Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Amendment of Parts 1 and 22 of the	)	
Commission's Rules with Regard to the	)	WT Docket No. 12-40
Cellular Service, Including Changes in	)	
Licensing of Unserved Areas	)	
	)	

To: The Commission

EX PARTE COMMENTS OF PERICLE COMMUNICATIONS COMPANY AND SHULMAN, ROGERS, GANDAL, PORDY & ECKER, P.A.

Pericle Communications Company (*Pericle*) and Shulman Rogers Gandal Pordy & Ecker, P.A. (*Shulman Rogers*), pursuant to Section 1.1206 of the Commission's Rules, 47 C.F.R. §1.1206, hereby respectfully submit the following Ex Parte Comments, as well as Notice of an Ex Parte communication.

I. BACKGROUND

On November 19, 2015, Alan Tilles (*Shulman Rogers*) and Jay Jacobsmeyer (*Pericle*) spoke with Mr. Brian Marenco of the Public Safety & Homeland Security Bureau on the topic of Power Flux Density (PFD) limits in the 800 MHz cellular band. Specifically, the parties discussed the bandwidth over which PFD should be measured, how the wireless carriers should design for compliance with this limit and how the PFD limit should be verified through field measurement, when necessary. There was also a brief discussion regarding how to specify PFD compliance in a spatial sense.

Mr. Jacobsmeyer explained that while Power Spectral Density (PSD) is by its very nature specified in units of bandwidth (e.g., Watts per Hertz), PFD is different. The purpose of specifying a PFD limit is to protect public safety receivers from harmful interference in the 800 MHz bands. This harmful interference is created in the front end of the receiver where there is typically no selectivity over the entire ESMR band (862-869 MHz) and very little selectivity over the 800 MHz cellular band (869-894 MHz). While it is true that broadband interferers create intermodulation (IM) products with lower power spectral density than narrowband interferers of the same carrier power, and only a fraction of the IM product's bandwidth appears in the public safety receiver's IF bandwidth, the dominant contributor to harmful IM interference is the total *power* of the interferer, *not its power spectral density*. **In other words, interferers with equal power spectral density do not cause equal harm.** The math proving this assertion for the classic linear amplifier case is found in the Appendix to these comments.

Further, automatic gain control, receiver components, and other design choices result in vastly different performance among receiver makes and models when comparing narrowband interferers to broadband interferers. This behavior can be seen by comparing our January 21, 2015 comments showing narrowband interferer IM to our February 20, 2015 and June 25, 2015 comments showing broadband interferer IM. The measurements summarized in these past comments show no linear relationship between strong signal IM rejection and the bandwidth of the IM product, even for equal power interferers. Please bear in mind that our recommended PFD limits of 625 $\mu W/m^2$ (near term) and 3,000 $\mu W/m^2$ (long term) are based on our bench measurements using modern broadband interferers, not narrowband interferers.

Consequently, there is no simple formula that would grant a wideband interferer (e.g., LTE) a higher allowed PFD than a narrowband interferer (e.g., GSM) without either compromising the public safety receiver or applying such a conservative standard that it would be impractical for the wireless provider to implement. Creating complex tables showing the allowed PFD for every combination of interferers and every make and model of public safety receiver is impractical and would prove impossible to enforce. Instead, we propose in these comments some simple regulatory language that should

- satisfy the vast majority of interference scenarios,
- prove easy to implement and enforce, and
- minimize complaints of harmful interference.

Other topics, including proper specification of a PFD limit and verifying compliance through modeling and measurement were addressed in our January 21, 2015 comments and are captured in our suggested regulatory language in the next section of these comments.

II. SUGGESTED REGULATORY LANGUAGE

Accordingly, we propose the following regulatory language be added to Part 22.970:

§ 22.970. Unacceptable interference to Part 90 non-cellular 800 MHz licensees from cellular radiotelephone or Part 90 800 MHz cellular systems.

[(a)-(b) no change]

(c) *Power Flux Density (PFD) Limit For Stations Operating With Greater Than 50 kHz Bandwidth.* Power flux density limits are implemented in two phases. Effective immediately, the power flux density per 800 MHz RF carrier per antenna sector, measured at ground level anywhere in the vicinity of the cell site, shall not exceed 625 $\mu W/m^2$. Effective January 1, 2021, the PFD limit is increased to 3,000 μW/m^2.

(1) Grandfathered Existing Cell Sites (ERP ≤ 500 Watts). Existing cell sites that increase their ERP per RF carrier above 500 Watts are not grandfathered. Existing cell sites that continue to operate below 500 Watts ERP per RF carrier are partially grandfathered. Non-compliant existing cell sites (ERP below 500 Watts) shall be corrected following notification of harmful interference by the Part 90 non-cellular 800 MHz licensee and verification of non-compliance through field measurement. Regardless of any interference complaints filed, existing cell sites shall be brought into compliance (verified by engineering calculation) whenever base station radio equipment or antennas are replaced or the ERP is raised above 500 Watts.

(2) Above Ground Level Locations. The same PFD thresholds and effective dates apply to locations above ground level in structures near the cell site provided these locations are accessible to public safety personnel in performance of their duties.

(3) Compliance with the applicable PFD limit does not excuse broadband licensees from other responsibilities of this rule part.

(4) Verifying Compliance. Compliance shall be verified in two ways: New facilities or modifications to existing facilities shall be verified through engineering calculation using power density calculations consistent with OET-65 (i.e., line-of-sight assumption, actual antenna patterns, 2.56 power reflection factor) but using the PFD limit of this rule part rather than the public exposure limits of Parts 1.1307-1.1310. If interference complaints are filed by the Part 90 non-broadband 800 MHz licensee, compliance shall be verified through field measurement.

(5) Method of Measurement. Power flux density should be measured with instruments specifically designed for this purpose. Average power (versus peak power) detectors are

acceptable. Spatial average measurements from hip to head height are acceptable. Further measurement guidance is found in OET-65 and ANSI C95.3.1-2010 (or most recent edition).

(6) Reimbursement of Reasonable Expenses for Public Safety Licensees. In the event that a Broadband Licensee (as described in this Section) causes interference to an 800 MHz Public Safety Radio System, the Broadband Licensee shall compensate the Public Safety Radio System Licensee for reasonable costs expended to locate and mitigate the interference. Disputes between the parties regarding such costs shall be determined by the Chief, Public Safety and Homeland Security Bureau.

Respectfully submitted,

PERICLE COMMUNICATIONS COMPANY and
SHULMAN, ROGERS, GANDAL, PORDY & ECKER, P.A.

By:

Jay M. Jacobsmeyer, P.E., President
Pericle Communications Company
7222 Commerce Center Drive, Suite 180
Colorado Springs, CO 80919
(719) 548-1040
jacobsmeyer@pericle.com

Alan S. Tilles, Esquire
Shulman Rogers Gandal Pordy & Ecker, P.A.
12505 Park Potomac Ave., Sixth Floor
Potomac, Maryland 20854
(301) 230-5200
atilles@shulmanrogers.com

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Appendix - 3rd Order IM with Interferers of Unequal Bandwidth But Equal Power Spectral Density

The purpose of this Appendix is to compare the IM product power captured in the IF bandwidth of the public safety receiver between a pair of narrowband interferers and a pair of wideband interferers where the narrowband interferers and the wideband interferers are adjusted in power to have the same power spectral density. The power and bandwidth relationships are shown graphically in Figure 1.

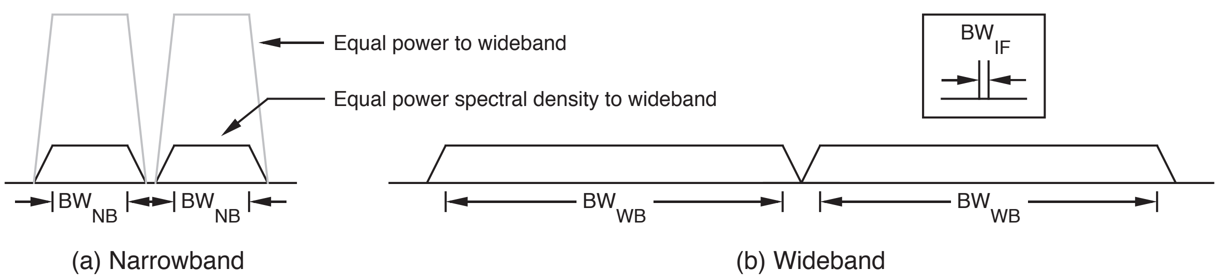

Figure 1 - Narrowband and Wideband Interferers with Identical Power Spectral Density

For simplicity, assume a classic linear amplifier like the low noise amplifier found in the front end of a land mobile radio receiver. We know that a linear amplifier operating in its linear region produces a two-tone, equal amplitude 3rd order IM product with a predictable amplitude that is a function of the amplitude of each interferer and the third order intercept of the amplifier (3IIP). For our purposes, we just need to know that the power of this IM product increases 3 dB for every 1 dB increase in interferer amplitude.

Definitions:

BW_{IF} = IF bandwidth of the receiver

BW_{NB} = bandwidth of the narrowband interferer

BW_{WB} = bandwidth of the wideband interferer

P_{NB}=power of the narrowband interferer

P_{WB}=power of the wideband interferer

η = ratio of bandwidths of the two types of interferers

PIM_{NB}= power of the narrowband 3rd order IM product

PIM_{WB}= power of the wideband 3rd order IM product

PIF_{NB}=the power present in the IF bandwidth of a RX from the narrowband IM product

PIF_{WB}=the power present in the IF bandwidth of a RX from the wideband IM product

Because the narrowband and wideband interferers have the same power spectral density, the wideband interferer has greater power by a factor equal to the ratio of the interferer bandwidths, η, i.e.,

$$\frac{P_{WB}}{P_{NB}} = \frac{BW_{WB}}{BW_{NB}} \triangleq \eta .$$

Also, the total power of the wideband IM product is greater than the power of the narrowband IM product to the third power (due to the well-known behavior of linear amplifiers). Therefore, the power of the wideband IM product relative to the narrowband IM product is given by

$$\frac{PIM_{WB}}{PIM_{NB}} = \left(\frac{P_{WB}}{P_{NB}} \right)^3 = \eta^3 .$$

The narrowband IM product power appearing in the IF bandwidth is simply the power of the IM product divided by the ratio of the IM product bandwidth to the IF bandwidth and is therefore given by

$$PIF_{NB} = PIM_{NB}\left(\frac{BW_{IF}}{3BW_{NB}}\right)$$

where the factor of 3 occurs because the bandwidth of the IM product is three times the bandwidth of each interferer.[1] Similarly, the wideband IM product power appearing in the IF bandwidth is

$$PIF_{WB} = PIM_{WB}\left(\frac{BW_{IF}}{3BW_{WB}}\right)$$

which can be related to the narrowband intermodulation product power using the expressions above:

$$PIF_{WB} = PIM_{WB}\left(\frac{BW_{IF}}{3BW_{WB}}\right) = PIM_{NB}\eta^3\left(\frac{BW_{IF}}{3BW_{WB}}\right).$$

Now, the ratio of the wideband IF interference power to narrowband IF interference power is given by

$$\frac{PIF_{WB}}{PIF_{NB}} = \frac{PIM_{NB}\eta^3 BW_{IF}\,3BW_{NB}}{PIM_{NB}BW_{IF}\,3BW_{WB}} = \frac{\eta^3 BW_{NB}}{BW_{WB}} = \frac{\eta^3}{\eta} = \eta^2\ .$$

Thus, a pair of wideband interferers will create more harmful interference than a pair of

[1]In general, the bandwidth of an IM product is a function of the order of the product and is roughly equal to the sum of the products of each interferer's bandwidth and its IM product coefficient (a crude but useful approximation). Thus, a 2A-B type product would have three times the bandwidth of the two equal bandwidth interferers.

narrowband interferers (with the same power spectral density) by a factor equal to the square of the ratio of the wideband interferer bandwidth to the narrowband interferer bandwidth. Consider some examples:

UMTS (5 MHz) versus GSM (200 kHz), impact = 28 dB

CDMA (1.25 MHz) versus GSM (200 kHz), impact = 16 dB

UMTS (5 MHz) versus CDMA (1.25 MHz), impact = 12 dB

LTE (10 MHz) versus CDMA (1.25 MHz), impact = 18 dB

LTE (10 MHz) versus UMTS (5 MHz), impact = 6 dB

Another way to think about this problem is that the wideband interferer puts less power into the IF in *direct* proportion to the bandwidth ratio but its IM product is stronger by a factor equal to the *cube* of the bandwidth ratio. **Thus, interferer power wins out over bandwidth and a PFD limit based directly on power spectral density should not be used**. Further, real-world receivers are much more complex than the simple linear amplifier model would indicate due to AGC and other considerations, so it is best to base the PFD limit on measurements with *actual* interferers and derive the standard from these measurements, as Pericle has done.