Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of Part 15 of the	)	ET Docket No. 99-231
Commission's Rules Regarding	)	
Spread Spectrum Devices	)	

REPLY COMMENTS OF
PROXIM, INC. AND MICRILOR, INC.

Proxim, Inc. ("Proxim") and Micrilor, Inc. ("Micrilor") hereby submit these joint reply comments in support of the Commission's proposal to refine its rules governing the measurement of the processing gain of direct sequence ("DS") spread spectrum systems.

In separate initial comments filed in this proceeding, Micrilor and Proxim commented that:

- The current CW Jamming Margin test is flawed when used with systems that employ fewer than ten chips per symbol.
- The Gaussian Noise test yields substantially more reliable results for systems with low chipping rates (*i.e.*, fewer than ten chips per symbol). It is based upon the well-accepted Jamming Margin equation but, in contrast to the existing CW Jamming Margin test, it employs valid statistics to determine the required signal-to-noise ratio.
- The Gaussian Noise test is easier to perform and easier to specify than the existing test.

For all of these reasons, Proxim and Micrilor urged the Commission to substitute a Gaussian Noise test for its current CW Jamming Margin Test for low chipping rate DS systems.

A relatively small number of companies commented on the Commission's proposal to refine its DS measurement rules. Two companies in addition to Micrilor and Proxim – Aironet and Nortel Networks – supported use of the Gaussian Noise test.[1] Aironet's support is particularly noteworthy because Aironet's products employ eight chips per symbol and, as a result, will be affected directly by the proposed changes. Aironet's conclusions that the Gaussian Noise test is achievable for low chipping rate systems, is easily implemented, and is equitable therefore merit substantial weight.

[1] In addition, WLANA and Samsung "applaud[ed]" the Commission's efforts to clarify its processing gain measurement rules but did not take a position on the Commission's specific proposals. WLANA Comments at 2; Samsung Comments at 1.

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One additional entity – BreezeCOM – agreed that many recently introduced DS systems are "abusing" the jamming margin definition and, fairly measured, do not meet the Commission's processing gain requirements. BreezeCOM, however, contended that the Commission should permit at least some non-compliant equipment to operate as long as these devices are capable of falling back to a slower data rate if interference levels increase.

In contrast, four entities (Apple Computer, Intersil, Lucent Technologies, and the IEEE 802.11 LAN/MAN Standards Committee) opposed use of the Gaussian Noise test and argued that use of a CW jamming margin test with mathematical proof standard should be employed, while one entity (Glenayre Western Multiplex) opposed any change to the existing rules.[2] An additional two entities (Clearwire Technologies and the Wireless Ethernet Compatibility Alliance) did not take a position on the use of a Gaussian Noise test *per se*, but contended that the Notice of Proposed Rulemaking ("NPRM") did not discuss the matter with sufficient specificity and, therefore, urged the Commission to defer this issue to a subsequent Notice of Proposed Rulemaking.

As discussed in Proxim and Micrilor's comments and in these reply comments, the use of a Gaussian Noise test will provide substantial benefits. Moreover, the opponents' claims – that this test has not yet been described with the necessary specificity, that it will be too difficult to use in practice, or that an alternative method based on the existing CW Jamming Margin test also should be allowed – are technically without foundation and misplaced as a matter of policy.

I. THE CURRENT CW JAMMING MARGIN TEST SHOULD BE REPLACED.

As discussed in the NPRM, it is important to ensure that only "true" spread spectrum systems are certified under the Commission's spread spectrum rules.[3] The authorization of non-spread systems under the spread spectrum rules causes two distinct problems.

First, it increases interference in the spread spectrum bands. Spread spectrum systems are allowed to operate at higher power levels than other Part 15 devices because they have less potential

[2] Nortel stated that it "supports the Commission's proposal, included in the Notice, to clarify the jamming test for direct sequence systems employing fewer than 10 chips/symbol." Nortel Comments at 2. Because the Commission's proposal contained two separate elements, it is unclear whether Nortel supports use of the Gaussian Noise test, supports the use of the CW Jamming Margin test with mathematical proofs, or both.

[3] NPRM at ¶ 11.

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to produce harmful interference than non-spread systems.[4] If non-spread spectrum systems operate at these higher power levels, they will increase the interference suffered by other users of the bands and undermine efficient operation within the bands.

Second, allowing non-spread spectrum systems to invoke the spread spectrum rules confers an anticompetitive advantage on certain entities, allowing them to obtain the benefits of the spread spectrum rules without also accepting the constraints imposed by those rules.

Yet the Commission's rules, as currently written, do not ensure that only "true" spread spectrum systems are certified under the spread spectrum rules. This failure results from the fact that one of the two tests used to determine processing gain – the CW Jamming Margin test – yields questionable results for systems with a low chipping rate.[5] Indeed, several of the proponents of the CW Jamming Margin test effectively conceded in their comments that, without a supplemental mathematical proof, its results cannot be relied upon,[6] and none of the test's defenders offered any technical evidence to counter the Commission's conclusion that the test is unreliable for low chipping rate systems.[7]

The problem created by the low chipping rate "loophole" in the current rules is beginning to be felt. Several companies are manufacturing (and obtaining FCC certification for) DS systems using 8 chips per symbol. These systems lie on the edge of what generally is considered to be a true spread spectrum system: while a well-designed 8 chip-per-symbol system can achieve a processing gain of 10 dB, a poorly-designed 8 chip-per-symbol system cannot when tested using an accurate

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[4] Id. at ¶ 3; compare 47 C.F.R. § 15.209 (general Part 15 radiated emission limits) to 47 C.F.R. § 15.247 (special rules for spread spectrum systems).

[5] Micrilor Comments at Appendix 2; Proxim Comments at 6. Briefly stated, the flaw with the current CW Jamming Margin test arises from the fact that the test was based on military direct-sequence spread-spectrum systems, which used many chips per symbol and which, therefore, resulted in approximately Gaussian post-processing interference distribution, consistent with the use of standard formulas for required SNR based upon Gaussian statistics. Commercial spread-spectrum equipment, in contrast, emphasizes high data rates rather than useful processing gain and, therefore, these systems generally employ a small number of chips per symbol. For small N_C, SNR formulas based upon Gaussian statistics greatly over-estimate the required SNR and, hence, yield higher-than-reasonable values for processing gain.

[6] See Lucent Comments at 6 ("for direct sequence systems with fewer than 10 chips per symbol, a mathematical calculation demonstrating the required 10 dB processing gain should accompany the CW jamming test results") (emphasis added); IEEE 802.11 "Third Ex Parte Letter" at 3 (filed October 2, 1999) (conceding that mathematical justifications are needed to confirm processing gain for systems utilizing codes with fewer than 10 chips); Apple Comments at 2 (same).

[7] Compare NPRM at ¶ 12 to IEEE 802.11 Third Ex Parte Letter at 2, Comments of Intersil Corporation at 1-2; see also Glenayre Western Multiplex Comments at 4-5 (asserting that the current test yields valid results but offering no evidence in support of this assertion).

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measurement procedure.[8] Yet, using the existing "loophole," all of these systems are eligible for certification as spread spectrum systems.

The loophole's effect will become more pronounced as time goes on. Using any reasonable definition, a system using six or four chips per symbol cannot be considered to be a "spread spectrum" system. Yet even these systems could meet the 10 dB processing gain requirement and qualify as spread spectrum systems through the creative manipulation of the current test. For this reason, the Commission should not delay its adoption of a more reliable method for indirectly measuring the processing gain of low chipping rate systems.

II. THE GAUSSIAN NOISE TEST OFFERS SIGNIFICANT BENEFITS OVER THE EXISTING CW JAMMING MARGIN TEST.

A. The Gaussian Noise Test Is More Reliable Than The CW Jamming Margin Test For Low Rate Systems.

As Micrilor and Proxim previously have demonstrated, use of the Gaussian Noise test will restore to the Commission's rules a reliable means of measuring the true processing gain for low chipping rate systems.[9]

None of the comments refuted this basic fact. Notably, even some parties who did not support the Commission's proposal conceded that the existing test has flaws and that the Gaussian Noise Test could be an appropriate measurement standard.[10]

B. The Gaussian Noise Test Is Simple To Implement.

Not only is the Gaussian Noise test significantly more reliable than the CW Jamming Margin test for low chipping rate systems, it also is less complex to employ. As Proxim and Micrilor discussed in their comments, the Gaussian Noise test does not involve more stressing equipment

[8] In order to qualify as a spread spectrum system under the Commission's rules, a system must have a processing gain of 10 dB. 47 C.F.R. § 15.247(e).

[9] E.g., Micrilor Comments at Appendix 1, p. 1 and Appendix 2.

[10] Lucent Comments at 6 (contending that the Gaussian Noise Test will be difficult to use in practice but conceding that, if a specific test procedure existed, this test would be an appropriate measurement standard). As discussed below, Lucent's claims regarding the difficulty of the Gaussian Noise Test are unfounded.

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requirements, in terms of expense and calibration, relative to the CW test, and the actual performance of the Gaussian Noise test is far simpler than the CW test.[11]

Aironet's comments confirmed Micrilor and Proxim's conclusion. According to Aironet, the Gaussian Noise test "is a more direct way of measuring overall processing gain," "provides for a simpler test than the current CW method," and "is a lot less time consuming" to perform.[12] Aironet quantified this fact, demonstrating that the Commission could reduce the number of data points required for a four-data-rate system from 1,280 to 4 (a factor of 320) by replacing the CW Jamming Margin test with a Gaussian Noise test.[13]

The comments of Aironet, Proxim, and Micrilor set forth a simple and reliable test for measuring spread-spectrum processing gain based upon Gaussian Noise interference. A key element is to ensure that the total noise power, measured using a simple power meter, falls within the processed band of the receiver. Micrilor and Proxim recommend that the noise bandwidth be greater than 25% and less than 50% of the transmitted signal's noise-equivalent bandwidth ("NEB"). This information already is documented to the FCC by the manufacturer (the transmitted spectrum), provides for a sufficiently wide bandwidth so that spectral anomalies can be avoided, and will ensure that the total measured noise power is within the processed bandwidth.[14] With this restriction on the Gaussian Noise bandwidth, the detailed specifications of the filters become inconsequential.

The opponents' claims that the Gaussian Noise test will be difficult to implement do not withstand scrutiny. Lucent, for example, went to great lengths in its comments to prove the difficulty of making noise-spectral-density measurements.[15] Yet the Gaussian Noise test requires only power meter measurements for signal and noise – exactly the same measurements as are required under the existing CW jamming margin test. It is well known by practitioners of spread-spectrum signaling that spread spectrum techniques were developed for combating power-limited jamming; spread-

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[11] E.g., Micrilor Comments at Appendix 1, p. 1; Proxim Comments at 6.
[12] Aironet Comments at 4.
[13] Id.
[14] Aironet's proposal is very similar, but would be based upon a hardware detail (receive IF filter) that is not normally specified to the FCC by a manufacturer. As a result, use of the receive IF filter might enable a manufacturer to inflate the measured processing gain by artificially widening the IF bandwidth, then restricting the processed bandwidth in the baseband filter. Thus, while Aironet, Proxim and Micrilor agree that the noise bandwidth used in the processing gain measurement should be limited to about the same range, Proxim and Micrilor urge the Commission to use 25% to 50% of the signal NEB because this is an easier specification to apply and is less subject to manipulation.
[15] Lucent Comments at 5.

spectrum signaling does not provide any improvement against white noise. When the noise is limited in bandwidth, as suggested by Aironet, Proxim and Micrilor, the measurement of noise power becomes no more complex than the power-meter measurement for the desired signal.

Similarly, Intersil and the IEEE 802.11 LAN/MAN Committee contended that the Gaussian Noise test is prone to errors and that "implementation loss plays a more prominent role" in the Gaussian noise test.[16] These claims are without foundation. Implementation losses are a "non-specific" allowance for the deviation from theoretically ideal performance. Some deviation is always anticipated for <u>any</u> design/implementation, but conceptual implementation loss cannot be ascribed any general properties pertaining to any implementation approach.[17] Notably, neither Intersil nor the IEEE 802 Committee even attempted to submit any evidence in support of their claims.

C. Properly Designed 8 Chip Per Symbol Systems Can Pass The Gaussian Noise Test.

Opposition to use of the Gaussian Noise appears to arise, not from any deficiency in the test itself, but from the fear that its use will reflect the true processing gain of 9 dB for devices based upon the use of 8 chip-per-symbol signaling, thus forcing the implementation loss for these devices to be tighter in order to meet to the Commission's 10 dB standard.[18]

This, however, is an appropriate outcome. As Aironet's comments demonstrate, a properly designed 8 chip-per-symbol device can meet the 10 dB standard using the Gaussian noise test. Thus, use of this test preserves a meaningful 10 dB processing gain requirement. At the same time, it does not prevent the use of 8 chip-per-symbol systems but, rather, merely forces manufacturers who elect to use such systems to design their systems carefully in order to keep implementation loss to an achievable minimum.

D. "Technological Neutrality" Is A Red Herring.

Intersil and the IEEE 802 Committee claimed in their comments that the CW Jamming Margin test was introduced as a "technology neutral" means of assessing the effective performance of

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[16] Intersil Comments at 2; IEEE 802.11 "Third Ex Parte Letter" at 3.

[17] The claim that implementation loss is more pronounced when a Gaussian Noise test is used thus is akin to saying that gasoline mileage is more important for six-cylinder automobiles than for eight-cylinder automobiles.

[18] The Commission's rules assume 2 dB of "implementation loss." If a system has an actual processing gain of 9 dB, it must have at most 1 dB of implementation loss in order to pass the 10 dB standard.

spread spectrum systems.[19] This statement misrepresents the Commission's reasons for adopting the CW Jamming Margin test.

As the Commission discussed in the NPRM, the CW Jamming Margin test was introduced to accommodate equipment for which disabling the spreading function was not possible.[20] Moreover, it has been retained this long only because evidence of the test's deficiencies for low chipping rate systems came to light after the CW Jamming Margin rule was finalized and, thus, a rulemaking proceeding was required to modify the test.[21] Contrary to Intersil and the IEEE 802.11 Committee's implication, the Commission did not adopt and has not retained this test because it is more "technologically neutral" than other tests.

Indeed, the Gaussian Noise test is more-nearly "technology neutral" than is the CW Jamming Margin test. The use of standard symbol-error-probability formulas based upon Gaussian statistics to estimate the required output SNR is highly questionable for the CW Jamming Margin test for $N_c<10$, while these apply exactly for the Gaussian Noise test. As the IEEE 802.11 high-rate standard is based upon only 8 chips per symbol, most practitioners of the spread-spectrum art would ascribe to it a theoretical processing gain of only 9 dB. The claim of "technological neutrality" in this case, thus, is meaningless: The 802.11 high-rate standard exploits the statistical anomaly of the CW Jamming Margin test, using post-processing statistics that are far from Gaussian for $N_C=8$, in order to achieve nominal compliance with the Commission's 10 dB spread spectrum standard.

III. THE COMMISSION SHOULD NOT ALLOW CONTINUED USE OF THE CW JAMMING MARGIN TEST WITH A MATHEMATICAL CALCULATION OF PROCESSING GAIN.

A small number of parties urged the Commission to allow manufacturers to continue using the CW Jamming Margin test, but to require a mathematical processing gain calculation for low chipping rate systems.[22] Proxim and Micrilor oppose this proposal.

First, such an approach would open up a Pandora's box. Commission staff would be forced to review mathematical proofs for each and every low chipping rate device for which certification is

[19] Intersil Comments at 1; IEEE 802.11 "Third Ex Parte Letter" at 2-3.
[20] NPRM at ¶ 12.
[21] Id. at ¶ 13.
[22] E.g., Lucent Comments at 3-4.

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sought. Moreover, manufacturers' calculations could rely on arbitrary and not-generally-accepted definitions and equations. Such a regime would dramatically expand the burden on the Commission and increase the potential for abuse. In addition, absent an infusion of new resources for the Commission, it almost certainly would slow the certification process for all Part 15 devices.

Second, the "mathematical proof" approach perpetuates the problems with the current CW Jamming Margin test. As demonstrated in Micrilor's comments, poorly designed low chipping rate systems can pass the CW Jamming Margin test *only* because this test incorporates a statistical anomaly, not because these systems truly achieve 10 dB of processing gain. Contrary to the claims of the test's proponents, it is the existing statistical anomaly – and not any "internal coding gain" or other legitimate characteristic – that permits poorly designed low chipping rate systems to pass.

The use of mathematical "proofs" does nothing to cure this fundamental problem; to the contrary, it institutionalizes the process of generating new loopholes in the equation. For example, in attempting to justify the use of mathematical proofs, Lucent offered arguments that are irrelevant to any legitimate determination of processing gain.[23] Spread-spectrum practice and the FCC's use of "information bandwidth" clearly refer to the symbol waveform processed in the correlator or matched filter. Nowhere is the bit rate mentioned, nor is it relevant. The measurements depend upon the symbol-level SIR, and the required symbol SNR (E_S/N_0). The bit rate does not appear in the jamming margin equation, nor does it belong. There are only three terms required to compute the processing gain using the Jamming Margin test: Input SIR, the Required symbol SNR, and the Implementation Loss. E_B/N_0 does not apply here. If there is apparent coding in terms of E_B/N_0, it is of no consequence. It is well known for orthogonal signaling that as the number of bits/symbol is increased the required symbol SNR *increases* while the E_B/N_0 *decreases*. The reduced E_B/N_0 does not reduce the higher required E_S/N_0 value. If a lower value of E_S/N_0 is required for the CW test, then it is the statistical anomaly for small N_C, which is responsible, not any form of "internal coding."

The Commission has the opportunity to solve the problem with its current processing gain rules here and now, by keeping the original form of the Jamming Margin equation but using Gaussian Noise to make the required E_S/N_0 exact. If the Commission fails to seize this opportunity and, instead, adopts a "mathematical proof" approach, it will create a future rich with variant equations for

[23] Lucent Comments at 4 and Attachment 2 at 5-6.

the CW test, all claimed to be equivalent to the original, all requiring *de novo* scrutiny by the FCC, but many representing merely a means for getting around the Commission's legitimate and necessary requirement that only true "spread spectrum" systems be authorized under Section 15.247 of its rules.

IV. THE COMMISSION SHOULD PROVIDE A REASONABLE PHASE-IN FOR ITS REVISED TESTING RULES.

Several parties asked the FCC to ensure that devices designed in under the 802.11 High Rate Standard will continue to meet the requirements of Section 15.247, notwithstanding any rule change.[24] Micrilor and Proxim strongly oppose such an outcome. It is truly extraordinary to ask that the FCC write its rules to accommodate particular devices: Manufacturers must comply with the Commission's rues, not *vice versa*.

As Aironet's comments demonstrate, a well-designed 8-chip-per-symbol system can satisfy the Gaussian Noise Test.[25] If other parties have adopted more marginal implementations that rely on the existing loophole in the processing gain measurement rule in order to satisfy the Commission's requirements, they should not now be allowed to complain. Similarly, if the IEEE 802.11 standard condones the use of the loophole to obtain certification for devices that do not, under any fair measurement process, satisfy the 10 dB processing gain requirement, this standard should not be granted special protection.[26]

While Proxim and Micrilor oppose granting special protection to existing products, we recognize that it is in everybody's interest to permit reasonable reliance upon Commission rules.[27] As a result, Micrilor and Proxim recommend that the Commission make the change in its measurement rules effective six months after their adoption, and permit any device that is certified before the effective date to be manufactured, sold, and used indefinitely. Such an approach will

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[24] Samsung Comments at 1; WLANA Comments at 2.

[25] Proxim and Micrilor recognize that a radio with a theoretical processing gain of only 9 dB can pass the Gaussian Noise test only because the FCC's rules allow for 2 dB of implementation loss. We do not, however, object to the use of the implementation loss allowance to overcome an otherwise deficient processing gain or recommend that the Commission change its policy of allowing 2 dB for implementation loss.

[26] In fact, from July 1997 to July 1998 a spirited debate took place in the IEEE 802.11 Committee over whether the new standard should employ fewer than 10-chips/symbol. Of the three proposals which showed strongest in the final voting for down-selection to a single waveform, Micrilor's used 16 chips/symbol, Lucent's used 11 chips/symbol, and only Harris' (now Intersil) used 8 chips/symbol. In Proxim and Micrilor's considered opinion, the use of 8 chips/symbol was based upon "getting past" the CW Jamming Margin test, not upon consistency with the spirit of the FCC regulations.

[27] See, e.g., Glenayre Western Multiplex Comments at 6-7.

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protect all parties' investment in their existing product lines. At the same time, market-based product cycles in the spread spectrum industry will ensure that systems that do not comply with the new rules are phased out over time and provide for a clear, unavoidable transition to the new measurement rules.[28]

V. CONCLUSION.

Proxim and Micrilor strongly support the FCC's proposal to correct the deficiencies of the CW Jamming Margin test and urge the Commission to require demonstration of direct-sequence processing gain for fewer than 10 chips per symbol exclusively using the Gaussian Noise test.

Respectfully submitted,

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[28] Proxim and Micrilor's proposed transition schedule is quite generous to manufacturers with existing products that, fairly measured, do not satisfy the 10 dB processing gain requirement when compared to other Part 15 transition rules. For example, in the early 1990s Proxim was forced completely to sunset from production and recall from the field certain products operating in the 902-928 MHz band in light of changes to the Commission's rules governing that band.