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

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

These reply comments are submitted in response to FCC 14-181, Report and Order and Further Notice of Proposed Rulemaking, adopted November 7, 2014.

Pericle Communications Company ("Pericle") is a consulting engineering firm specializing in wireless communications. Founded in 1992, Pericle consults for the public safety, personal wireless, transportation and broadcast industries. Through its client, the City and County of Denver, the company was deeply involved in the formulation of the 800 MHz rebanding plan adopted by the Commission in 2004. Pericle continues to help public safety agencies hunt down and resolve 800 MHz interference, including recent work for the City of Oakland, California.

Shulman, Rogers, Gandal, Pordy & Ecker, P.A. ("Shulman Rogers") is a full service law firm located in Potomac, Maryland. The Firm's Telecommunications Department represents clients involved in all areas of communications, including private radio, common carrier, broadband and broadcast. The firm also represents hundreds of public safety licensees (state, counties and cities) in securing spectrum for their operations and negotiations involving the 800 MHz Rebanding Program.

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I. SUMMARY

Pericle and Shulman Rogers file these joint reply comments based upon each firm's work for over ten years in mitigating interference from cellular licensees to public safety entities. Pericle and Shulman Rogers' work in this area is extensively documented in WT Docket No. 02-55, and supplemented with current experience attempting to achieve cellular interference mitigation in various areas of the country, most particularly Oakland, California and Ann Arbor, Michigan.

While the band separation created by 800 MHz rebanding greatly mitigated the public safety interference problem, public safety radios are still vulnerable to cellular band interference. This interference will only increase over time as Sprint builds its new 800 MHz CDMA and LTE networks and both operators build new sites with low antenna heights. Increasing the authorized cellular band ERP will only worsen this problem unless it is accompanied by a power flux density (PFD) limit.

We have no objection to adopting new ERP and power spectral density limits in this band and we are sympathetic with the desire to harmonize with the 700 MHz band, but these rule changes must be accompanied by a limit on PFD. Further, Verizon's proposed power flux density limit of 3,000 $\mu W/m^2$ will result in significant interference to some manufacturer's radios in some jurisdictions, and for this reason, we ask that the FCC emphasize that its proposed rules do not excuse the cellular operator from compliance with Parts 22.970-22.973. In addition, we encourage the FCC to adopt receiver standards as a permanent solution to this problem, using comments on ET Docket No. 13-101 as the basis for these standards.

Strong forward link cellular radio carriers create two types of interference in the public safety subscriber radio receiver: blocking and receiver intermodulation (IM). Our previous comments on this proceeding disclosed the measured strong signal intermodulation (SSIM) rejection performance of several public safety portable subscriber radios, showing that vulnerability to receiver intermodulation from strong interferers (-40 to -10 dBm) varies dramatically between radio vendors and between different models from the same vendor. These measurements were conducted using narrowband FM interferers, similar to the small signal receiver intermodulation test specified in TIA-603-D. Also, these measurements were limited to 3rd order intermodulation products of the type 2A-B and did not consider 5th order products of the type 3A-2B.

In the field, 800 MHz public safety subscriber radios are exposed to narrowband (GSM) and wideband (CDMA, UMTS, LTE) interferers. Wideband cellular interference is different than narrowband because, for the same average interference power, the interferer power density is much lower than a narrowband interferer, resulting in less intermodulation product power in the IF bandwidth of the receiver. On the other hand, modern wideband cellular signals employ modulation schemes with high peak-to-average ratio which might result in worse performance than FM for the same average power.

These reply comments address these two technical issues by summarizing new subscriber radio measurements conducted using these wideband interferers and new measurements of 5th order SSIM rejection.

II. SSIM REJECTION MEASUREMENTS

Pericle operates a well furnished electronics laboratory with a suite of calibrated test equipment, including signal generators, vector signal analyzers and land mobile radio service monitors. The firm has measured subscriber radio performance and vulnerability to strong signals since its early work for the City and County of Denver starting in 2001.

A. Intermodulation Products from Cellular Radio Carriers

The two main types of interference created by strong cellular signals are blocking and strong signal intermodulation. Both occur in the public safety receiver.

Blocking is caused by one or more strong interfering signals within the RF passband of the receiver that do not have the mathematical relationship to cause intermodulation. It is measured referenced to the receiver's sensitivity (typically -120 dBm) and a good receiver will achieve blocking rejection between 95 and 105 dB.[1]

Strong signal intermodulation is a mixing of two or more interfering signals in the receiver front end to create an intermodulation product that overlaps the receive frequency. The strong signal IM rejection at interfering levels of -13 dBm, for example, vary widely by manufacturer make and model and can range from 40 dB to 75 dB. Even the best make and model radio does not match typical blocking rejection. Thus, SSIM, when it occurs, is the most difficult type of interference to mitigate. SSIM rejection is rarely published by the radio manufacturer and two radios with similar small signal IM rejection can have widely different SSIM rejection.

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[1] Pericle has measured blocking rejection of several public safety radio makes and models using the TIA-603-D method.

Because of frequency separation between bands, an A-Band cell site alone normally causes blocking or 5th order IM (which are weaker) rather than 3rd order IM because for third order products to fall in the public safety band, the upper 1.5 MHz of the band (890-891.5 MHz) must be involved and frequencies this high are normally attenuated by the receiver's filter. Sprint, on the other hand, operates with two wideband carriers and can put IM products in the upper part of the public safety band. This behavior is shown in the upper half of Figure 1.

The worst-case situation is a co-location of Sprint and the A-Band operator. In this case, three third-order products together span the *entire* public safety band, from 851 to 861 MHz. See the lower half of Figure 1.

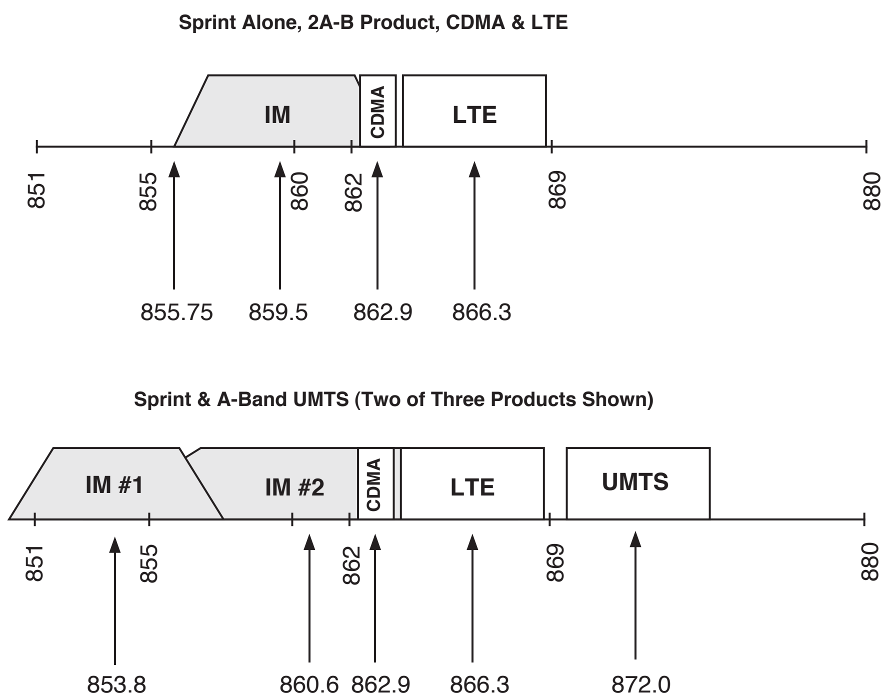

Figure 1 - 800 MHz Cellular 3rd Order Intermodulation Products (amplitude not to scale)[2]

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[2] The third product in the co-location case is A+B-C type, roughly 12.25 MHz wide and centered on 856.7 MHz. 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). The power density of these IM products is typically not uniform even if each interferer is uniform (i.e., square) because the convolution of the two signals creates a trapezoidal shape in the frequency domain.

Fifth order products of the type 3A-2B can occur solely between radio carriers in the A-Band and do not require Sprint radio carriers for the IM product to fall in the public safety band, as shown in Figure 2. In Figure 2, IM product #1 is a 5th order mix between the two UMTS carriers while IM product #2 is a 5th order mix between the lowest GSM carrier (869.4 MHz) and the upper UMTS carrier (877 MHz).

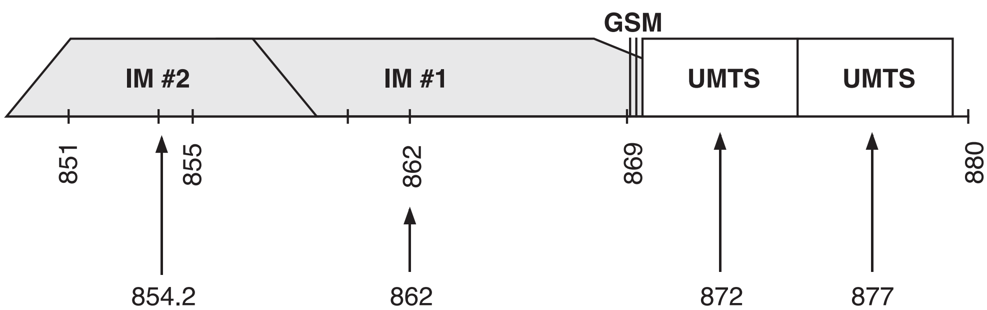

Figure 2 - 800 MHz 5th Order Cellular Intermodulation Products (amplitude not to scale)

B. Measured SSIM Rejection Performance

In our previous comments, we presented SSIM rejection of four public safety radios from two different manufacturers, using narrowband interferers and considering just 3rd order products. Here, we present the results of new measurements of portable subscriber radios from the two original manufacturers and a new, third manufacturer and this time using wideband interferers and considering both 3rd order and 5th order products.

Referring back to Figure 3 of our original comments, Vendor 1, Model A is now referred to as Radio 1, Vendor 2, Model B is Radio 2 and a new portable radio from a third manufacturer is Radio 3. All three vendors are leading public safety radio manufacturers and the radios tested are both new models (Radio 1 and Radio 3) and an old model (Radio 2), but all are still widely used in P25 networks.

Third-order SSIM rejection is plotted in Figure 3 for each of the three radios and for both narrowband and wideband interferer cases.

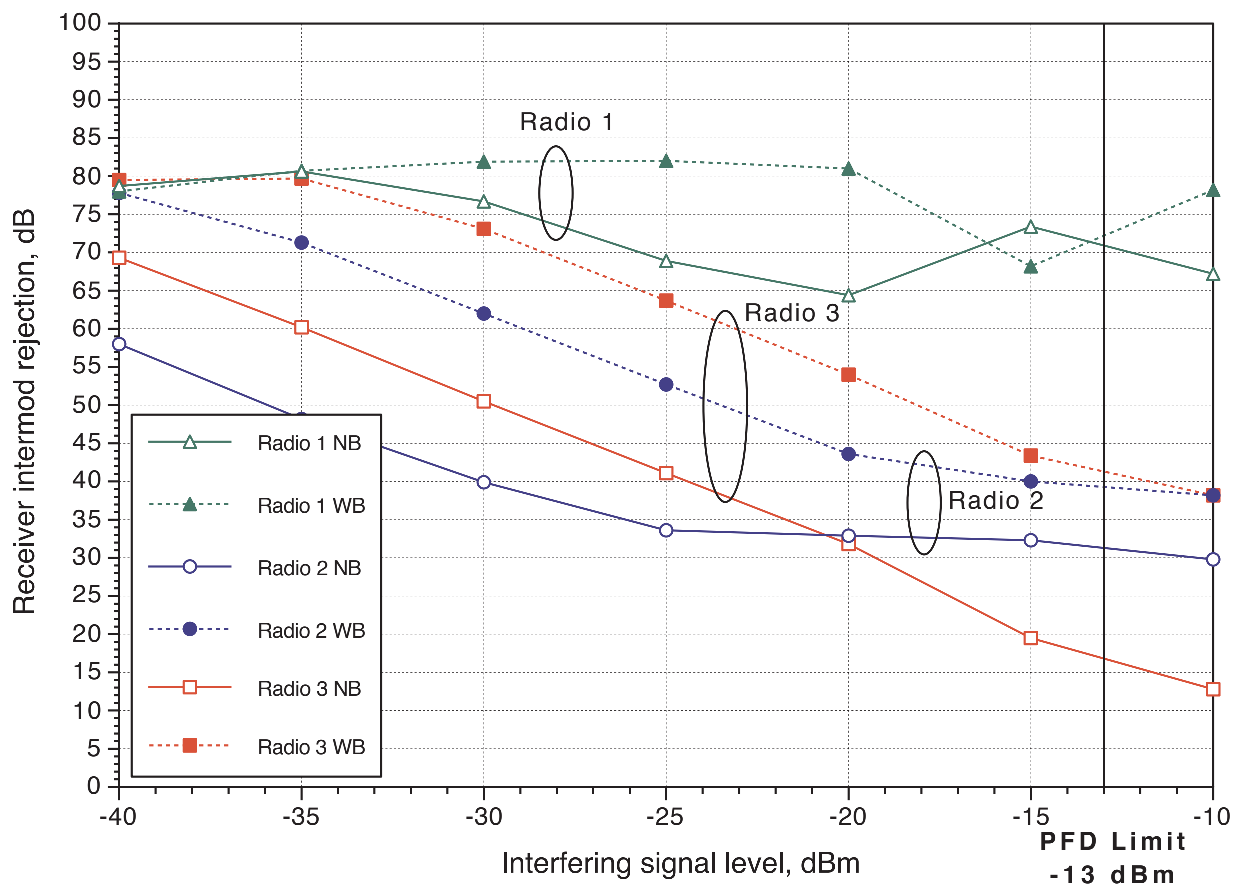

Figure 3 - 3rd Order SSIM Rejection for Three Portable Radios

In the case of the wideband interferers, one CDMA and one UMTS signal were generated on the bench. As expected, performance generally improves for wideband interferers, presumably due to the lower power density, but the improvement is not the same for all radios. Radio 2, for example, improves by less than 9 dB at -13 dBm despite the fact that the power density of the wideband interferers was lower by more than 20 dB. Radio 3 (a modern P25-

capable radio) improves by 25 dB, but the narrowband performance was much worse than the other two radios. Radio 1 shows improvement for interference levels between -35 and -16 dBm and is slightly worst over a narrow range of interferer levels around -15 dBm. Overall, Radio 1 is superior to the other two radios and to any that Pericle has measured to date.

A measure of the goodness of each radio operating in the presence signals at the 3,000 $\mu W/m^2$ PFD limit (equivalent to -13 dBm) is the minimum desired signal level required to overcome the resulting SSIM interference. This level is listed in Table 1 for each radio and for both the narrowband and wideband cases (3rd order only).

Table 1 - Minimum Desired Signal to Overcome 3rd Order SSIM Interference (Two equal power interferers at -13 dBm, CDMA + UMTS)

Portable Radio	Narrowband	Wideband	Units
Radio 1	-84.5	-85.5	dBm
Radio 2	-44.0	-52.0	dBm
Radio 3	-29.5	-55.0	dBm

Consider the wideband case in Table 1. To overcome interference at the level of Verizon's proposed PFD limit, Radio 1 requires a minimum desired signal level of -85.5 dBm which is a common outdoor signal level in a well-designed urban trunked radio network. Radio 3, on the other hand, requires a minimum signal level of -55 dBm to overcome the same interference, a level which generally occurs only in the immediate vicinity of a repeater site. Radio 2 is 3 dB worse than Radio 3 and will encounter more areas of harmful interference.

As mentioned previously in these reply comments, it is not necessary for the Sprint and A-Band sites to be co-located for harmful SSIM to occur. An isolated A-band site can cause third order IM if radio carriers from the extended band (890-891.5 MHz) are part of the mix or if the mix is 5th order. It is common in the U.S. for the A-Band operator to employ GSM carriers in the 869-870 MHz portion of the band and UMTS carriers at 872 and 877 MHz. GSM is more problematic than UMTS due to the higher power density (GSM is 200 kHz wide while UMTS is nominally 5 MHz wide). In Figure 4, we have plotted the 5th order SSIM rejection performance of the three radios using a 3A-2B type mix between the lowest GSM carrier (869.4 MHz) and the upper UMTS carrier (877.0 MHz).

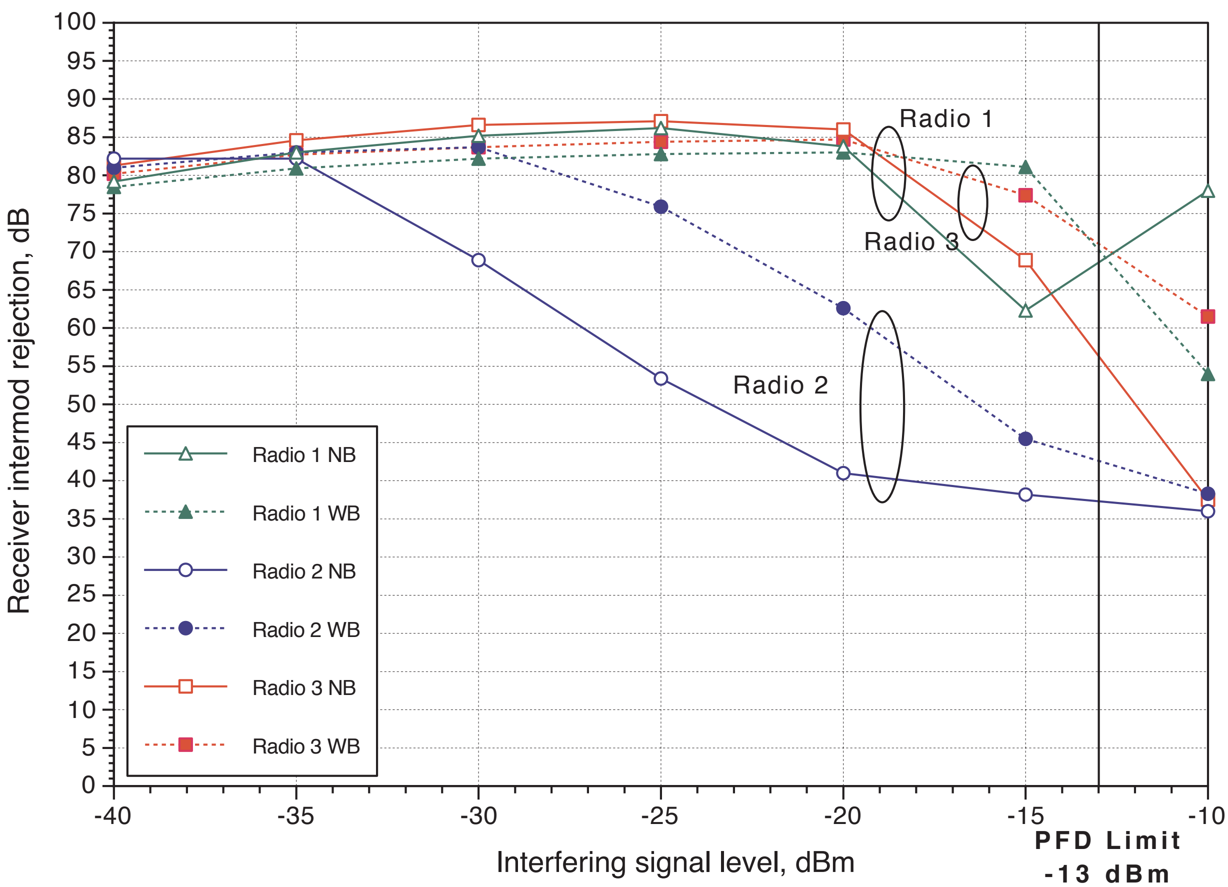

Figure 4 - 5th Order SSIM Rejection for Three Portable Radios (GSM+UMTS)

From Figure 4 we see that rejection of the 5th order product, despite the greater power density of the GSM carrier, is better than 3rd order for Radios 1 and 3. Radio 2 is significantly worse than the other two radios. The minimum desired signal required to overcome the 5th order

SSIM is listed in Table 2 for each radio and for both the narrowband and wideband cases.

Table 2 - Minimum Desired Signal to Overcome 5th Order SSIM Interference (Two equal power interferers at -13 dBm, GSM + UMTS)			
Portable Radio	**Narrowband**	**Wideband**	**Units**
Radio 1	-81.5	-83.5	dBm
Radio 2	-50.0	-56.0	dBm
Radio 3	-69.0	-84.0	dBm

We see from Table 2 that 5th order SSIM rejection, while somewhat better than 3rd order SSIM, is still a problem, especially for Radio 2 where a desired signal of -56 dBm is required to overcome interference coming from a single A-Band cell site producing the proposed PFD limit on the ground.

III. RECOMMENDATIONS AND CONCLUSIONS

Adoption of the proposed rules for increased ERP in the cellular 800 MHz band in the absence of ground-level PFD limitations is likely to have a significant detrimental effect on public safety radio performance in the immediate vicinity of 800 MHz cell sites, especially Sprint cell sites and co-located Sprint and A-Band cell sites. This is largely a receiver performance issue, but the receiver problem will not be corrected in the near term. While future generations of equipment may be more interference-resistant, a large-scale, nationwide replacement of public safety equipment is not a feasible alternative today. Thus, the Commission must deal with the interference environment as it stands today, while addressing future equipment requirements in ET Docket No. 13-101. Toward that end, a limit on ground level power flux density is essential and must be adopted as part of the proposed rules.

Measurements of strong signal intermodulation rejection show that Verizon's proposed PFD limit of 3,000 μW/m^2 (equivalent to -13.2 dBm in the public safety receiver) will cause harmful interference to many existing receivers in many U.S. jurisdictions. Because of their lower power density, wideband cellular radio carriers create less harm than narrowband carriers, but subscriber radios from leading manufacturers are still vulnerable to harmful interference. This conclusion is borne out by lab measurements and also by field experience in Oakland, CA; Ann Arbor, MI; Charleston, SC and other U.S. cities. Consequently, it is important that the Commission protect public safety users by adopting the recommendations made in our January 21, 2015 comments.

Respectfully submitted,

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

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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

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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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