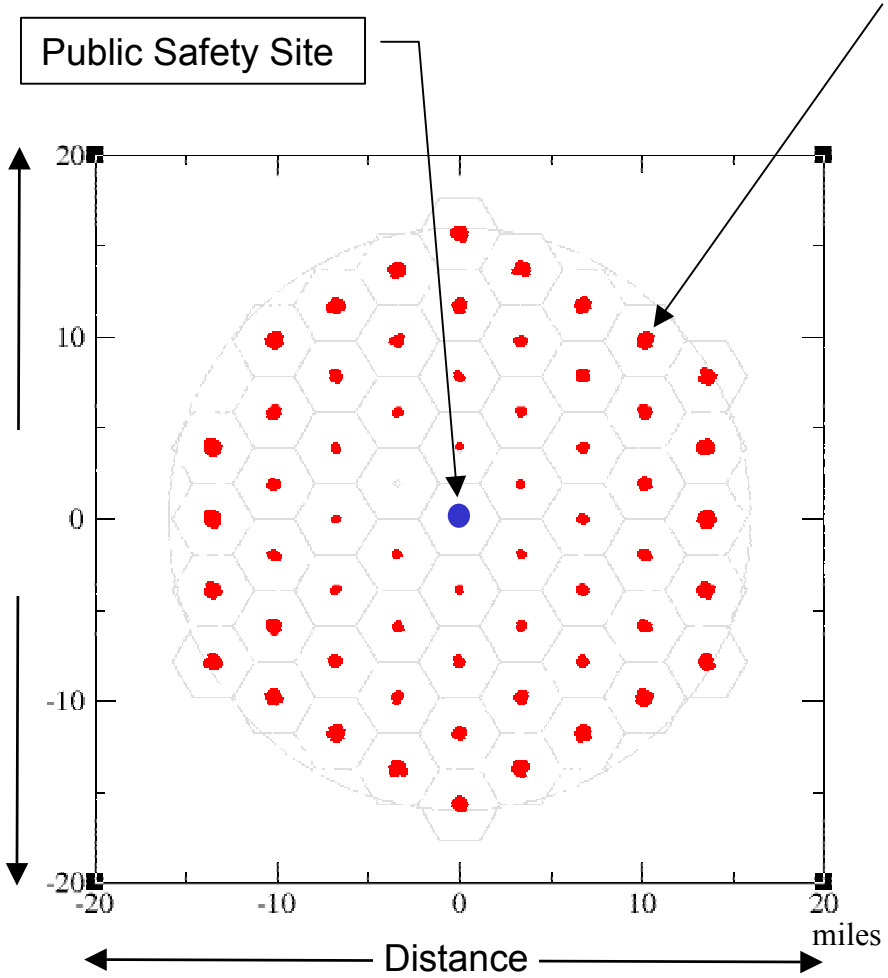
- **Cellular Type Systems can cause Interference with private systems**
  - **Classic Near-Far Problem**
    - **Interference Zone around Multi-transmitter Sites**
    - **Strong Interference Signal and Medium to Weak Desired Signal**



- **Average Power kept high to provide portable in-building coverage**

Private unit **far** from desired private site is interfered with when close (**near**) to nearby undesired cellular channel base.

Base to Mobile Interference Pattern

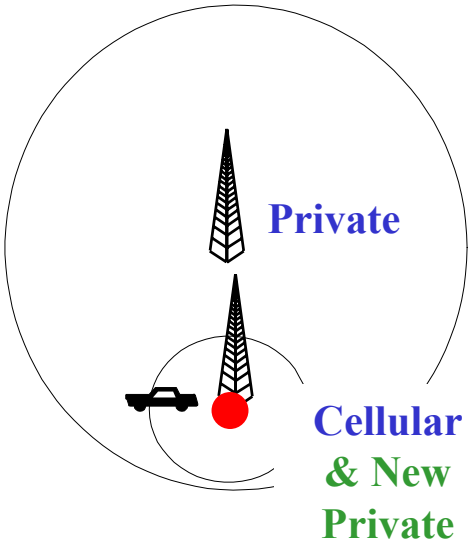


- **"Red"** spots are potential interference areas
  - Occur near cell base station sites
  - Found across service area
  - Interference area grows with distance from PS Site
- Primary interference is Intermodulation (IM) in the PS receiver
- IM can occur when frequencies are uncoordinated between PS and Cellular Type Systems
- To increase Capacity Cellular Type Systems need to make Frequent Changes to Frequency Plan

Best Practice Guide - Summary

- Retune CMRS Channels
  - Away from the Public Safety Operator's Channels
- Modify CMRS Power Levels - Reduce "ERP"
  - Antenna Height
  - Antenna Characteristics
- Assure Proper Operation of Base Equipment
  - Both CMRS and Public Safety
- Improve the Local Signal Strength of Public Safety System
  - Increasing "ERP"
  - Adding more proximate Public Safety Sites

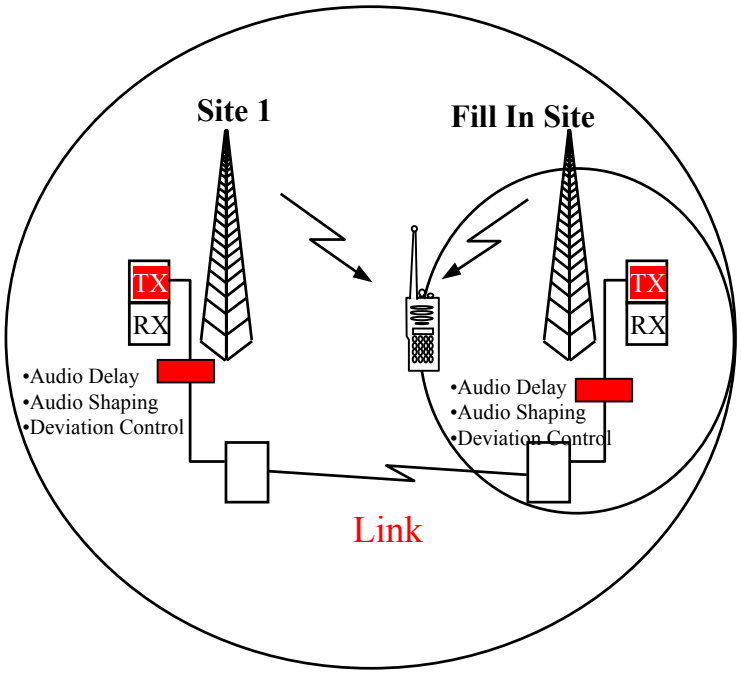
Increasing Desired Signal - Adding a "Fill-in" Site



Consequences of Adding a "Fill-in" Site

- Single Site Systems become Multi-site Systems
  - New sites must be leased, zoned and permitted
- Most Systems become Simulcast Systems
  - New site requires full set of frequencies
  - Limited number of frequencies translates into a need to simulcast
- Delivers more desired signal to small area
  - More immune to interference but does not eliminate
    - –Just get 1 dB of improvement for every 1 dB of more desired signal (C/I)
- Additional On-going expense - Link costs, maintenance, etc.

Simulcast - More than timing

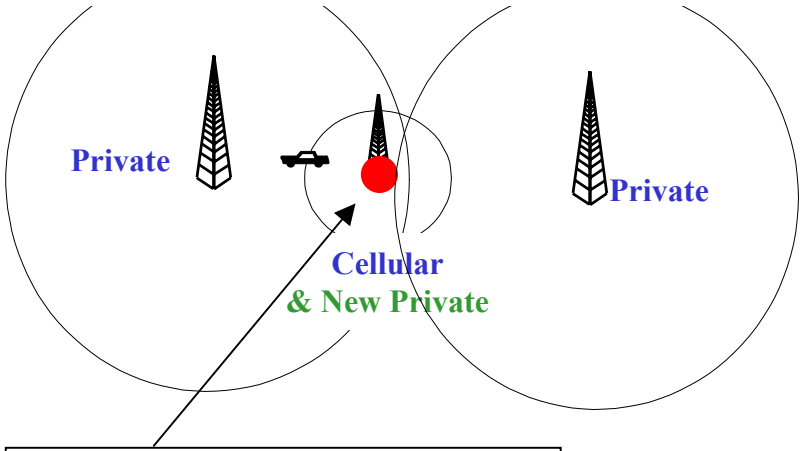


- Simulcast audio must be the same
  - Levels controlled to tight tolerance
  - Across the frequency response
  - T1 or Microwave link
- Deviations of transmitters must be the same
  - Deviation controlled to tight tolerance
- Carrier Frequencies must be the same
- Sites must transmit at the same time
  - Delay equalization at all sites
- System designs have evolved to solve simulcast problems
  - Motorola is on 5th generation Simulcast design
- Higher Maintenance Costs

Simulcast Systems are complex and high maintenance

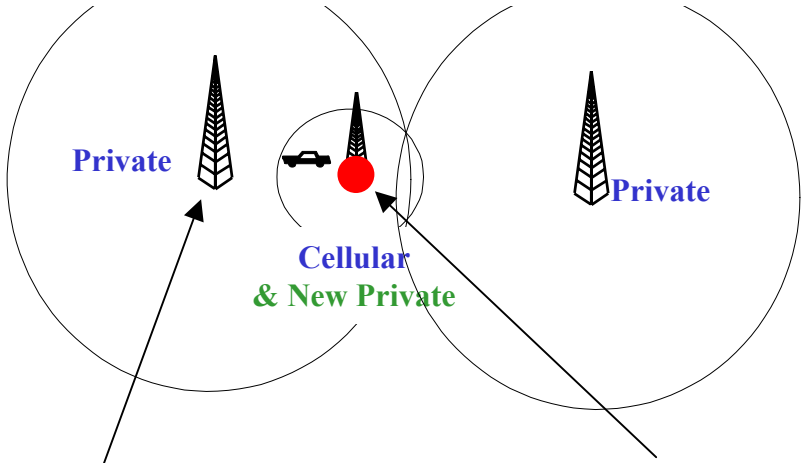
System Changes

Existing PS Simulcast System



Add new site:
- Add site
- Add base stations
- Add simulcast site controller
- Add backhaul
  - T1 or Microwave

Existing PS Non - Simulcast System

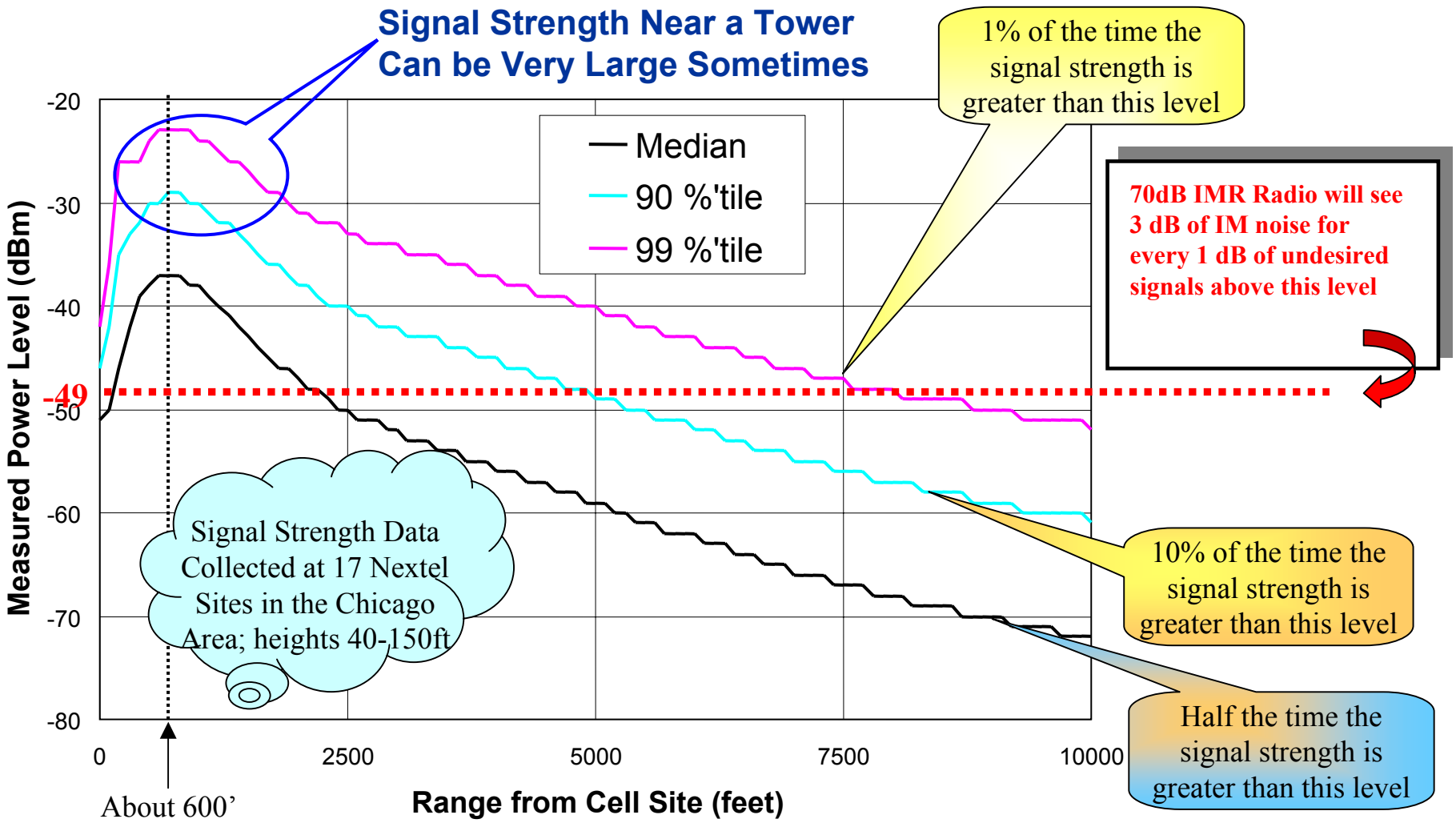


Upgrade Existing Sites:
- Add High Stability Osc
- Add Audio Delay
- Shaping / Deviation Ctrl
- Add simulcast controller
- May require new basestations and controllers

Add new site:
- Add site
- Add base stations
- Add simulcast site controller
- Add backhaul
  - T1 or Microwave

New Site and Existing Site Equipment Vintage Must Match

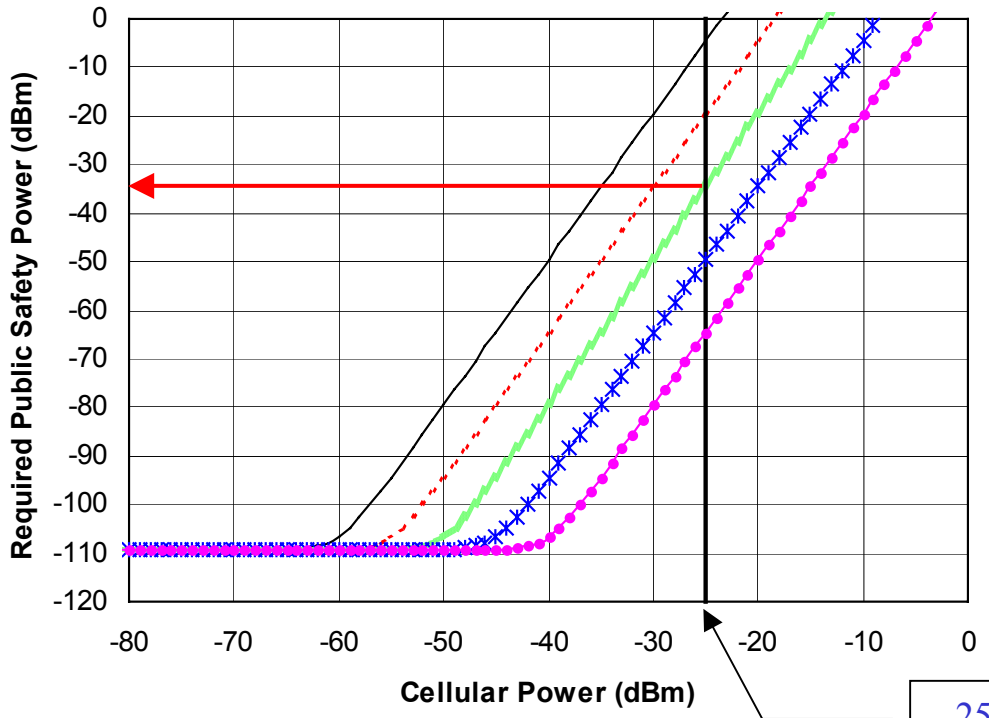
Interference will be Close to Small Cell Tower



-49 dBm = -119 dBm (12 dB SINAD) + 70dB (IMR)

Transmit Power for Simulcast Fill-in Site

Fill-in Site needs to TX at -35dBm



Assumes
70dB IMR Radio
DAQ 3.0 Audio Quality

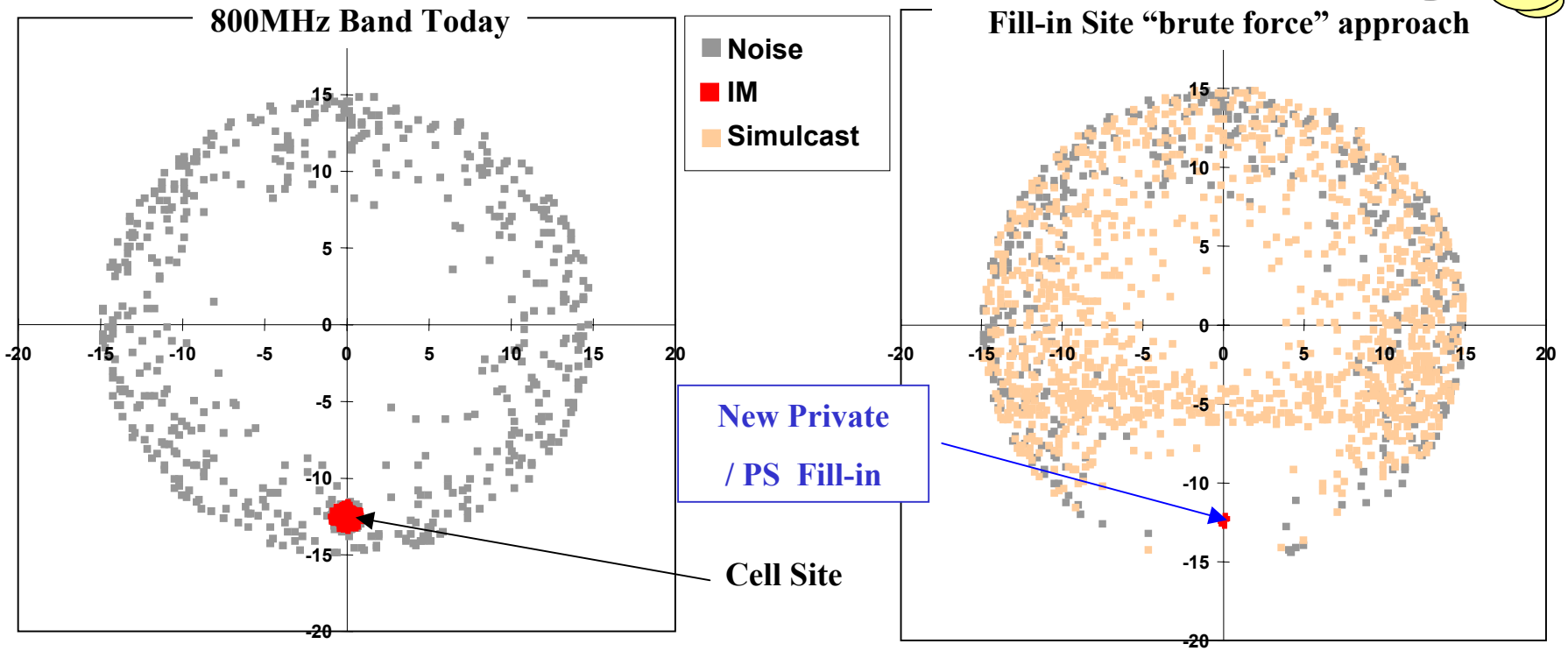
-25dBm observed near Cell Sites *

Fill-in TX Power only 10dB below Cell transmit power

* Based on measurements of 19 Chicago area Nextel sites in Feb 1999

Simulcast Fill In Site

Note: Special simulcast design to improve interference versus typical simulcast system



70 dB IMR - no fill-in site or RF attenuator.

Note: P-25 Modulation

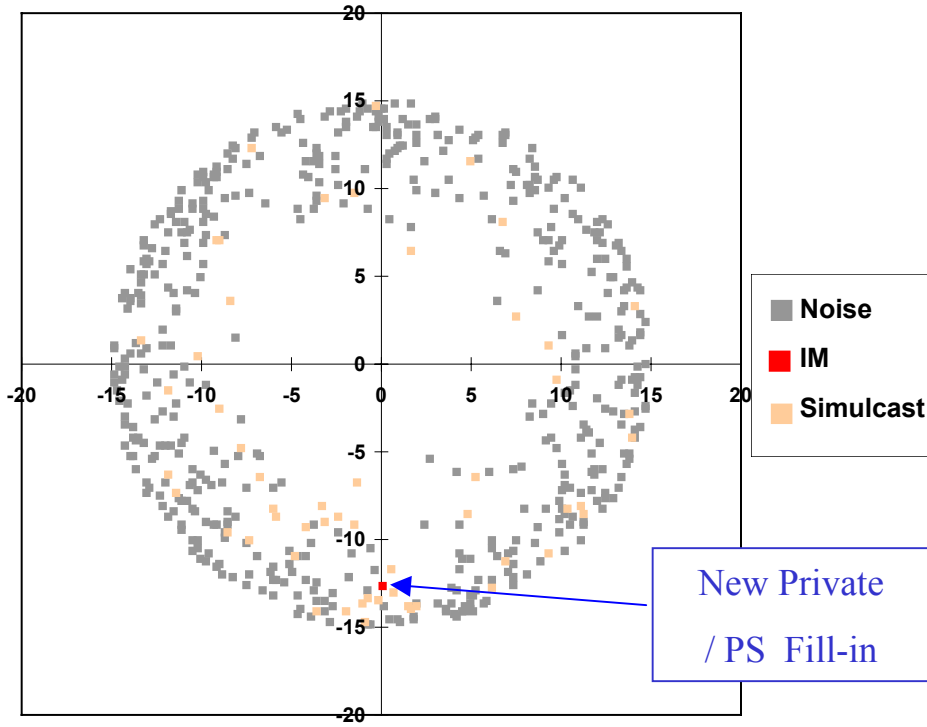
70 dB IMR radio; fill-in site power is –10 dB with respect to the cellular TX power; no RF attenuator,

Launch time adjusted to minimize simulcast outage

IM Outage Reduced but Simulcast Outage Over Entire Coverage Area

Simulcast Fill-In Site with PS Receiver F/E Switchable Attenuator

- Fill-in site power must be lowered 30dB to reduce simulcast outages
  - At the cost of increased IM outage
- F/E Switchable Attenuator in PS Receiver added to reduce IM outages
- Some Simulcast outages still present over entire coverage area
- Simulcast outages will increase as fill-in sites are added



Fill-in transmitter power is –40 dB relative to cellular transmitter power; 22.5 dB of attenuation was inserted when the RSSI reached –80 dBm.

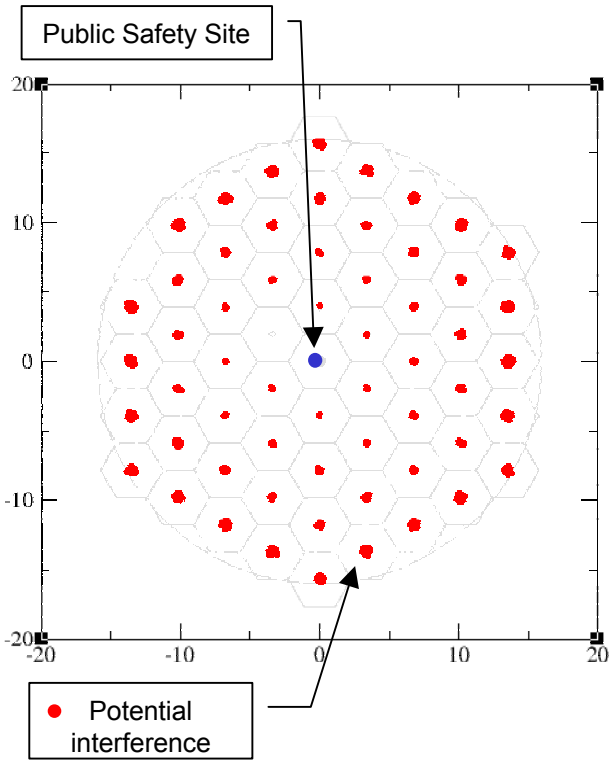
New PS Radios with F/E Switchable Attenuators are required with Fill-in Site

Receiver F/E Switchable Attenuator

- Add Switchable Attenuator in front of pre-selector
  - Activation decision is a function of signal level
  - Issue with complex features like scan
- Must overcome significant problems to make viable
  - Mission Critical Performance
    - Can't Miss a Call….risk of attenuating at wrong time
  - Adds Complexity and Uncertainty to Feature Interaction
    - Scan, Fading, System Handover, Trunking
    - Attenuator Hysteresis
- Cannot retrofit into existing radios - need new designs
- Noise Limited System Design….attenuator can't be turned on at low desired signals at the fringe of large public safety systems!

Switchable Attenuators have problems to overcome and do not resolve IM in weak signal conditions

Fill-in Sites...



Are Reactive

- Require a lot of effort and time
- Adds System Cost & Complexity for small coverage area

Improve Only One Interference Spot

- Need may disappear if Cellular Type System Frequency Plan Changes

Do not prevent Interference elsewhere in system

- Potential interference across entire PS Service Area
- Cellular Type Systems need to make frequent changes to Frequency Plan to increase capacity

Require new PS Radios with F/E Switchable attenuators

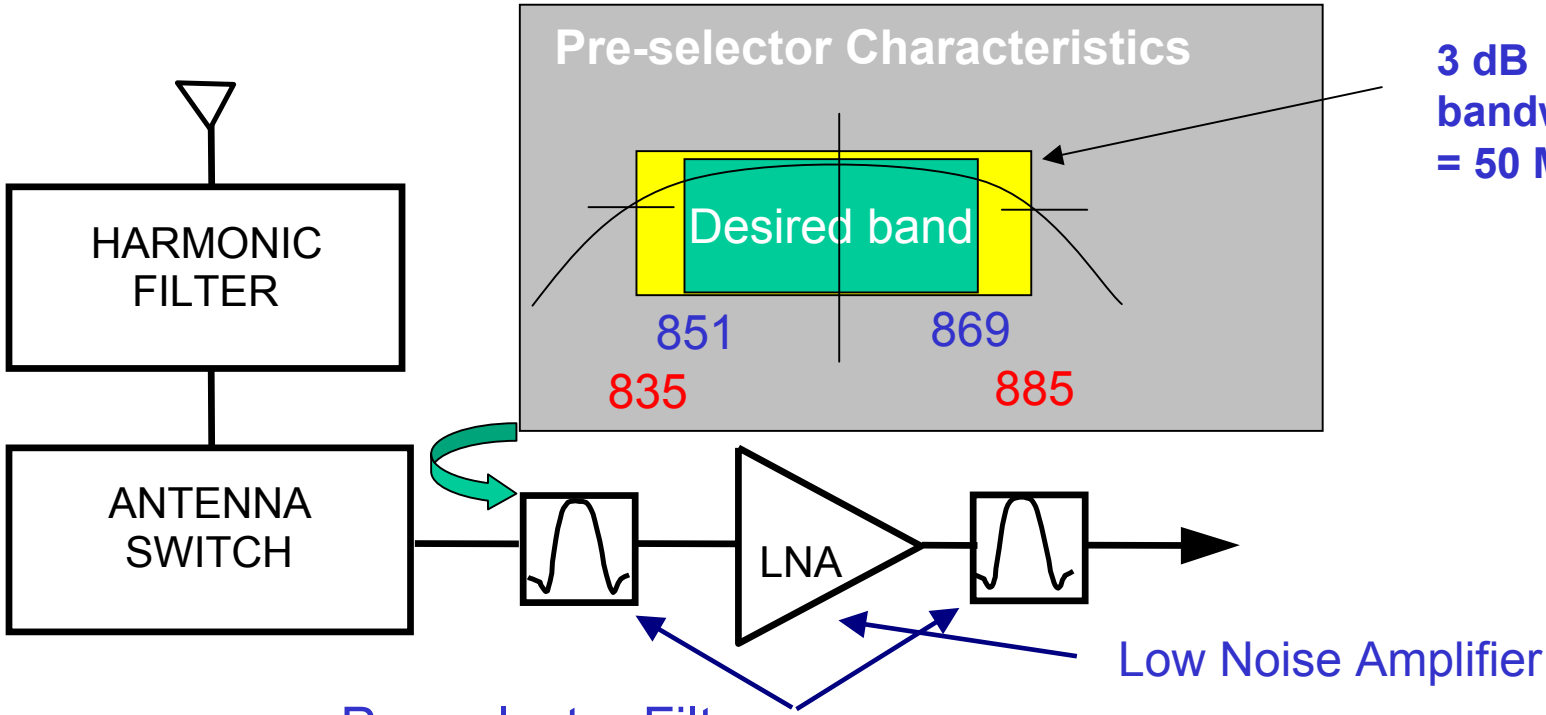
Fill-in Sites are not a solution for IM Interference

Fill-in Sites Summarization

- Requires New PS Radios with Switchable F/E Attenuator
  - Technical challenges remain
- Adds costs otherwise not required
  - Adds a new site to system design
  - Most systems will need new equipment at the primary site
  - Older systems may not be upgradeable to simulcast
  - Operating costs increase
- Simulcast outages will be present over whole coverage area
- Doesn't prevent IM interference outages at a different point in the System
- Do not prevent Interference elsewhere in system
  - Cellular Type Systems need to make frequent changes to Frequency Plan to increase capacity
- Adds significant system design complexity and maintenance cost

Fill-in sites are reactive, take time and effort, adding cost otherwise not required

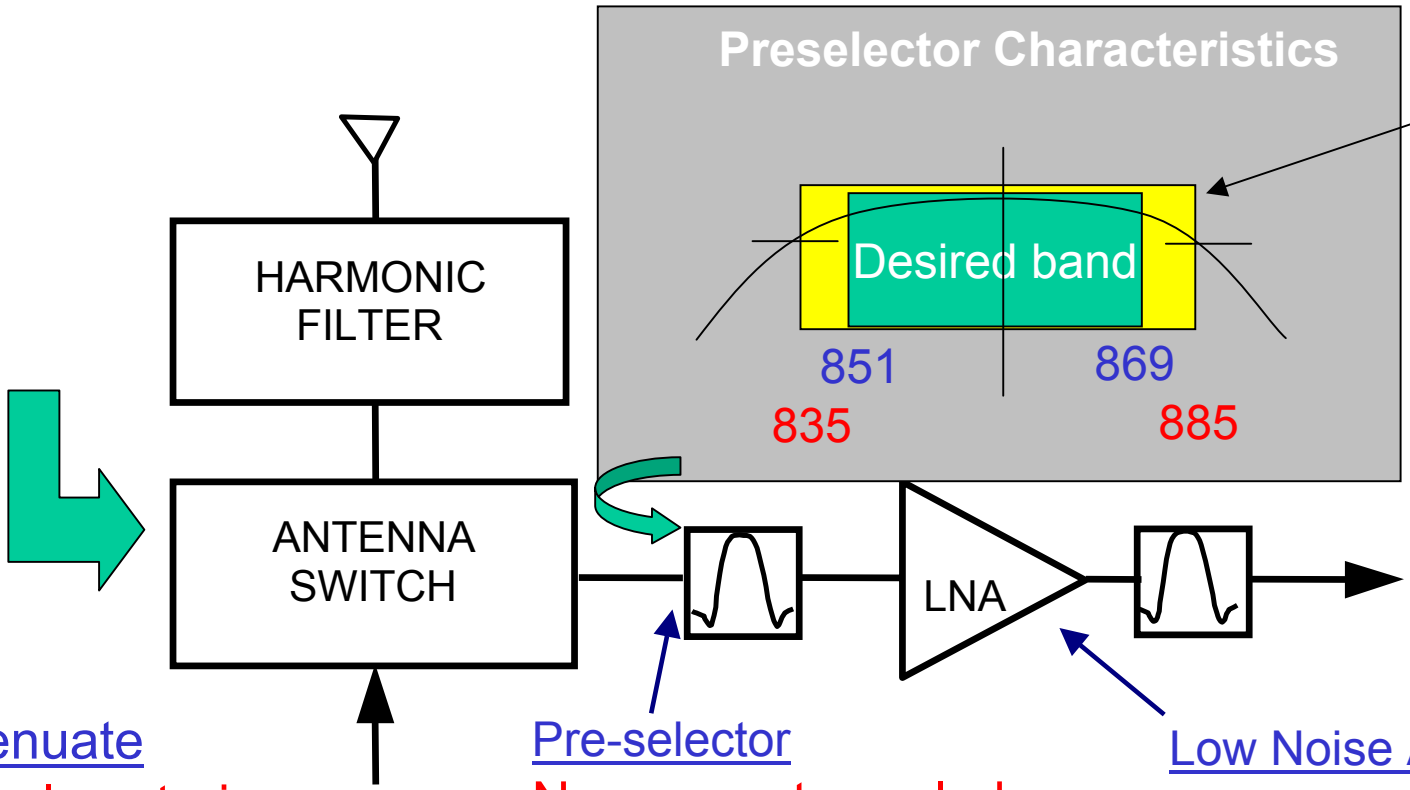
Receiver Front-End Functions



Pre-selector Filters:

- Protects receiver from Image Spurs
- Pass Band flat over desired band
  - Margin for temperature, mfg variance
- Poles (roll off)
  - Minimize Insertion Loss
  - Roll off fast enough to meet Receiver Spur Spec (Image)
- Portable designs restrict size

Potential Receiver Mitigation



Attenuate
signals entering receiver…but affects desired signal

Pre-selector
Narrow up to exclude undesired signals….but, adds insertion loss

Low Noise Amplifier
Improve IM performance....but increases current drain reducing battery life

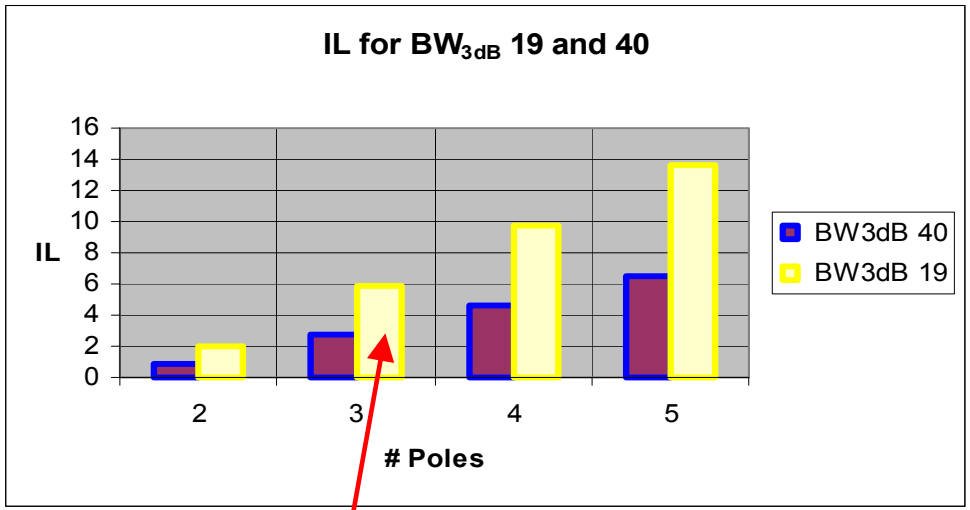
Pre-selector Filtering is not an IM Solution

Current Filtering Designs

Band (MHz)	Application	Size (mils)	Type		# of Poles	Passband Bandwidth	3 dB Bandwidth	Insertion Loss
935-941	Portables	440x415x80	Stripline	Fixed	3	6 MHz	40 MHz	2.1 dB
851-870	Portables	440x415x80	Stripline	Fixed	3	19 MHz	50 Mhz	2.5 dB
851-869	Portables	220x220x110	Ceramic	Varactor Tuned	3	19 MHz	60 MHz	2.0 dB
935-941	Mobiles	3000x500x500	Block	Fixed	6	6 MHz	50 MHz	
851-869	Mobiles	768x354x234	Block	Fixed	3	19 MHz	36 MHz	1.5 dB

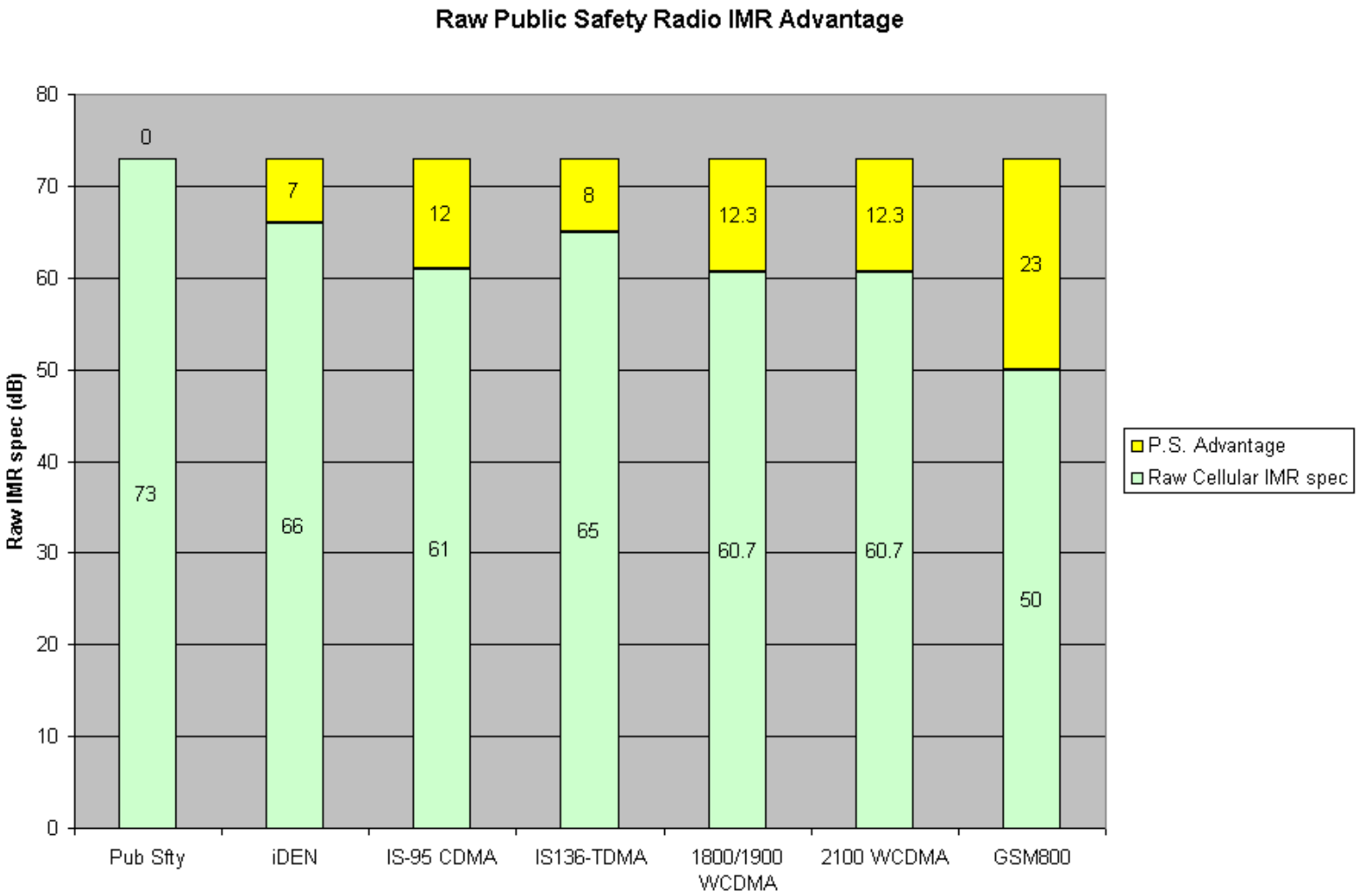
Pre-selector Filter

- –3dB corner extends >15MHz beyond passband
- –Adding poles adds loss
- ⇨Pre-selector will not provide protection from adjacent operations

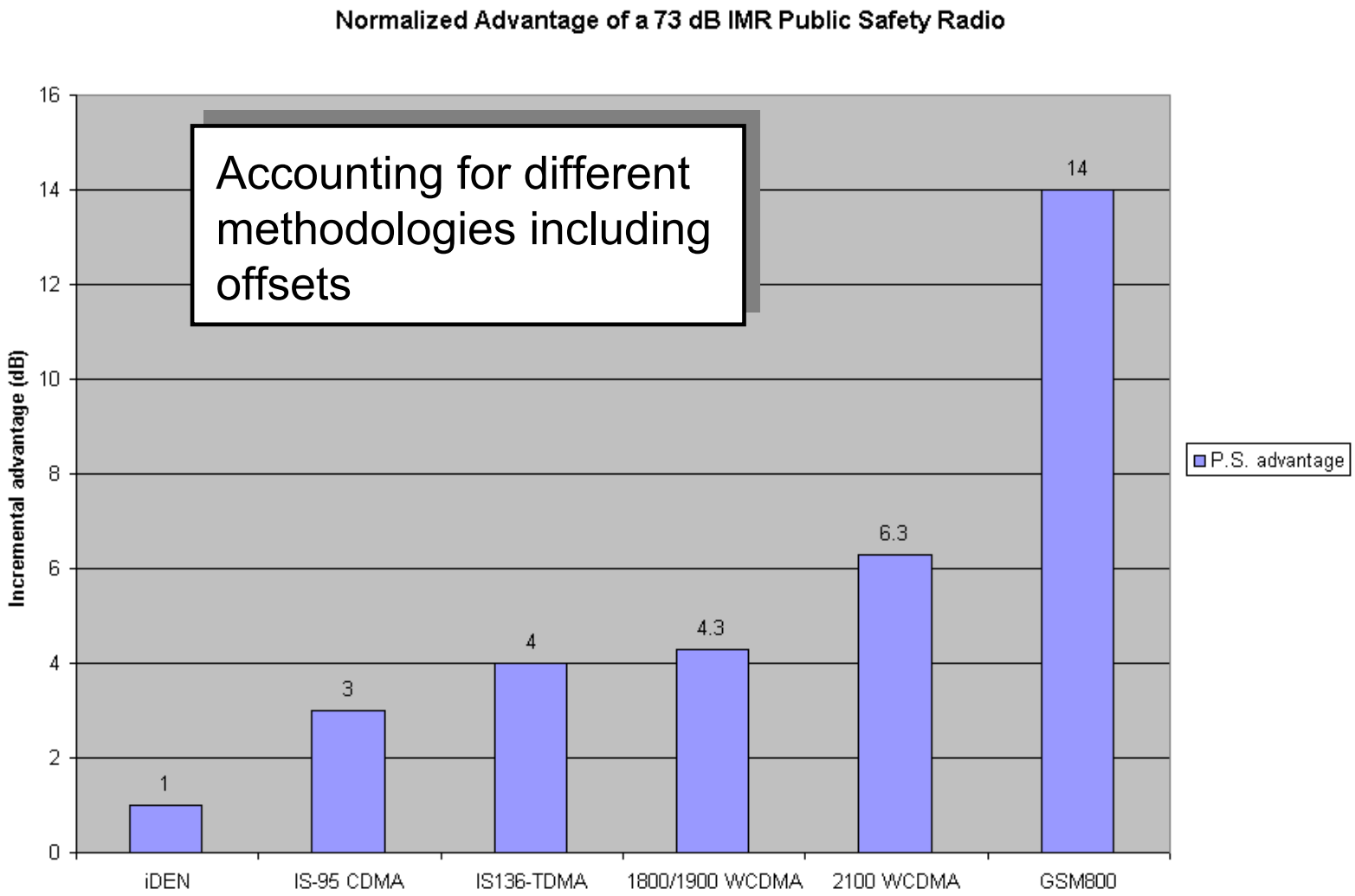


Narrower filters add loss, reducing range

Low Noise Amp: Public Safety Radios Today are Already World Class Receivers …on a raw spec basis



Low Noise Amp: Public Safety Radios Today are Already World Class Receivers…on a normalized basis as well



Improving Receiver IM

- Radios have improved IM performance 10-15dB during last 15 years
- Latest private radios have better IM performance (e.g. 70-75 dB typical)
- Improving IM spec, with current generation technology, requires substantially more current drain
  - Standby current drain for 80 dB IMR doubles….cutting standby time in half….chopping hours off battery life, below one shift…and the highest energy density batteries don't work in the cold as required by public safety
  - Customer access time requirement eliminates opportunity for radio to sleep
- Public safety customers demand a battery that will go one shift and have fast access time too

Public Safety IM performance is state of the art, given Customer Requirements

Interference Summary

- Increased signal strength overcomes interference in some situations but adds significant costs not otherwise required
- Public Safety Receivers are already state of art, future innovations may provide incremental improvements
  - Impractical to retrofit existing portables/mobiles

There is no single solution ... A Combination of Steps are Required to Mitigate IM Interference

- Rebanding helps to provide mitigation opportunities
- Frequency Planning and Best Practices Techniques are imperative to impact issue--even after band reorganization
- Motorola supports FCC adoption of TIA Class A receiver specifications
- Motorola recommends that FCC discuss viability of increasing service area contour limit to 50dBμ with frequency coordinators