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.

Respectfully submitted,

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June 25, 2015

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SUMMARY

These *ex parte* comments are submitted in response to FCC 14-181, Report and Order and Further Notice of Proposed Rulemaking, adopted November 7, 2014. Pericle and Shulman Rogers have no objection to the Commission's adoption of new ERP and power spectral density limits in the 800 MHz cellular band but these rule changes must be accompanied by a limit on power flux density (PFD). In its comments, Verizon Wireless proposed a PFD limit of 3,000 $\mu W/m^2$ (-13.2 dBm at the antenna terminal) and we showed that a PFD limit this high will cause significant harmful interference to some manufacturer's radios.

Pericle has measured strong signal intermodulation SSIM rejection of additional new and old portable radios since our Reply Comments were filed on February 20, 2015. We found that several radios exhibit a marked drop in performance at interferer levels near -20 dBm versus the -13.2 dBm level proposed by Verizon. Accordingly, we recommend that the FCC adopt an interim power flux density of 625 $\mu W/m^2$ (equivalent to -20 dBm at the antenna terminal) with a goal of transitioning to 3,000 $\mu W/m^2$ over some period that would enable a significant number of radios to be replaced with better-performing models.

Following the philosophy of harm claim thresholds, we suggest that flux densities above 625 $\mu W/m^2$ and eventually above 3,000 $\mu W/m^2$ are not necessarily violations of the rules, but their existence entitles the public safety agency to remedies, including reimbursement of reasonable expenses incurred during the discovery and remediation process. In accordance with Parts 22.970 - 22.973, cellular operators would continue to cooperate and mitigate interference to agencies with qualifying radios and minimum desired signal levels in the vicinity of the offending cell site, *regardless* of measured power flux density on the ground.

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I. BACKGROUND

In our previous Comments and Reply Comments to this NPRM, Pericle and Shulman Rogers stated we have no objection to the Commission's adoption of new ERP and power spectral density limits in the 800 MHz cellular band and we are sympathetic with the desire to harmonize with the 700 MHz band, but these rule changes must include a limit on power flux density (PFD). We also showed that Verizon's proposed PFD limit of 3,000 $\mu W/m^2$ will result in significant interference to some manufacturer's radios. The full extent of the problem is exceedingly difficult to know as significant detective work is required on the part of the public safety agency to gain even a cursory understanding at each problem location. Most public safety agencies are short on resources and react to complaints rather than seek out problems

where complaints have yet to surface.[1]

In these comments we seek to answer the question: If a PFD limit of 3,000 $\mu W/m^2$ is too high, what is the alternative? Setting a single power flux density limit that is fair to all parties is difficult because the agency's susceptibility to strong signal intermodulation (SSIM) depends on many factors:

- Performance of the radio receiver, which varies widely between manufacturers and between models from the same manufacturer.
- The number of good and poor performing radios in service which we can only guess because no nationwide database exists of such information.
- The amplitude of the desired signal on the ground
- The number and elevation of the cellular operator's sector antennas
- The number of co-located cellular A-Band and ESMR cell sites in the jurisdiction (the worst-case scenario)

Since we filed our Reply Comments on February 20, 2015, we have measured SSIM rejection of several more new and old portable radios. At least one leading manufacturer's newest portable radio already exhibits acceptable SSIM rejection and one other manufacturer recently introduced a new model that shows marked improvement over its existing radios. While we are encouraged by these results, there are still millions of older model radios in service from these and other manufacturers and it will be many years before a substantial number of these

[1] This highlights a significant problem with the structure of the Commission's Rules. Public safety agencies are expected to contribute to these extremely important rulemakings and these contributions require significant field work. Yet these efforts, which benefit the commercial wireless provider, are not compensated. As a result, the public must fund such efforts or the wireless provider's claims go unchecked. Pericle and Shulman Rogers have undertaken this work on behalf of the public safety industry on a *pro bono* basis to ensure public safety interests are protected.

radios are replaced.

Several radios show a significant drop in performance at interferer levels near -20 dBm. Toward that end, we recommend that the FCC adopt an interim power flux density of 625 $\mu W/m^2$ (equivalent to -20 dBm at the antenna terminal) with a goal of transitioning to 3,000 $\mu W/m^2$ over some reasonable period that would enable a significant number of radios to be replaced with better-performing models.

II. NEW 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. New measurements were collected this spring on several additional radios in an attempt to better understand the susceptibility of popular portable radios used by U.S. public safety agencies.

A. Radios Tested

Radios were tested from four leading manufacturers, Motorola Solutions, Harris Corp., Kenwood and Tait. A radio from EF Johnson was requested, but was not available before these comments were prepared. In keeping with our past approach, we use generic labels for each radio and do not identify manufacturer by name. Our intent is to convey an understanding of the scope of the problem rather than invite protests from competing manufacturers seeking to improve their standing in the market. Separate from this NPRM, we do encourage public safety agencies to specify SSIM rejection in requests for proposal for new land mobile radio systems.

The following radios have been tested to date using broadband cellular interfering signals. The first digit indicates manufacturer and second digit indicates model.

Manufacturer #1.

Radio 1.1 - New model marketed to public safety agencies. *Identified as Radio 1 in our Reply Comments*. This is the best performer overall. It employs two stages of AGC and a sophisticated algorithm to maximize SSIM rejection. Performance presented here is the basic performance. An optional advanced RF AGC feature was also tested and it provides better performance for interferers between -25 and -15 dBm, including a 17 dB improvement in SSIM rejection at -20 dBm.

Radio 1.2 - Older but very popular model, P25 Phase I compatible. There are estimated to be several million of this model radio in service. Important due to its very large customer base.

Manufacturer #2.

Radio 2.1 - New model. Main public safety portable for this manufacturer.

Radio 2.2 - Recently developed enhanced version of Radio 2.1. Significantly better SSIM rejection. Shows an awareness and appreciation for the SSIM problem.

Radio 2.3 - New model. Same generation as Radio 2.1. Lower cost version marketed for public safety and non-public safety applications.

Radio 2.4 - Older model, P25 Phase I compatible. *Identified as Radio 2 in our Reply Comments*.

Manufacturer #3.

Radio 3.1 - Current P25 model marketed to public safety agencies. *Identified as Radio 3*

in our Reply Comments.

Radio 3.2 - Newest model, NXDN with upgrade path to P25.

Manufacturer #4.

Radio 4.1 - Current model marketed to public safety agencies.

B. Third Order Intermodulation Products from Cellular Radio Carriers

The potential third order products are shown in Figure 1. The portable radios identified above were measured using the third order product created by mixing the Sprint CDMA carrier with the A-Band operator UMTS carrier (IM #1 in Figure 1).

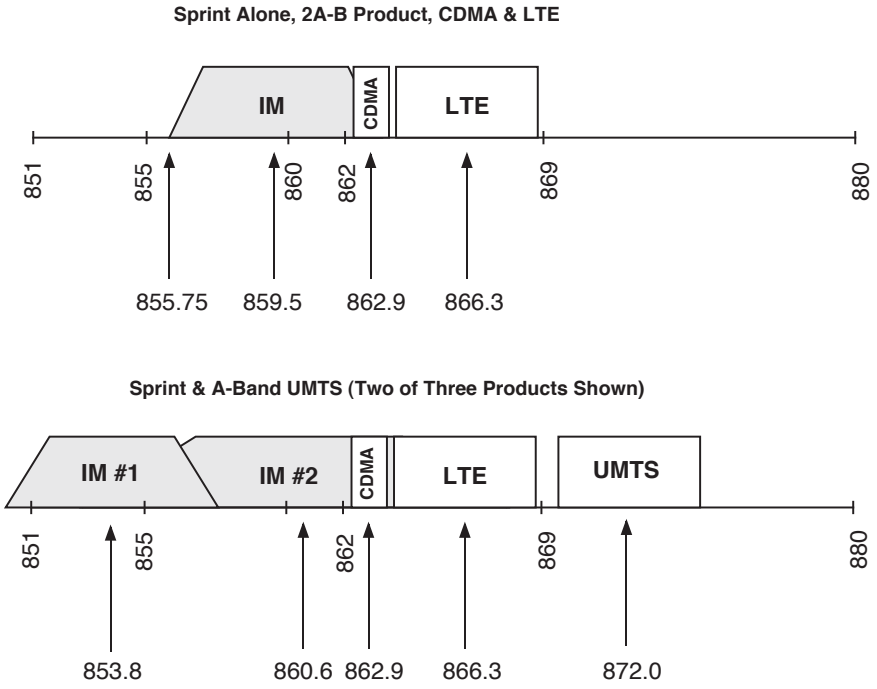

Figure 1 - 800 MHz Cellular 3rd Order Intermodulation Products (amplitude not to scale)[2]

[2] The third product in the co-location case is A+B-C type, roughly 12.25 MHz wide and centered on 857.2 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.

The results of these measurements are shown in Table 1. Note that Radio 1.1 is the best performer, but the older radio from this same manufacturer (Radio 1.2) is one of the worst performers for interfering signals above -20 dBm. This result is unfortunate because so many of this model radio are still in use.

Table 1 - Third Order Strong Signal IM Rejection of Various Public Safety Portable Radios (dB)							
	Broadband Interferer Power Level (dBm)						
Vendor & Model	**-40**	**-35**	**-30**	**-25**	**-20**	**-15**	**-10**
Radio 1.1	78.0	80.7	81.9	82.0	81.0	68.2	78.2
Radio 1.2	78.5	78.5	71.8	62.5	51.5	41.2	35.5
Radio 2.1	79.0	79.0	72.0	62.5	53.0	51.2	50.5
Radio 2.2	77.5	80.5	81.8	82.2	80.5	73.5	63.5
Radio 2.1 with ext. filter	78.8	81.0	81.5	78.8	70.5	60.5	56.8
Radio 2.3	78.0	79.2	75.5	66.5	50.5	38.0	33.5
Radio 2.4	77.8	71.3	62.0	52.7	43.6	40.0	38.2
Radio 3.1	79.5	79.7	73.1	63.7	54.0	43.4	38.2
Radio 3.2	79.0	80.0	75.2	67.5	58.5	47.0	42.0
Radio 4.1	80.0	81.8	82.0	80.2	74.8	70.0	63.0

We see that the enhanced version of Radio 2.1 (Radio 2.2) does in fact provide significantly better performance above -25 dBm. This same manufacturer developed an external filter that is inserted between the radio antenna port and the portable antenna. Performance of Radio 2.1 with this filter is also shown in Table 1. The external filter might be a low cost alternative to replacing radios, but further evaluation is needed by user agencies. Durability and altered antenna performance are legitimate concerns. An alternative version with the filter molded into the antenna base is desirable.

It is encouraging that a manufacturer is considering this type of solution. The transmission plot of the filter is shown in Figure 2. Note that the device is essentially a bandstop filter for the cellular A-Band.

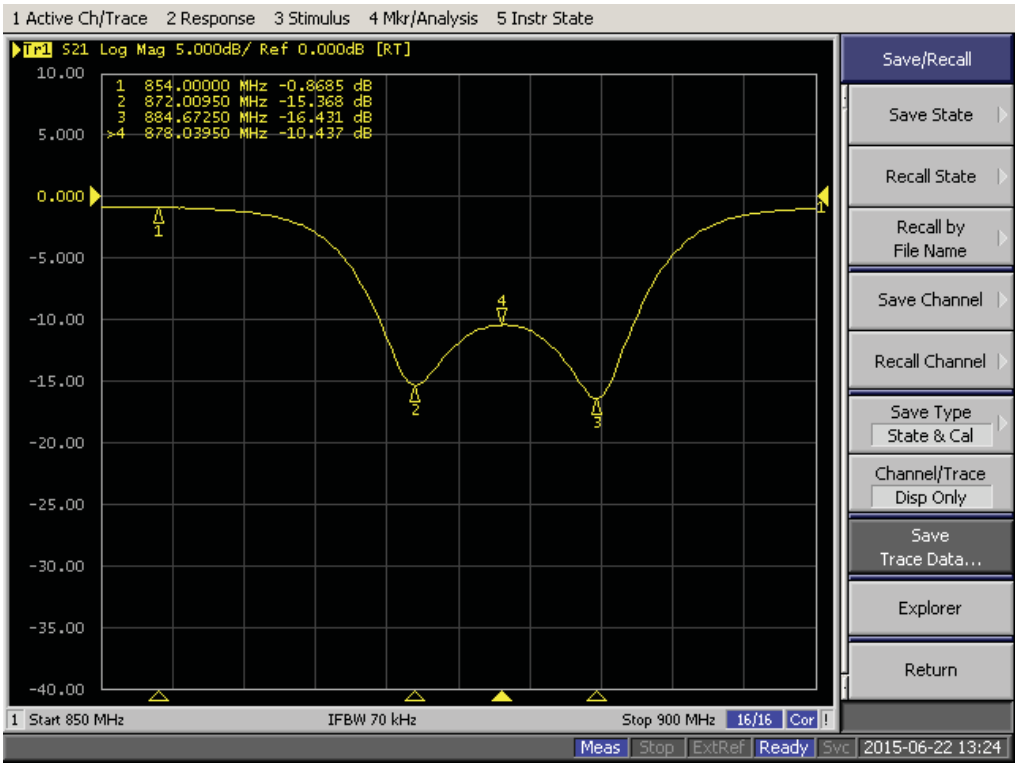

Figure 2 - Transmission (S12) Plot of External Bandstop Filter

Another observation from Table 1 is that two *new* model radios perform very poorly in the presence of Verizon's recommended PFD limit of 3,000 μW/m^2 (-13.2 dBm at the antenna terminal). These are Radio 2.3 and Radio 3.1 which perform as bad or worse than Radio 2.4 which is obsolete but still in service. Thus improvements in new radios are uneven and sufficient market pressures do not yet exist to bring all manufacturers up to an acceptable standard.[3]

C. Fifth Order Intermodulation Products from Cellular Radio Carriers

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,

[3] It should be noted that all of these radios meet the Commission's definition of a public safety grade radio, and therefore entitled to protection from broadband interference under the Commission's Rules.

as shown in Figure 3. In Figure 3, 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).

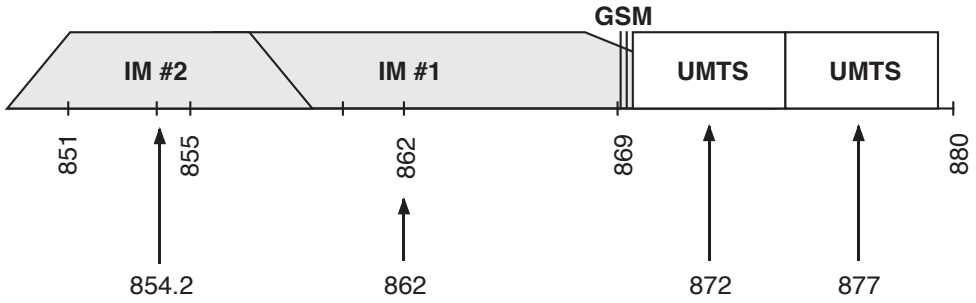

Figure 3 - 800 MHz 5th Order Cellular Intermodulation Products (amplitude not to scale)

The radios identified above were measured for 5th order SSIM rejection using the GSM/ UMTS IM product, IM #2 in Figure 3. The results are shown in Table 2.

Table 2 - Fifth Order Strong Signal IM Rejection of Various Public Safety Portable Radios (dB)							
	Broadband Interferer Power Level (dBm)						
Vendor & Model	-40	-35	-30	-25	-20	-15	-10
Radio 1.1	78.5	80.9	82.2	82.8	83.0	81.1	54.0
Radio 1.2	78.8	81.0	82.0	82.5	82.0	65.5	48.8
Radio 2.1	79.2	81.5	82.5	83.0	82.0	69.0	57.8
Radio 2.2	77.8	81.0	82.2	82.8	83.0	83.0	83.0
Radio 2.1 with ext. filter	79.0	81.5	82.5	83.0	83.0	83.0	82.5
Radio 2.3	78.0	80.5	81.5	82.0	72.8	59.5	48.8
Radio 2.4	81.0	83.0	83.7	75.9	62.6	45.5	38.3
Radio 3.1	80.2	82.7	83.7	84.4	84.7	77.4	61.5
Radio 3.2	79.2	81.5	82.5	83.0	82.0	68.5	55.5
Radio 4.1	80.5	82.0	82.8	83.0	83.2	83.0	80.2

Fifth order IM rejection is better than third order rejection, as expected. Radios 1.2, 2.3 and 2.4 are the weak performers at high interferer signal levels. Interestingly, Radio 1.1 performs relatively poorly at an interfering signal level of -10 dBm but otherwise does very well. The best overall fifth order performance belongs to Radio 2.2 and Radio 4.1.

D. Effects of Poor SSIM Rejection in the Field

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 -13.2 dBm) is the minimum desired signal level required to overcome the resulting SSIM interference. This level is simply the interferer power level in dBm minus the SSIM rejection in dB. It is listed in Table 3 for three radios.

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

Portable Radio	Wideband	Units
Radio 1.1	-85.5	dBm
Radio 2.4	-52.0	dBm
Radio 3.1	-55.0	dBm

From Table 3 we see that to overcome interference at the level of Verizon's proposed PFD limit, Radio 1.1 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 3.1, 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 2.4 is 3 dB worse than Radio 3.1 and will encounter more areas of harmful interference.

We can show this result graphically using coverage measurements collected in Newport News, a city with an 800 MHz trunked radio system. The City operates three repeater sites and in Figure 4, we have color-coded measurements of the desired signal levels according to the -52 dBm and -85.5 dBm thresholds, corresponding to the minimum signal level required for Radio 2.4 and Radio 1.1, respectively. Green indicates those areas where the desired signal is strong

enough to overcome cell site interference at a level of -13.2 dBm using Radio 2.4 (the worst performer) while green plus yellow indicates where the desired signal is strong enough to overcome cell site interference at -13.2 dBm using Radio 1.1 (the best performer). Stated another way, Radio 1.1 can operate interference-free in 96.4% of the City while Radio 2.4 can operate interference-free in only 13.6% of the City. In our experience, the distribution of desired signals in Newport News is typical of a well-designed urban 800 MHz trunked radio system.

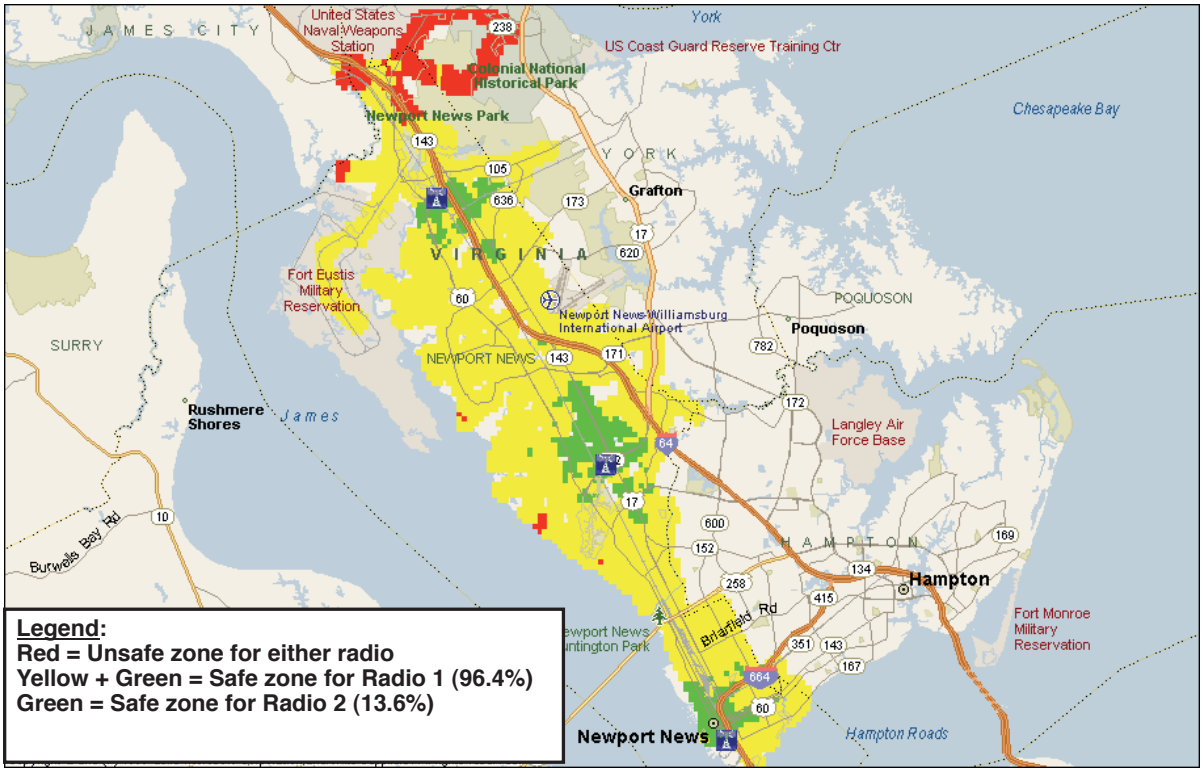

Figure 4 - Newport News Drive Test Results

Pericle's consulting practice has encountered or is aware of SSIM interference in several cities as described in our original Comments. This spring, we participated in mitigation of one interfering cell site in Arvada, CO and two in Denver, CO.

III. CONCLUSIONS AND RECOMMENDATIONS

While there is no clear breakpoint that applies to all radio models where performance drops precipitously, we do observe that several radios degrade rapidly above -20 dBm and one of these radios, Radio 1.2, is widely used (we estimate several million units in the U.S.). This particular radio is in its second year of a seven-year manufacturer phase out and a significant number will remain in service even after this time, based on past experience. Accordingly, we recommend the FCC adopt an interim PFD limit of 625 $\mu W/m^2$, (corresponding to -20 dBm at the antenna terminal) with an ultimate PFD limit of 3,000 $\mu W/m^2$. These limits should be treated similarly to a harm claim threshold. Ground level power flux densities above the limit are not necessarily a violation of the rules, nor would they cause harmful interference in all cases, but their existence entitles the public safety agency to remedies, including reimbursement of reasonable expenses incurred during the discovery and remediation process. FCC Parts 22.970 - 22.973 would remain in effect.

Respectfully submitted,

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June 25, 2015