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TIA TELECOMMUNICATIONS SYSTEMS BULLETIN

WIRELESS COMMUNICATIONS SYSTEMS PERFORMANCE IN NOISE AND INTERFERENCE-LIMITED SITUATIONS

Part 3: Recommended Methods for Technology Independent Performance Verification Addendum 1-Broadband-to-Narrowband Interference Scenarios

TSB-88.3-D-1 February 2017

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Foreword

(This foreword is not part of this addendum)

Working Group TR-8.18.1 prepared this Addendum. Subcommittee TR-8.18 of TIA Committee TR-8 approved this Addendum.

Changes in technology to support the public safety nationwide broadband network have recently occurred, which may impact narrowband public safety systems. These events necessitate keeping the TSB-88 documents current to assure the documents provide the methodology of modeling the various interference mechanisms to support frequency coordinators in determining the best assignments to be made for the available pool of frequencies and mixtures of technology.

To provide information about new broadband-to-narrowband interference scenarios, TR-8.18 has adopted this addendum, which will be added to TSB-88.3-D as the Annex D contained in this document.

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Patent Identification

The reader's attention is called to the possibility that using this document might necessitate the use of one or more inventions covered by patent rights. By publication of this document no position is taken with respect to the validity of those claims or any patent rights in connection therewith. The patent holders so far identified have, we believe, filed statements of willingness to grant licenses under those rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such licenses.

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1. Addendum Introduction

The purpose of this addendum is to add Annex D to **TSB-88.3-D**, which will provide informational information about broadband-to-narrowband interference scenarios**.**

2. Addendum Scope

This addendum simply adds Annex D to **TSB-88.3-D***.* No other changes in TSB-88.3-D are contained in this addendum or intended to be effectuated by this addendum.

3. Specific Change to TSB-88.3-D

This addendum requires the addition of the following Annex D to **TSB-88.3-D**.

Annex D Broadband Transmitter Characteristics and Interference Cases (Informative)

The focus in this section will be on interference analysis that is unique to broadband networks employing single frequency reuse such as LTE. Analysis and examples will be provided for the case where the broadband system is the aggressor and a narrowband LMR communication system is the victim. The minimum required transmitter specifications for that broadband technology (e.g. for LTE these are defined in 3GPP TS-36.101 for devices and 3GPP TS-36.104 for base stations) may be used in conjunction with the tools provided in [88.1] to estimate the impact of new broadband communications on existing LMR voice and data systems.

D.1 LTE Transmitter Characteristics

LTE systems can be deployed in several different channel bandwidths with the most common being 5, 10, and 20 MHz channel bandwidths. Resource blocks are defined as the minimum allocation unit in the downlink and uplink shared channels for carrying signaling and traffic. Resource blocks are 180 kHz wide and consist of 12 15 kHz wide $\frac{Sin(x)}{x}$ subcarriers. The subcarriers can be modulated with various levels of modulation and coding to provide data rates that vary with the SINR. A scheduler determines the desired parameters based on the subscriber units received signal level. Channel bandwidth characteristics are listed in Table 1.

Table 1: Channel Bandwidth Characteristics

Channel BW	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Resource Blocks	6	15	25	50	75	100
Resourced Subcarriers	72	180	300	600	900	1200

This multiple access technology (OFDMA) assigns a sub-set of the resource blocks to different subscribers. Thus simultaneous varying data rates are available for different users based on their location and available link budget. OFDMA is also robust against multipath fading and provides high spectral efficiency.

Table 2: Theoretical SNR Vs Modulation and Code Rate

Theoretical SNR Requirements Vs. Coding Rate and Modulation Scheme		
Modulation	Code Rate	SNR (dB)
QPSK 2 bits/Symbol	1/8	-5.1
	1/5	-2.9
	1/4	-1.7
	1/3	-1.0
	1/2	2.0
	2/3	4.3
	3/4	5.5
	4/5	6.2
16 QAM 4 bits/Symbol	1/2	7.9
	2/3	11.3
	3/4	12.2
	4/5	12.8
64 QAM 6 bits/Symbol	2/3	15.3
	3/4	17.5
	4/5	18.6

Table 2 shows examples of modulation and coding schemes vs. theoretical required SNR for each. Linear transmitters are utilized for eNodeB stations while subscriber units have a different method for combining resource blocks, SC-FDMA, therein eliminating the need for a linear transmitter. QPSK, 16QAM, and 64QAM modulations are supported in the standard, however at this time device and some eNodeB vendors do not support the 64 QAM modulation in the uplink.

LTE eNodeB transmitters are generally deployed in 10, 20 and 40 Watt configurations for macro cells (small, e.g. micro and pico cells typically utilize lower transmitter power levels). They utilize sectored antennas with high gain values in the range of 13 and 15 dBi. After transmitter filtering the ERP generally ranges between 48 and 56 dBm. When MIMO 2x2 is deployed the ERP is 3 dB higher. If a 70 dB minimum coupling loss value is considered[1], the resulting signal levels on the ground range between -22 dBm and -14 dBm near a site. There are various different regulatory requirements such as one for the 700 MHz band[2] that does not allow Power Flux density to exceed 3000 μW/m^2 on the ground over the area extending to 1 km from the base of the antenna mounting structure. This is -12.3 dBm and -13.2 dBm for the 700 and 800 MHz bands respectively. These are strong signals that can create Near/Far blocking scenarios. Recent waivers have been granted for even higher ERP. In addition there are other sources of interfering power from transmitters such as OOBE and BNBE that can create interference as the energy falls on a victim receiver's authorized frequency.

Table 3 lists signal bandwidth versus channel bandwidth. Except for the 1.4 MHz channel bandwidth, the signal bandwidth is 90% of the channel bandwidth.

Table 3: LTE Signal Bandwidth vs. Channel Bandwidth

Channel BW	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Signal BW	1.08 MHz	2.7 MHz	4.5 MHz	9.0 MHz	13.5 MHz	18 MHz

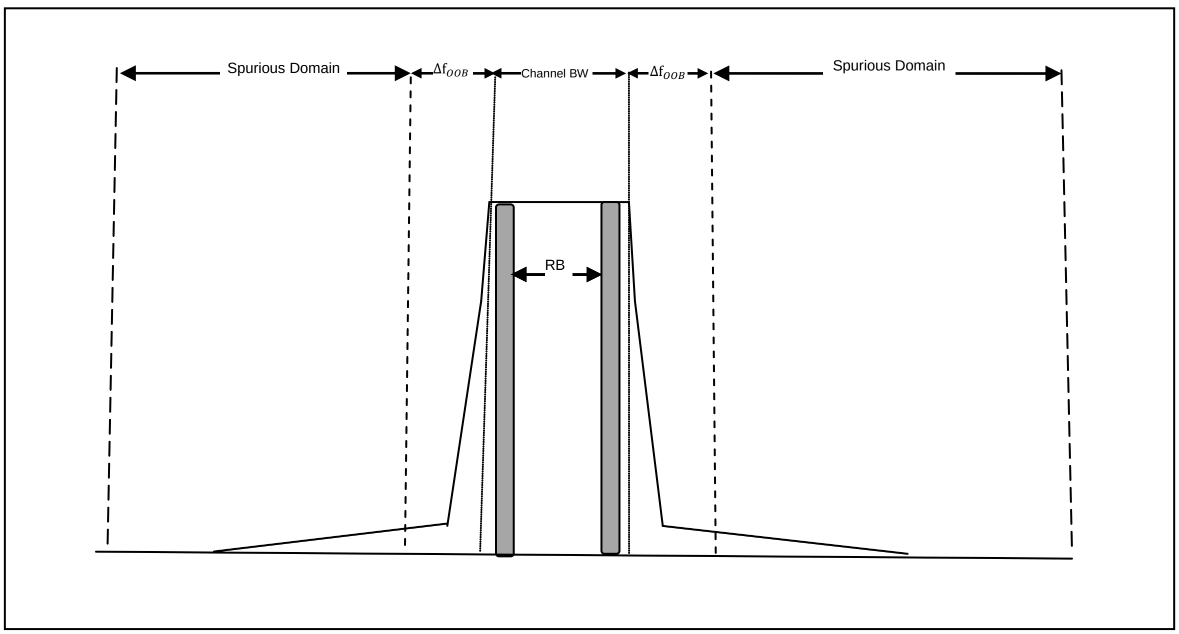

Figure 1: Graphic for OOBE and BNBE

[1] 3GPP assumes 70 dB minimum coupling loss in the specifications, taking into account typical panel antenna gain directly below the antenna, typical LTE antenna height (30m), and free space path-loss.
[2] 47 CFR §27.55(c)

There are FCC as well as ETSI 3GPP specifications for the OOBE and BNBE power. The graphic in Figure 1 shows the OOBE and spurious domains, while Table 4 lists relevant OOBE/ENBE limits. The FCC rules differ by frequency band while the ETSI specifications vary with channel aggregation, channel bandwidth, E-UTRAN Operating band and special network signaling options.

The measurement bandwidth for LTE is considerably wider than the narrow bandwidths used in narrowband LMR. This can be compensated by adjusting for the LMR channel bandwidths, e.g. 6.25, 12.5 and 25 KHz.

Table 4: Emission Spectrum OOBE/ENBE Limits

ETSI Base Station Transmitter Characteristics				
Power (EIRP) dBm/antenna		61(up to 5 MHz Channel) 64 (≥10 MHz Channel		
Max antenna gain, boresight		+18 dBi		
Emission Spectrum OOBE/BNBE Limit (dBm), as a function of the Frequency Offset of the measurement filter center frequency (ΔF) from the channel edge (MHz)		Limit (dBm)	Meas BW	ΔF (MHz)
	5 MHz BW	-15	30 kHz	0≤ΔF<1
		-13	1 MHZ	1≤ΔF
	10 MHz BW	-13	100 kHz	0≤ΔF<1
Corrections		-13	1 MHZ	1≤ΔF
30 kHz to 6.25 kHz = -6.8 dB				
100 kHz to 6.25 kHz = -12 dB	15 MHz BW	-15	100 kHz	0≤ΔF<1
1 MHz to 6.25 kHz = -22 dB		-13	1 MHZ	1≤ΔF
6.25 kHz to 12.5 kHz = +3 dB	20 MHz BW	-16	100 kHz	0≤ΔF<1
6.25 kHz to 25.0 kHz = +6 dB		-13	1 MHZ	1≤ΔF

Device (UE) Transmitter characteristics are specified in more detail over a wider spectrum. The maximum transmit power is 23 dBm with power control over a range of 63 dB (i.e. -40 to 23 dBm). Higher power units are permitted for Band 14 vehicular modems with a maximum transmit power of 31 dBm.

Figure 2 plots power versus frequency offset for different LTE channel bandwidths.

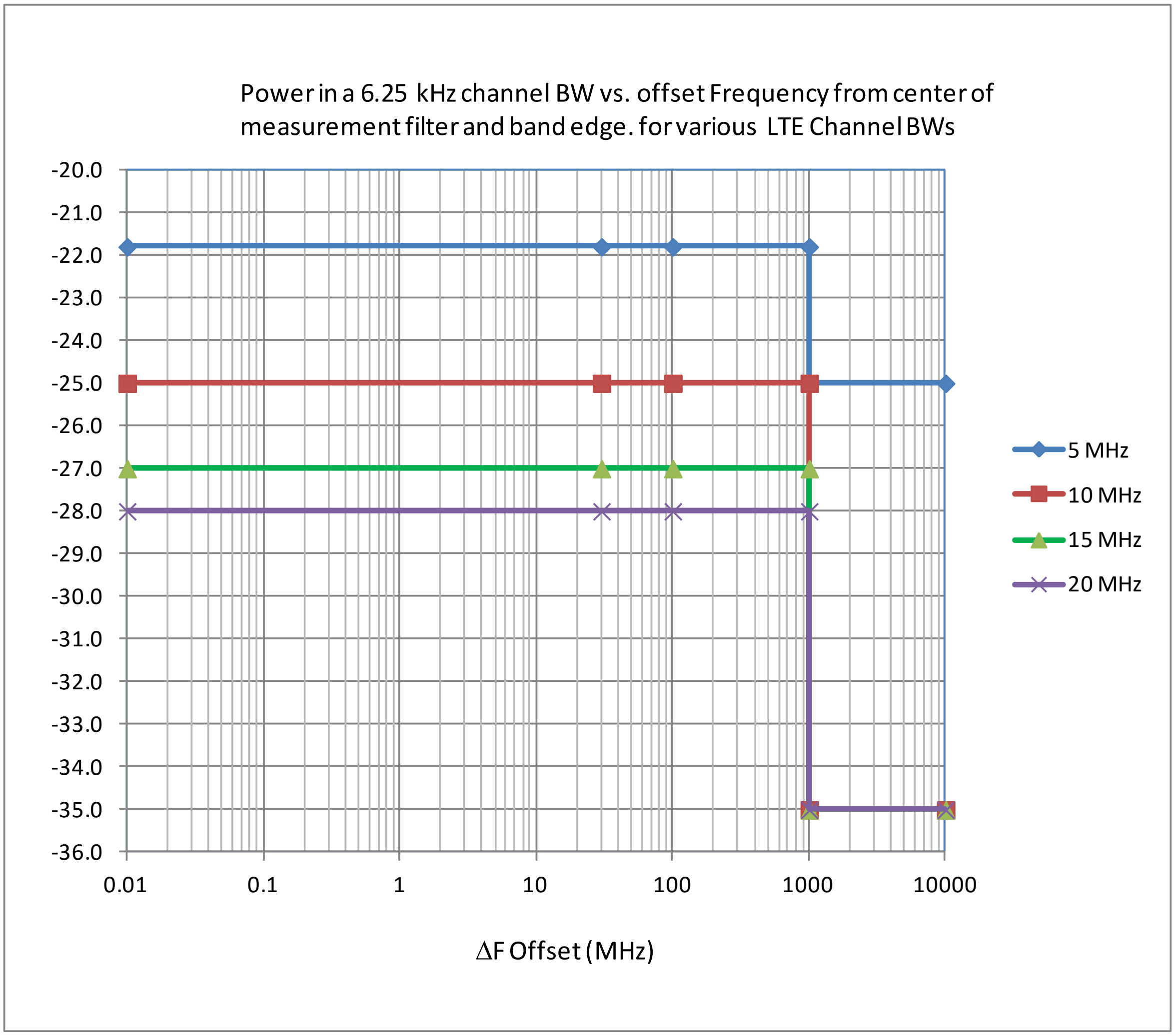

Figure 2: Power vs. Offset Frequency For Various LTE Channel Bandwidths

D.2 700 MHz Band FCC Rules

FCC rules for Band 14 and adjacent bands, which include LTE (B13) and 700 MHz Public Safety Narrow Band (PS NB), were harmonized under 47 CFR § 90.543. The relevant rules for potential interference scenarios between these bands, as of the publication date of this document, are summarized below. Note that government regulations are subject to change.

47 CFR 90.543 Emission limitations [partial listing]

Transmitters designed to operate in 769-775 MHz and 799-805 MHz frequency bands must meet the emission limitations in paragraphs (a) through (d) of this section. Class A and Class B signal boosters retransmitting signals in the 769-775 MHz and 799-805 MHz frequency bands are exempt from the limits listed in paragraph (a) of this section when simultaneously retransmitting multiple signals *and instead shall be subject to the limit listed in paragraph (c) of this section when operating in this manner. Transmitters operating in 758-768 MHz and 788-798 MHz bands must meet the emission limitations in (e) of this section.*

(e) For operations in the 758-768 MHz and the 788-798 MHz bands, the power of any emission outside the licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following:

(1) On all frequencies between 769-775 MHz and 799-805 MHz, by a factor not less than 76 + 10 log (P) dB in a 6.25 kHz band segment, for base and fixed stations. [-46 dBm]

(2) On all frequencies between 769-775 MHz and 799-805 MHz, by a factor not less than 65 + 10 log (P) dB in a 6.25 kHz band segment, for mobile and portable stations. [-35 dBm]

(3) On any frequency between 775-788 MHz, above 805 MHz, and below 758 MHz, by at least 43 + 10 log (P) dB.[-13 dBm]

(4) Compliance with the provisions of paragraphs (e)(1) and (2) of this section is based on the use of measurement instrumentation such that the reading taken with any resolution bandwidth setting should be adjusted to indicate spectral energy in a 6.25 kHz segment.

(5) Compliance with the provisions of paragraph (e)(3) of this section is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater. However, in the 100 kHz bands immediately outside and adjacent to the frequency block, a resolution bandwidth of 30 kHz may be employed.

(f) For operations in the 758-775 MHz and 788-805 MHz bands, all emissions including harmonics in the band 1559-1610 MHz shall be limited to -70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and -80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth. For the purpose of equipment authorization, a transmitter shall be tested with an antenna that is representative of the type that will be used with the equipment in normal operation.

D.3 Base Station to Device Interference Scenario

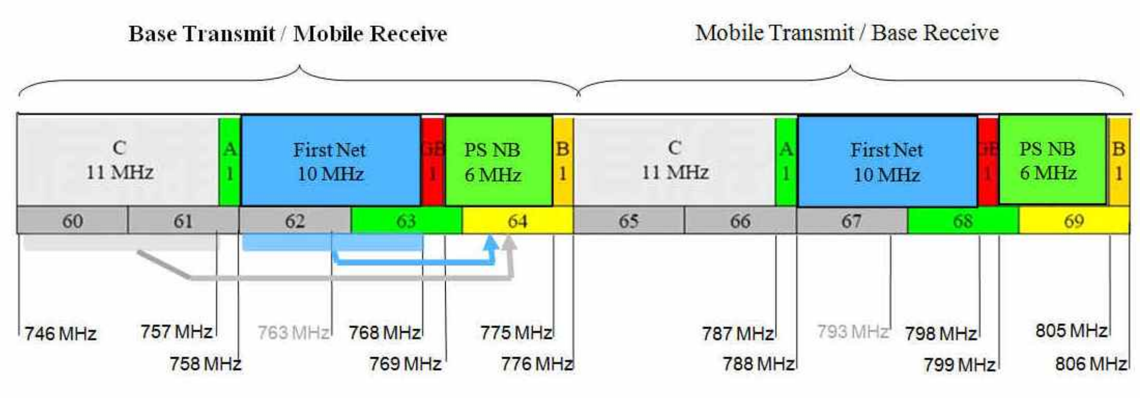

Figure 3: Base Station to Device Interference in the 700 MHz Band

This is a near-far interference scenario - high power, low antenna height, broadband base transmitters to PS narrowband subscriber receiver when operating in close proximity; typically receiver overload or receiver intermodulation. This is depicted in Figure 3.

In the 800 MHz band, the most likely interference scenario is near-far interference from high power, low antenna height, ESMR / cellular / broadband base transmitters above 862 MHz to PS narrowband subscriber receivers in 851 to 862 MHz sub-band. This is depicted in Figure 4.

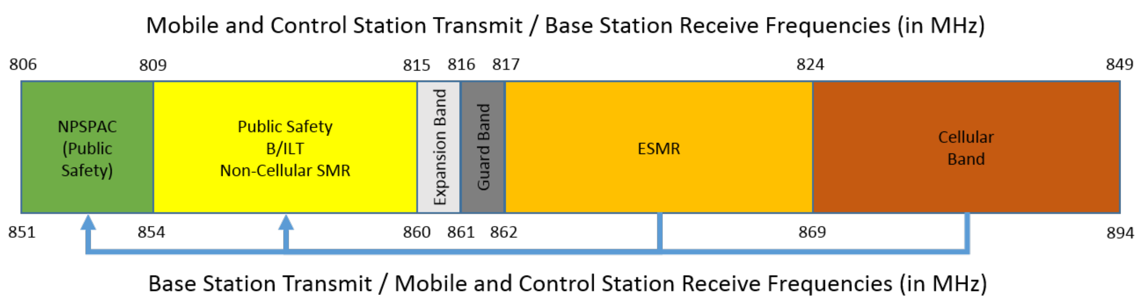

Figure 4: Base Station to Device Interference in the 800 MHz Band

D.4 Device to Device Interference Scenario

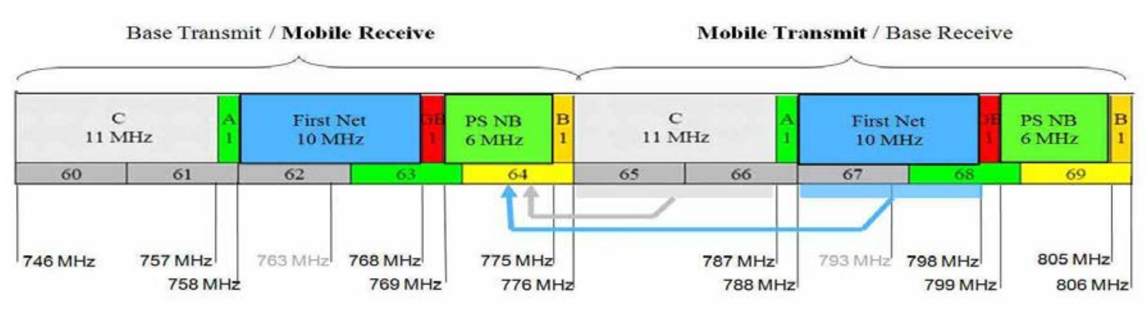

Figure 5: Device to Device Interference in the 700 MHz Band

Interference scenario (shown in Figure 5) - broadband subscriber transmitter to PS narrowband subscriber receiver when operating in very close proximity; typically out-of-band emissions. Higher power subscribers (vehicular modems and bi-directional amplifiers) could generate receiver intermodulation.

In the 800MHz band, ESMR/cellular subscriber transmitter to narrowband subscriber receiver operating in very close proximity. This is shown in Figure 6.

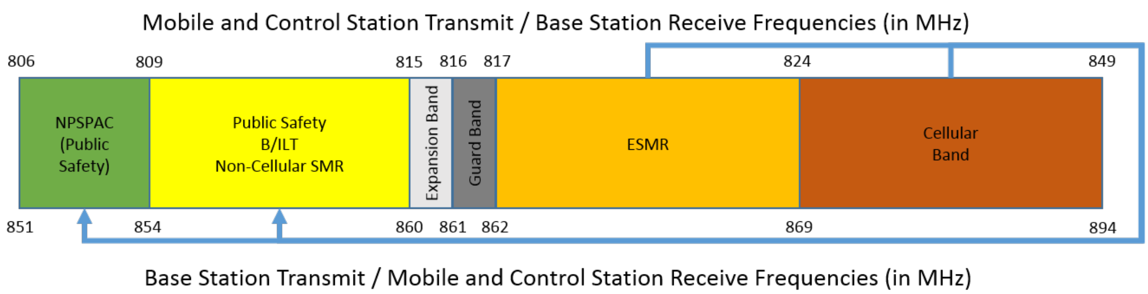

Figure 6: Device to Device Interference in the 800 MHz Band

D.5 Device to Base Station Interference Scenario

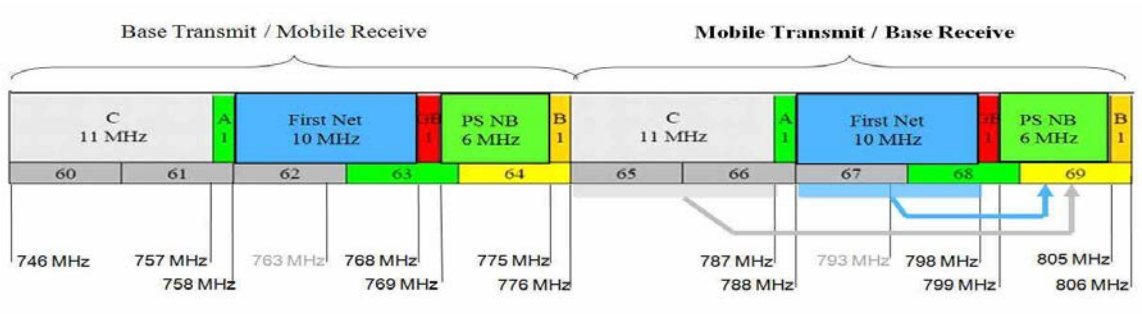

Figure 7: Device to Base Station Interference in the 700 MHz Band

Near-far interference scenario (shown in Figure 7) - broadband subscriber transmitter to PS narrowband base receiver when operating in close proximity. Most likely from high power subscribers (vehicular modems and bi-directional amplifiers).

In the 800 MHz band, broadband subscriber transmitter to narrowband LMR base receiver when operating in very close proximity, as shown in Figure 8.

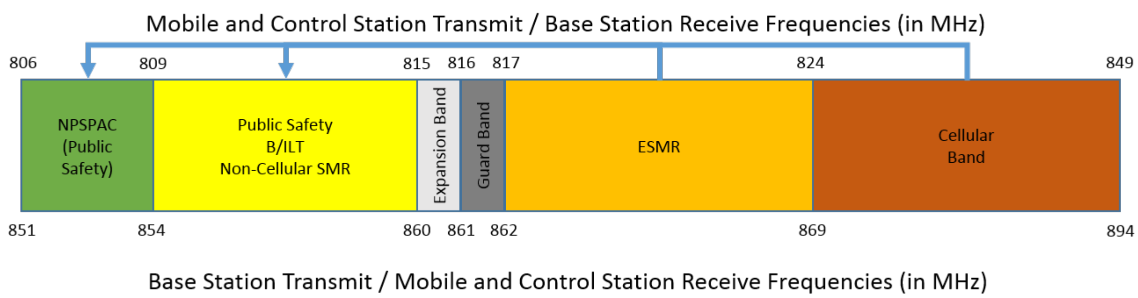

Figure 8: Device to Base Station Interference in the 800 MHz Band

D.6 Interference Issues For Narrowband Systems with Wide Preselectors

Many narrowband LMR receivers utilize a wide preselector in order to allow a single hardware configuration to support a wide range of frequencies. For these wide preselectors, the subcarriers of broadband systems operating within the preselector passband can directly overload (i.e., block) the receiver or generate intermodulation products that coincide with the narrowband and cause significant interference for the receiver. This issue is most prominent for 800MHz receivers operating in close proximity to broadband base stations. As the density of broadband sites increases, the percentage of the coverage area impacted increases as well. There are three approaches to limit the impact of this type of interference: (1) narrow the preselector passband, either by reducing the preselector bandwidth or by applying an external filter; (2) improve the IMR specification; and/or (3) implement Automatic Gain Control (AGC) to attenuate IM products. The details of how to implement these countermeasures are outside the scope of this document.

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