Impact of 800 MHz Rebanding upon

In–Building

Wireless Distribution Systems

Introduction:

The FCC has ruled the 800 MHz private radio band shared by public safety, industrial users and Sprint Nextel must be retuned to eliminate interference between Sprint Nextel and public safety. This is to be accomplished by exchanging frequencies, a complex and expensive process called rebanding (aka retuning). (see appendix A)

This is why a special public safety signal boosters that reject Sprint Nextel and cellular signals have been designed to be used in critical public safety in-building systems.

This paper address changes that will occur in collocated in-building systems that distribute public safety as well as other services, such as Sprint Nextel or cellular services. When these users share the same distribution system it is often referred to as a 'neutral host' system.

Basic technology review:

There are several basic technical frequency relationships that should be understood to understand the interactions between adding or mixing different bands in the same distribution system:

1. Signals on the same or nearby frequencies will interact with each other, causing poor or intermittent performance of one or all of the services.

2. RF Filter performance is limited by physics and, in practical broadband signal boosters, it is difficult to filter out the effects of an interfering signal that is on an adjacent channel a fraction of a megahertz from another, such as between the Cellular band and the current public safety NPSPAC channels.

3. Some frequency combinations generate intermodulation (IM) signal components that can interfere and impair some channel combinations. These are derived from mixing one or more signals and/or the harmonics of these signals.

Graphic representations of the different 800 bands and how they interact are included later in this report:

Existing channel assignment scenario:

The FCC has set aside a 3 MHz band for the exclusive use of public safety agencies. This band is called the "National Public Safety Plan Advisory Committee" band, or simply "NPSPAC".

The NPSPAC frequency bands are:
821 to 824 MHz (portable transmit) and 866 to 869 MHz (base transmit)

These frequencies lie above the 800 MHz SMR band used by Sprint Nextel and below the Cellular "A" Band. This leads to special considerations in in-building systems to prevent interaction or poor system performance such as adjacent band rejection filters.

Public safety agencies may also have been assigned channels in the 806 to 821 and 851 to 866 band which are interleaved with industrial users, Sprint Nextel, etc. Most of these are not included in the rebanding plan but the relocation of Sprint Nextel out of these bands will reduce interference problems.

The current "Sprint Nextel" band is 806 to 821 MHz (handset transmit) and 851 to 866 MHz (cell site transmit). Frequencies in the upper 820 to 821 MHz and 865 to 866 MHz range can interact with the NPSPAC channels.

The cellular radio services are split into two bands. Each band is used exclusively by one cellular service provider in any common location. These bands are:

- Cellular band A:
  824.040 to 834.990 MHz and 845.010 to 846.480 MHz (handset transmit),
  869.040 to 879.990 MHz and 890.010 to 891.480 MHz (cell site transmit)

- Cellular band B:
  835.020 to 844.980 MHz and 846.510 to 848.970 MHz (handset transmit)
  880.020 to 889.980 MHz and 891.510 to 893.970 MHz (cell site transmit)

Channel assignments after rebanding:

Note: The following is based on the original FCC plan and may vary at the time of rebanding. (see Appendix A)

The most important detail is the FCC's mandatory 800 MHz band realignment ruling concerning what channels public safety and Sprint Nextel must change to.

The public safety NPSPAC bands from 821 to 824 MHz and 866 to 869 MHz are scheduled to be relocated to the lower end of the 800 MHz band; 806 to 809 and 851 to 854 MHz. In other words, be lowered 15 MHz..

Sprint Nextel channels that are now scattered between 806 to 821 and 851 to 866 MHz will be relocated to space vacated by public safety and others into new 816 to 824 and 861 to 869 bands.

This relocation, or rebanding, is necessary to reduce the massive interference that now exists between the public safety band and the Sprint Nextel band of operation.

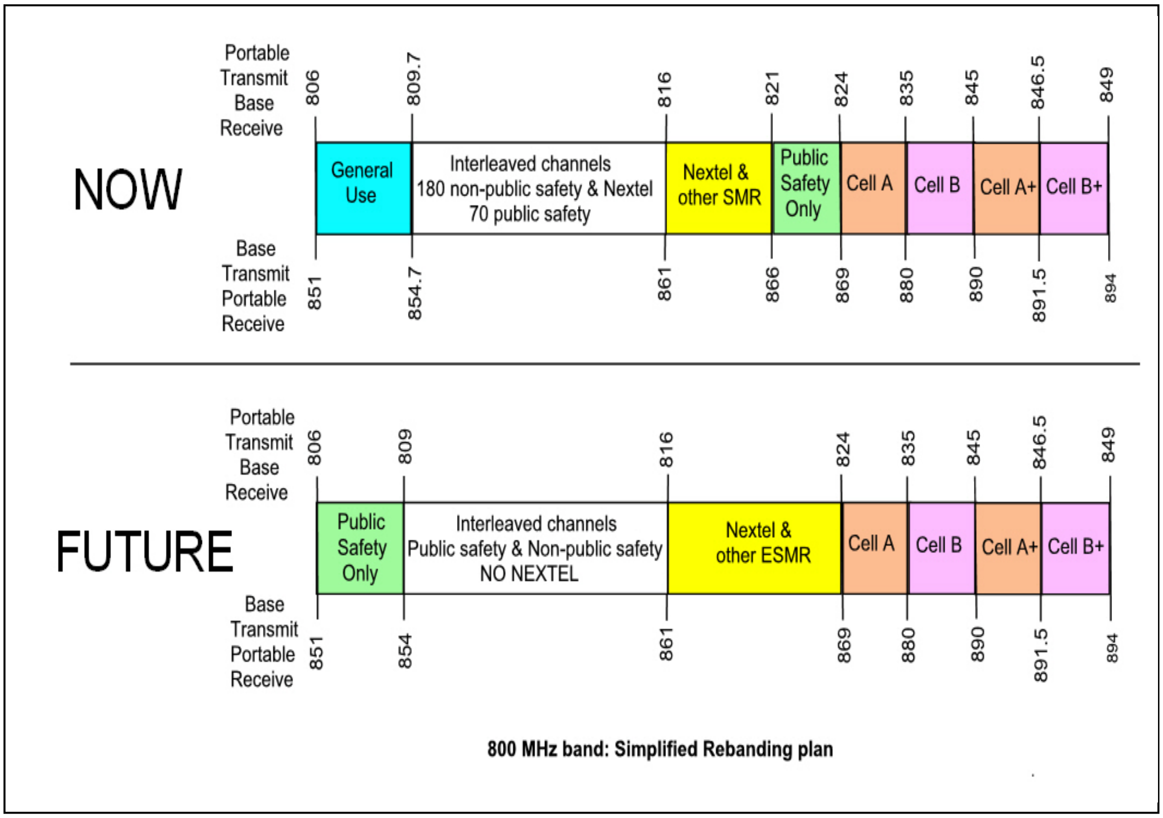
This process started in June 2005 and is expected to take four to five years.

When this occurs, the exiting in-building public safety systems will need to be retuned to the new frequency bands.

Most Sprint Nextel signal boosters that do not already cover the new Sprint Nextel bands will need to be replaced as most older models are not capable of being retuned.

Worse, existing wide band in-building Sprint Nextel signal boosters (18 MHz wide) that are not retuned to the new frequency plan can continue to cause interference to the new public safety band.

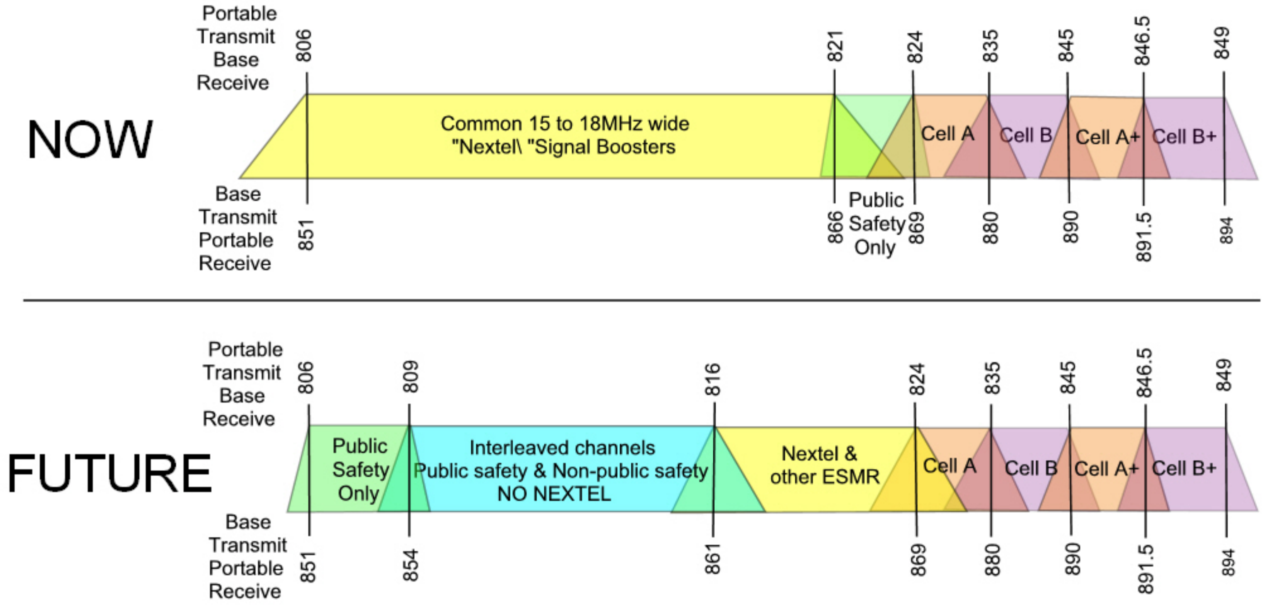
Rebanding Plan Illustration:



In this illustration note the Sprint Nextel and Cellular Band A services adjacent to the current exclusive NPSPAC public safety channels.

Many public safety grade signal boosters are intentionally designed to minimize most interference and reduce the amplification of Sprint Nextel and cellular signals.

Since the rf selectivity (i.e. filters) cannot be perfect, the practical impact of these relationships is better illustrated in the next drawing.



800 MHz Band: Simplified Band Filter Relationdships

From the above, the undesirable interactions (overlap) between adjacent radio services can be visualized.

Current concerns:
Obviously, Sprint Nextel and Cellular A bands are very close to the public safety NPSPAC band. It would be very difficult to share the same distribution system when using common signal boosters for each service as the edges of the passbands overlap and, when combined, the phase differences between same frequency signals amplified by separate signal boosters results in unpredictable performance at the band edges. Variations in signal levels over the air add to the potential problems.

Examples:

1. The separation between the highest Nextel/800 MHz channel and the lowest NPSPAC channel is 25 KHz.

2. The separation between the highest NPSPAC channel and the lowest cellular A Band channel is 22.5 KHz..

If base stations (BTS) were used for both the cellular and Sprint Nextel donor sources, there will still be variations in the public safety OTA signal levels.

AGC will not resolve this as AGC normal limits the upper power level and doesn't maintain a constant power level with lower input levels. Operating within continuous AGC control also invites additional distortion and IMs. AGC may also interact with leading edges of digital transmission bursts depending on attack response timing and control loop overshoot. Best practices indicate setting gains so normal signal levels are below the AGC threshold and AGC action is in response to abnormal, temporary, high input signals.

The use of filters with sharp band edges (saw, digital, etc.) might provide usable band-to-band separations if all levels were the same, however there can be great differences in public safety portables and the cellular-like handsets based on transmit power levels and relative location to the same inside antenna. Example;

5 watt Public safety handset 10 feet from antenna = ~ -6 dBm delivered to antenna.

0.6 watt handset 100 feet from antenna = ~ -32 dBm, BEFORE any forward power reduction.

The minimum two signal capture ratio (differential) is > 16 dB. Therefore adjacent service band bandpass filters in this example would require >42 dB adjacent channel attenuation at 22.5 KHz to assure isolation between the two bands to prevent interaction between two donor signal sources. Real life applications can have higher signal differentials due to clutter, etc.

In the extreme situation where all donor sources are stations, the uplink challenge still exists.

Downlinks versus Uplinks:
These systems operate in a full duplex mode. Duplexers used in the service areas must protect the uplink from downlink signals. The lowest Nextel/800 SMR downlink channel is 851.0125 and the highest cellular B uplink channel is at 848.9700, a difference of 2.055 MHz. The downlink signal levels can range up to +10 dBm. Minimum usable uplink signals may be -80 dBm or lower. Filters used in duplexers in the service areas must protect the uplink from downlink signals. Therefore downlink to uplink isolation at the service area device should be in excess of 90 dB. This quality of filtering is not provided in cheap signal boosters so there is insufficient isolation between bands when using one common antenna..

The isolation requirement between the 800 Nextel band and the cellular bands is being met in real applications when NPSPAC band channels are not included. This combination results in a 3 MHz guardband between Nextel/800 and Cellular, which is easier to duplex with more economical filters.

Most successful deployments of NPSTC channels in a common structure with Nextel/800 SMR and/or cellular RF distribution uses separate, parallel systems to solve this problem, with the inside antennas physically separated by each other as much as practical, usually 50 feet or more. 50 feet at 850 MHz provides an additional 55 dB isolation.

In 'neutral host' systems which are designed to provide indoor coverage for all cellular and PCS systems at the same time, a dual distribution system, with separated antennas, is becoming accepted practice.

It should be noted when using broadband amplifiers at remote locations, as is the case with fiber based distribution, more signals within the same amplifier passband also reduces the power per channel. There is also a greater potential for intermodulation products and wideband noise within the uplink passbands.

Third (and higher) higher order IMs formed by 800 and cellular band channels fall within both the 800 and cellular downlink and uplink bands. (3^{rd} order IMs are 808 to 937 MHz)

This further justifies separate systems.

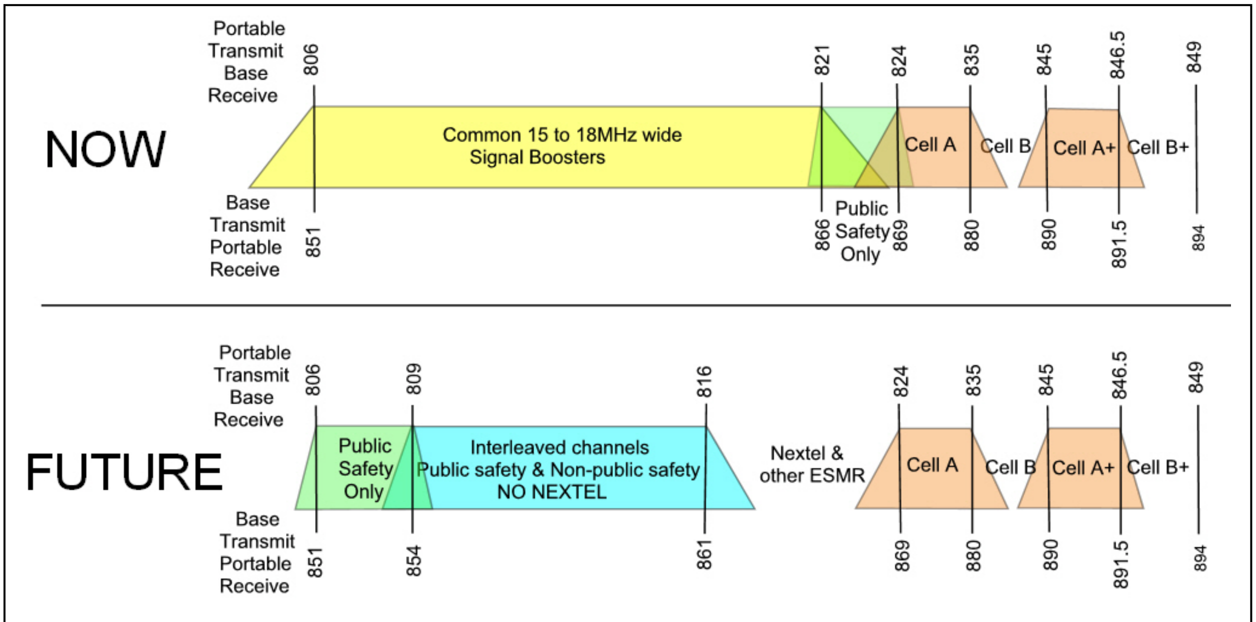
Future situation:

As intended by the FCC relocation of these radio services, the adjacent channel interaction between the new Sprint Nextel band and the new public safety band are minimized due to the increased separation between these bands.

After the retuning of the band, Cellular A will become compatible with the new public safety band. However the interaction between Nextel and cellular will increase.

A combined distribution of public safety and Cellular B band will result in improved public safety use. Cellular B uplink will become more susceptible to interference as public safety now occupies the adjacent downlink. The 2 MHz separation will still require additional filtering.

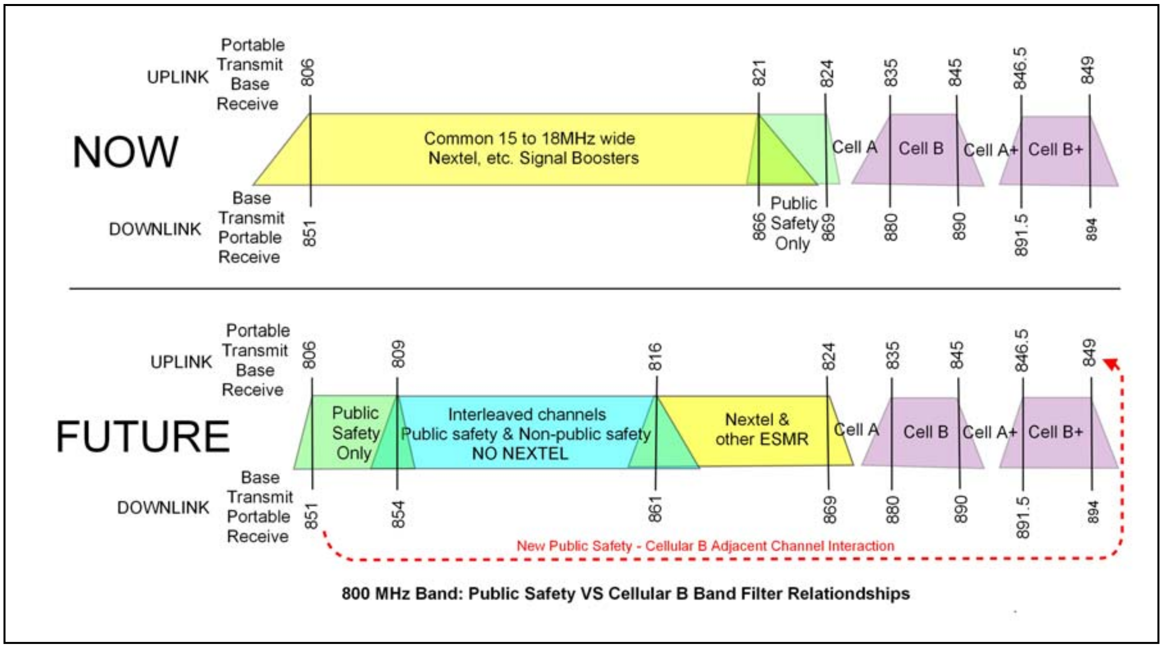
Here is an illustration of Cellular A band and pubic safety interactions:



800 MHz Band: Simplified Public Safety VS Cellular Band A Relationdships

Obviously, the NPSPAC and Cellular A Band are adjacent to each other now with no separation, making adeqaute separation by filters impossible.

Next is an illustration of Cellular B band and pubic safety interactions:



It is important to note after rebanding, the public safety band downlink will be as close as 2 MHz from the uplink input of Cellular B band in the same distribution area. The public safety base signal will compete with the cellular handheld transmissions and may, in effect, "desense" the cellular system performance. The solution will require high performance filters and antenna spacing between the antennas of each band.

In an existing single distribution system that has both public safety and Cellular B band, but not cellular A, the system will probably have to be converted to a dual distribution system to separate the indoor antennas.

If the existing system is a dual system with Cellular A and Cellular B on different distributions, the public safety problem after rebanding can be reduced by swapping the cellular carriers to the other to distribution system. In other words, Cellular B band and public safety would not be in the same distribution system.

CONCLUSION:

In-building system designers must anticipate new challenges in existing shared systems. In some cases it may require a duplicate distribution system to provide all the desired wireless services. Separate distribution for public safety is becoming the norm in neutral host type systems..

Appendix A

800 MHz Band Reconfiguration
Resolving Mobile Telephone Interference to Public Safety Radio Systems

Source:_ website

The Homeland Security obligations of the Nation's public safety agencies make it imperative that their communications systems are robust, highly reliable and free from harmful interference. To address harmful interference to public safety communication systems operating in the 800 MHz band, the Commission adopted a two-pronged plan. This plan is designed to protect the lives of first responders and other emergency personnel and fulfills the Commission's obligation to promote safety of life and property through the use of wire and radio communications.

800 MHz Band Reconfiguration Overview:

Public safety radio systems (such as those used by police, firefighters and emergency medical technicians) operating at 806-824 MHz/851-869 MHz—conventionally known as "the 800 MHz band"—are experiencing increasing levels of interference from commercial wireless carriers, such as Sprint Nextel and the cellular carriers which operate in the same part of the spectrum or in adjacent spectrum bands. A number of private radio systems also operate in the 800 MHz band. For example, utility companies use the spectrum for internal communications; but it appears these private radio systems are not a significant source of interference to public safety radio systems.

800 MHz Band Reconfiguration Overview - Emergency Medical Technician
Interference to 800 MHz public safety systems is primarily caused by the fact that public safety systems and commercial wireless systems operating in nearby spectrum use fundamentally different system architecture. Public safety systems traditionally use a single base station with a high antenna in a favorable location within the desired coverage area. The transmitted signal will be strongest near the base station and weaker in locations further away from it. Consequently, public safety systems use receivers that can receive relatively weak signals.

Commercial wireless services, including those operating in the 800 MHz band, have become extremely popular over the past few years and expanded dramatically in terms of both subscribership and usage. The commercial wireless carriers typically accommodated the resulting large volume of communications traffic by employing solutions that increase the efficiency of use of their spectrum (specifically, "frequency re-use", which permits the available communications channels throughout a service area to be used to their maximum potential).

This generally requires a "cellular-type" architecture consisting of a large number of base stations, using relatively high power, but relatively low-site antennas to limit coverage to a small area around that base station. To increase capacity in response to subscriber demand, the commercial operators must often build additional base stations – i.e., "cells".

For many years, public safety radio systems operated in the 800 MHz band with only occasional harmful interference. The original band plan did not anticipate the development and accelerated growth of the commercial wireless carriers using 800 MHz cellular-type architecture systems.

800 MHz public safety radio systems became more widespread and commercial wireless systems saw dramatically increased subscribership resulting in more vigorous reuse. This involved a greater number of cell sites and a greater number of frequencies in use at those cells. Consequently, public safety users began to encounter pockets of "dead zones" within their coverage areas, where the signals from commercial wireless systems overwhelmed the sensitive public safety receivers.

On March 15, 2002, the Commission released a Notice of Proposed Rule Making, (NPRM), seeking comment on how to resolve this interference problem. The NPRM addressed Sprint Nextel's proposal and other proposals that sought to resolve the harmful interference problem. The Commission received over 2,200 filings in response to this NPRM.

On August 6, 2004, the Commission released a Report and Order, Fifth Report and Order, Fourth Memorandum Opinion and Order, and Order, in which it established a two-pronged solution to the interference problem. First, to address individual interference problems more adequately, the Commission adopted an objective technical standard for determining whether an 800 MHz public safety or other non-cellular licensee is entitled to interference protection in a given area.

The second prong of the solution, which is intended to address the identified root cause of the interference, involves a reconfiguration of the 800 MHz band, placing generally incompatible technologies in separate band segments. Under this band reconfiguration, many 800 MHz private land mobile (including public safety) and commercial mobile radio licensees will have to move to another part of the 800 MHz band. In general, Sprint Nextel will pay for all direct and indirect costs associated with the reconfiguration. The costs, however, must be reasonable, well documented and the minimum necessary to obtain comparable facilities for relocated incumbent licensees.

800 MHz Band reconfiguration (retuning) began June 2005 and is ongoing.