Public Safety 800MHz Interference

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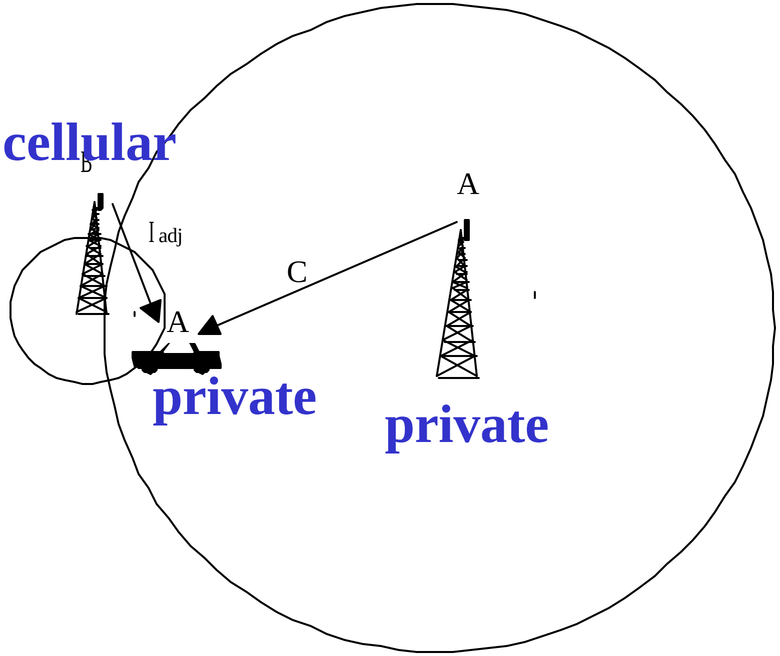
Agenda

- Summarize Factors that Contribute to Interference
- Viability of Adding Repeaters
- Receiver Design

Near - Far Scenario is a major cause of interference

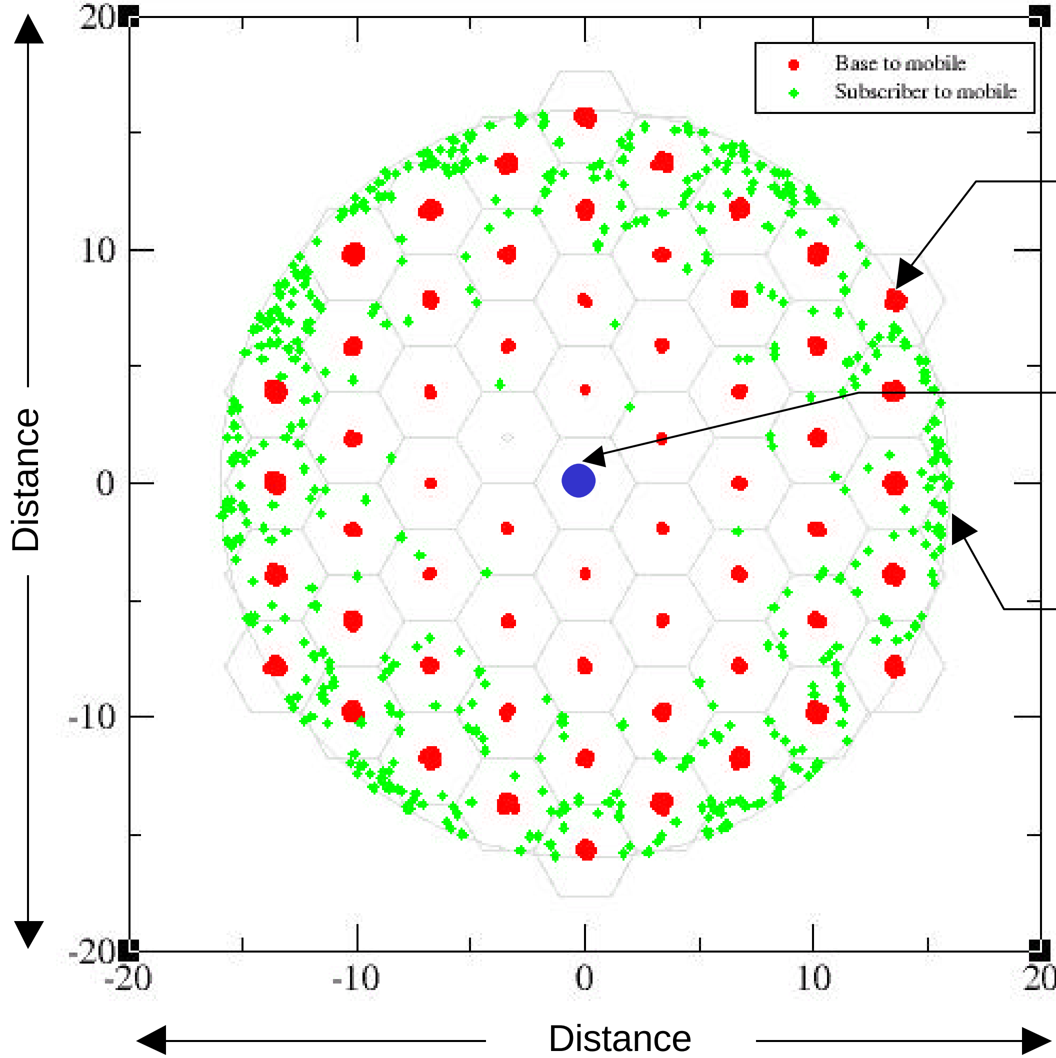
- **Cellular Type Systems can cause Interference with private systems**
  - **Classic Near-Far Problem**
    - **Interference Zone around Multi-transmitter Sites**
    - **Strong Interference Signal and Medium to Weak Desired Signal**
  - **Frequent Changes to Frequency Plan to increase Capacity**
  - **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 & Mobile to Mobile Interference Pattern

When freqs uncoordinated



miles

"Red" spots are interference areas near base station sites

Public Safety Site

"Green" areas are cellular subscriber to LMR subscriber interference at the fringe of the cell when subscriber power control is minimal)

Intermodulation Interference Mitigation

- Reduce Undesired Signal Level
  - 1dB reduction of undesired gives 3dB improvement in C/(I+N)
- Increase Desired Signal Level
  - 1dB increase of desired gives 1dB improvement in C/(I+N)
- Frequency Planning
  - Coordination to minimize possibility of IM hits

Repeaters Sites

- Sites are Driven by Customer Requirements

- Designing System for Robust Portable In-building Coverage
  - Delivers more desired signal
  - Additional dB Required Versus Portable On-street
    - Light Building: + 6dB
    - Medium Building: + 10-15dB
    - High Rise: + 20dB

- Impact of Increasing Number of Sites
  - Additional expense - Land acquisition, capital, link costs, maintenance, etc.
  - Additional Frequencies may be required merely to overcome interference
  - Simulcast can offset need for more frequencies but at additional cost

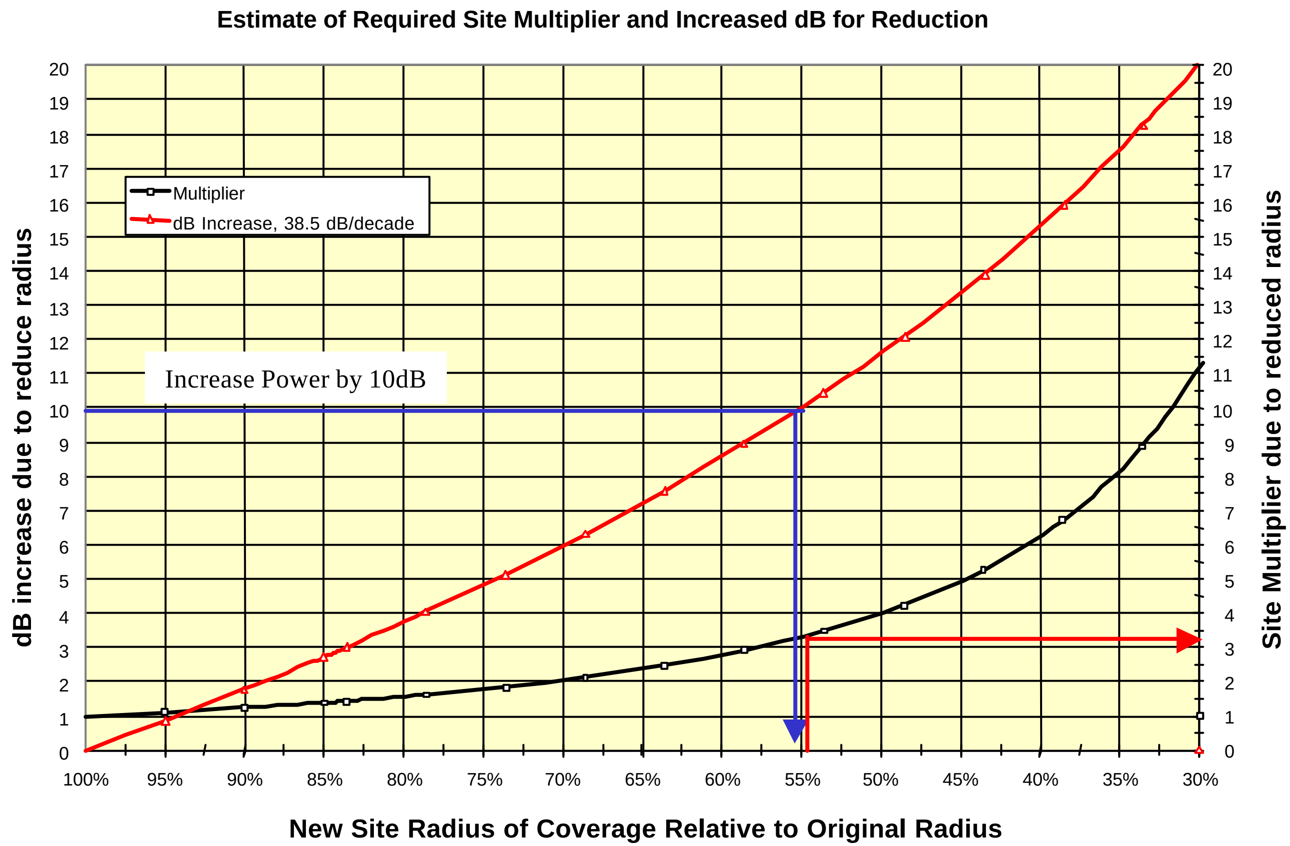
Additional Site Multiplier

Example: Portable on-street to in-building (medium density)

Assume:
10 Site System

New
3.3 X 10 = 33 Sites

33 Sites - 10 Original =
23 Additional Sites



Viability of Additional Repeater Sites

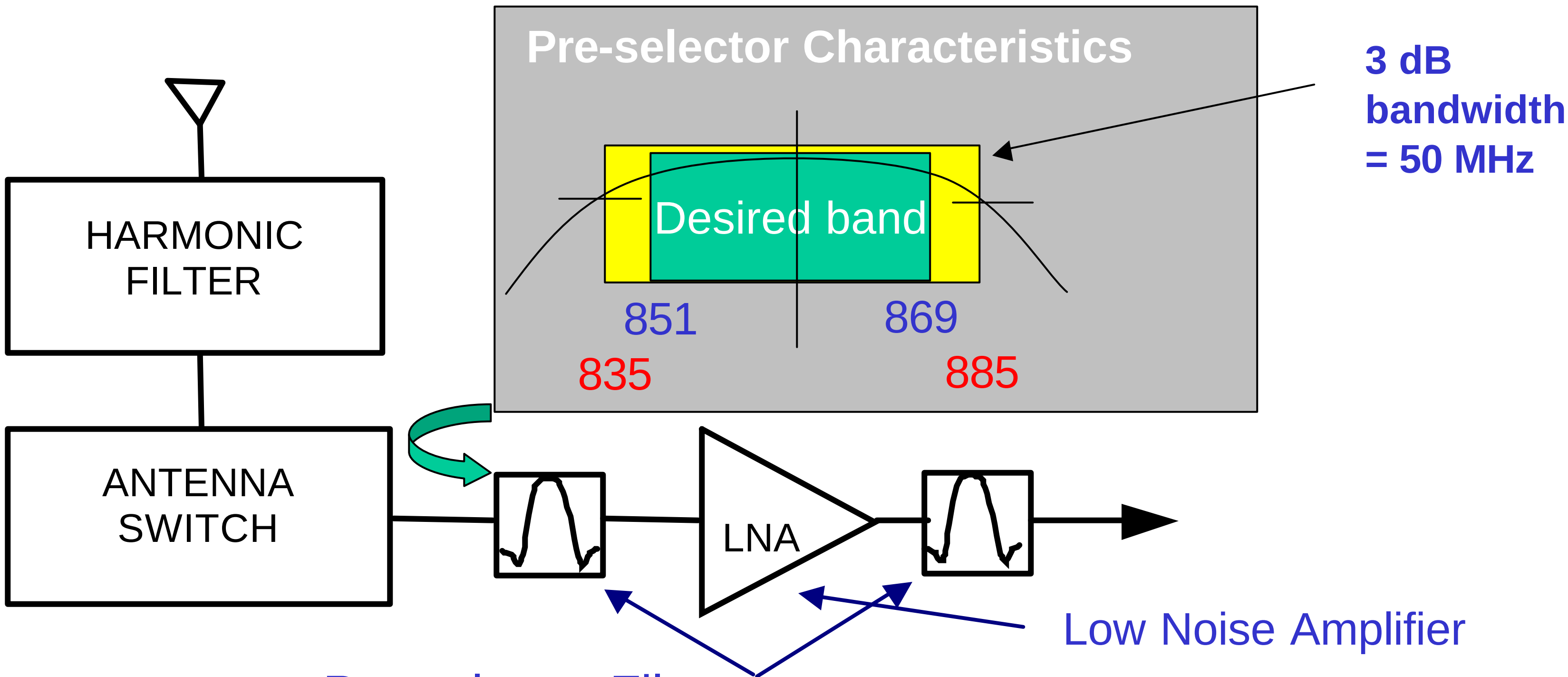
- Economics Drive System Design
  - Number of Sites Increases Significantly
    - Additional expense - Land acquisition, capital, link costs, maintenance, etc.
  - Number of Available Frequencies may limit number of sites

- Delivers more desired signal….more immune to interference
  - BUT just get 1 dB of improvement for every 1 dB of more desired signal (C/I)
  - Challenge to not exceed FCC rule of maximum -94dBm at edge of service area (the 40dBµ rule)
  - Frequency coordination challenge in some cases

- Delivers more desired signal....enables receiver innovations
  - Additional signal strength provides margin to add switchable attenuator
  - Cannot retrofit into existing radios - need new designs

Additional Sites are not always economical and not sufficient...
but allows switchable attenuators

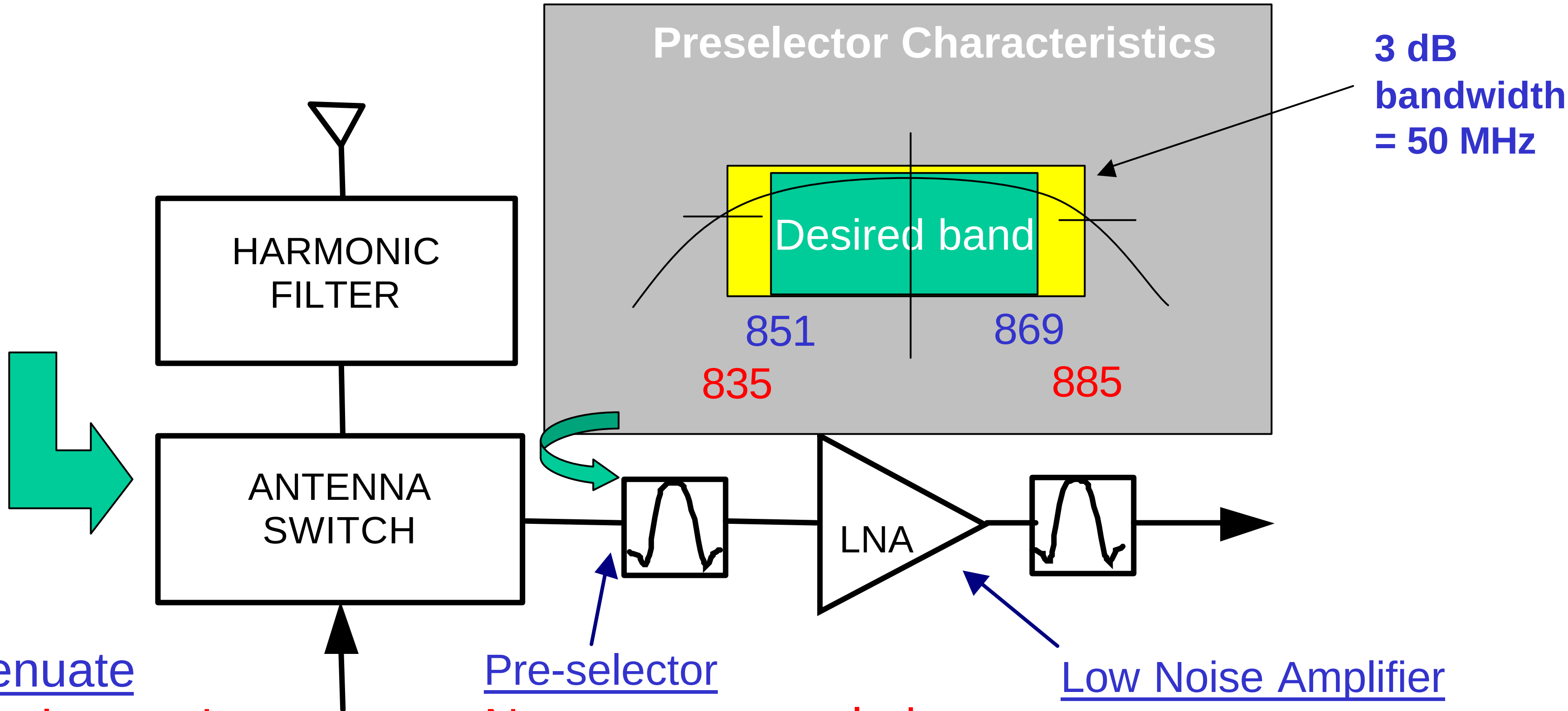
Receiver Front-End Functions



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

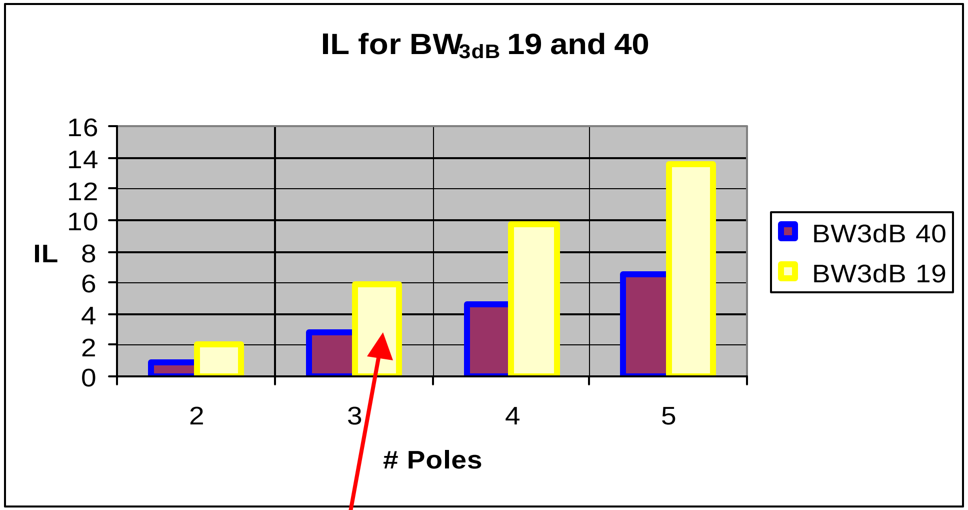
Pre-selector Filtering is not an IM Solution

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 too much loss
- ⇨Pre-selector will not provide protection from adjacent operations



Too much loss, even with band change

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….doesn't work for low desired signal possible in large cell public safety system!

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

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