Before the
Federal Communications Commission
Washington DC 20554

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's Rules	)	ET Docket 98-753
Regarding Ultra-Wideband Transmission	)	DA 01-171
Systems	)	

Reply Comments of XtremeSpectrum, Inc. On Issues of Interference Into GPS and PCS

Mitchell Lazarus
Fletcher, Heald & Hildreth, P.L.C.
1300 North 17th Street, 11th Floor
Arlington, VA 22209
703-812-0440
Counsel for XtremeSpectrum, Inc.

May 10, 2001

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XtremeSpectrum, Inc. hereby files these Reply Comments in response to Public Notice DA 01-753 in the above-captioned proceeding.[1] This pleading cycle concerns four studies investigating UWB interference into GPS receivers,[2] and one that discusses potential interference into PCS wireless phones.[3]

IMPORTANT: The attached *XtremeSpectrum, Inc. Technical Reply to Comments on Potential GPS and PCS Interference from UWB Transmitters* is not an appendix, but an integral part of these Comments.

XtremeSpectrum conducts research in ultra-wideband communications systems, and intends to become a manufacturer once the Commission authorizes certification of such systems. XtremeSpectrum takes no position on ultra-wideband radar applications.

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[1] *Comments Requested on Reports Addressing Potential Interference from Ultra-Wideband Transmission Systems*, DA 01-753, in ET Docket No. 98-153 (released March 26, 2001).

[2] National Telecommunications and Information Administration Special Publication 01-45 (NTIA) (filed March 9, 2001); Stanford University (filed March 20, 2001) (Stanford) (search ECFS under "National Telecommunications and Information Administration"); Johns Hopkins University (filed March 9, 2001); Department of Transportation (filed Oct. 30, 2000).

[3] *Report of Qualcomm Incorporated* (filed March 5, 2001). *See also* Letter from Charles W. McKee, Sprint PCS to Ms. Magalie Roman Salas, FCC (filed Sept. 12, 2000).

A. Summary

The adjustments previously offered by XtremeSpectrum to the proposed rules eliminate all practical risk of harmful interference to GPS. In the case of PCS, the Commission's original proposals rule out interference, once the incorrect assumptions in the studies are resolved.

B. XtremeSpectrum Has Proposed Specific Rule Adjustments in Response to Interference Concerns.

At earlier stages of this proceeding, XtremeSpectrum recommended four adjustments to the Commission's proposed rules:

1. ***Emission mask***. XtremeSpectrum proposes an emission mask intended to give added protection to GPS, among other services:

above 2.7 GHz: 500 uV/m at 3m ([4])

2-2.7 GHz: 6 dB below 500 uV/M

1.6-2 GHz: 12 dB below 500 uV/m

at and below 1.6 GHz: 18 dB below 500 uV/m.

(At boundaries, the more stringent limit applies.) These attenuations are intended to protect the following services:

2-2.7 GHz:	WCS and DARS at 2305-2360 MHz; MMDS and ITFS at 2150-2162 & 2500-2690 MHz
1.6-2 GHz:	PCS at 1850-1990 MHz
below 1.6 GHz:	GPS at 1227.6, 1381.05, and 1575.42 MHz.

[4] This field strength corresponds to Sections 15.209 (maximum emissions in bands not otherwise specified) and 15.109 (Class B digital devices). *See* Notice at para. 39.

2. Attenuation of spectral lines: The reported interference from UWB into GPS is due principally to spectral line emissions in the L1 band.[5] Eliminating these spectral lines will eliminate the interference detected in the studies. To bring any such lines down to a non-interfering level, XtremeSpectrum recommends that the Commission require an additional measurement at certain critical GPS frequencies using a 30 kHz resolution bandwidth, with a limit 15 dB below the 1 MHz bandwidth limits. This measurement would not require changes to noise-like signals having relatively uniform power spectral densities, but would force the reduction of strong spectral lines by about 15 dB.[6] This test applies only over the frequency range 1574.92 through 1575.92 MHz.

3. Measurement of peak/average ratio. XtremeSpectrum has noted that the Commission's proposed test to limit peak-to-average ratio does not completely accomplish its purpose,[7] as the test does not fully account for the presence or absence of spectral lines. We suggest the Commission consider requirements that use time domain and frequency domain measurements of UWB signals to limit the ratio of peak power to average power.[8]

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[5] *See* the attached Technical Reply. *See also* Comments of XtremeSpectrum, Inc. on Issues of Interference Into Global Positioning System Receivers (filed April 25, 2001).

[6] Note that 1 MHz/30 kHz = 33, or 15 dB. For a noise-like signal, the 15 dB smaller measurement bandwidth is offset by the 15 dB lower emission limit, so there is no net effect. But a spectral line taking up most of the 30 kHz measurement bandwidth would have to be reduced by about 15 dB.

[7] *See* Notice at paras. 42-43.

[8] For details on XtremeSpectrum's proposal, see XtremeSpectrum, Inc. Technical Statement on Reports Addressing Potential GPS Interference from UWB Transmitters at 5, *filed with* Comments of XtremeSpectrum, Inc. on Issues of Interference Into Global Positioning System Receivers (filed April 25, 2001).

4. ***Indoor operation only.*** XtremeSpectrum urges the Commission to limit UWB communications systems to indoor operation, at least at the outset.

C. UWB Will Not Interfere with GPS.

The rule adjustments urged by XtremeSpectrum, in combination, will more than adequately protect GPS against harmful interference from UWB.[9] First, the studies filed in this docket show that GPS interference is caused principally by spectral lines in the L1 band, which XtremeSpectrum recommends be suppressed by an additional 15 dB.[10] Second, the recommended emission mask adds 6 dB of protection to that proposed by the Commission -- a total of 18 dB below the very low Class B/Section 15.209 levels. Third, indoor-only operation adds at least another 9 dB attenuation through the exterior wall. A GPS device, moreover, typically must operate several meters from the exterior wall to avoid shadowing, and so benefits from further attenuation. These limitations, taken together, bring UWB line emissions at least 42 dB below Class B/Section 15.209. This is more than sufficient to afford complete protection to GPS.

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[9] Harmful interference, in the case of a radionavigation or other safety service (including GPS), is conservatively defined as any interference that "endangers" its functioning. 47 C.F.R. Sec. 2.1

[10] The proposed peak/average test will also help to control spectral lines.

D. UWB Will Not Interfere with PCS.

The PCS studies fail to establish that UWB will cause harmful interference.[11] Results that claim to show otherwise are due to errors in the studies, particularly false assumptions, that overstate the likelihood of interference:

- ***Limits***. The Qualcomm study uses Class B/Section 15.209 limits, even though the Commission has proposed limits 12 dB lower.

- ***Free-space propagation***. The studies assume free-space propagation losses, even to distances of hundreds of feet. Indoors, this ignores inevitable losses due to reflection, scattering, and absorption in indoor walls, floors, and ceilings. Outdoors, the attenuation in populated areas is almost as great. Either way, these losses are typically at least 10 dB higher than free-space.

- ***Noise floor***. The studies place the threshold for harmful interference from UWB devices at 6 dB below the thermal noise floor. But ambient RF noise and interference from other sources, including other PCS base stations, typically add 12 dB or more in metropolitan areas. PCS providers are understandably most concerned about UWB interference to handsets near the edge of a cell, where PCS forward link power levels are lowest -- but that is also where the signal from other PCS base stations is strongest, which tends to mitigate the effect of UWB.

- ***High device densities, all units operating***. The studies assume UWB device densities as high as 100,000 active emitters per square kilometer -- a carpet of emitters 3 meters apart. Simultaneously, the studies assume every UWB device transmits at full power 100% of the time. But neither assumption is true. As device densities increase, each unit must reduce its power, its duty cycle, or both; otherwise, UWB-UWB interference will shut down the network.

Once the assumptions and other errors in these studies are corrected, the results predict *no interference* into PCS. See the attached Technical Reply for details.

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[11] In the case of PCS, harmful interference is that which "seriously degrades, obstructs, or repeatedly interrupts" the service. 47 C.F.R. Sec. 2.1.

CONCLUSION

The Commission should expeditiously adopt the rules outlined above to authorize UWB devices.

No Further Notice is required. The original Notice specifically invited comment on the subject matter of each proposed rule adjustment,[12] and XtremeSpectrum's suggestions are all well within its scope.[13]

This proceeding is almost three years old, and with the present filing concludes its fourth complete pleading cycle. To be sure, the opponents have raised some valid concerns, and the UWB interests have answered each of these responsibly. We offer to accept additional limitations on UWB operation, beyond those specifically proposed in the Notice, and have shown in detail that these alleviate any realistic concerns of interference.

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[12] *See* Notice at paras. 36-37 (spectral lines), 39 (emission mask), 40 (indoor operation), 43-44 (peak-to-average methods), 50 (measurement resolution bandwidth).

[13] "An agency, after all, must be free to adopt a final rule not described exactly in the [notice of proposed rulemaking] where the difference is sufficiently minor, or agencies could not change a rule in response to valid comments without beginning the rulemaking anew." National Cable Television Ass'n v. FCC, 747 F.2d 1503, 1507 (D.C. Cir. 1984). Even if not among the options expressly outlined in the Notice, the suggestions here are certainly a logical outgrowth of the questions raised. *See* Omnipoint Corp. v. FCC, 78 F.3d 620 631 (D.C. Cir. 1996) (second round of comment not required where final rule is "logical outgrowth" of proposed rule), *citing* American Water Works Ass'n. v. EPA, 40 F.3d 1266, 1274 (D.C. Cir. 1994).

The public needs UWB technology. The interference issues have been resolved. Commission should move to adopt rules.

Respectfully submitted,

Mitchell Lazarus
Fletcher, Heald & Hildreth, P.L.C.
1300 North 17th Street, 11th Floor
Arlington, VA 22209
703-812-0440
Counsel for XtremeSpectrum, Inc.

May 10, 2001

XtremeSpectrum, Inc. Technical Reply to Comments on Potential GPS and PCS Interference from UWB Transmitters

XtremeSpectrum, Inc.

8133 Leesburg Pike, Suite 700

Vienna, VA 22182

Table of Contents

1. Introduction

These reply comments are submitted in order to address concerns expressed in various responses to the recently released GPS and PCS reports.[1]

These concerns arise from confusion about the effects of different UWB signal parameters on the potential for GPS interference.[2] One of the most important conclusions of these reports is that they have admirably characterized the basic interference mechanisms for UWB signals in GPS receivers. This characterization is essentially defined by two cases: UWB signals without spectral lines in the L1 band that produce effects similar to relatively benign broadband noise, and UWB signals with lines in the GPS L1 band that leads to jamming of some GPS receiver at substantially lower levels.

There also is concern that other systems, such as PCS, might experience harmful interference from UWB devices.[3] These concerns are based on conclusions contained in the Qualcomm report that UWB devices will cause interference in PCS CDMA receivers. In response, XtremeSpectrum has submitted an analysis of the Qualcomm PCS testing showing that by using different, but realistic, assumptions about propagation, interference thresholds, and UWB emission levels that the potential for harmful interference is eliminated.[4]

In the present comments we provide further analysis of earlier PCS testing and analytical modeling efforts, and demonstrate, once again, that adopting more realistic assumptions about real-world effects brings the analytical results into harmony with the lab and field testing, and further, demonstrates that there is little potential for harmful UWB interference to PCS networks.

Taken together, all of the reports and additional analyses demonstrate that using the rule modifications proposed by XtremeSpectrum, the FCC can be assured of the safe coexistence of UWB and existing systems, including GPS. At the same time, these rules will allow the nation to begin to realize many of the potential benefits of this new and exciting technology. The test and analysis results of these GPS reports, as well as the analyses in the other reports distributed in this proceeding, support the initial proposals in the NPRM. Together with the proposed logical extensions to the NPRM, they confirm that it would be prudent for the FCC to approve the use of UWB devices under a modified set of Part 15 rules without further delay.

[1] NTIA Special Publication 01-45, NTIA Report 01-384, a report by Johns Hopkins University/APL, "Final Report: UWB-GPS Compatibility Analysis Project", and a report by several Stanford University researchers and others, "Interference to GPS from UWB Transmitters."
[2] See comments by Boeing dated April 23, 2001, and Lockheed Martin and Motorola, dated April 25, 2001.
[3] See comments from Sprint PCS dated April 25, 2001.
[4] See XtremeSpectrum comments, dated April 25, 2001.

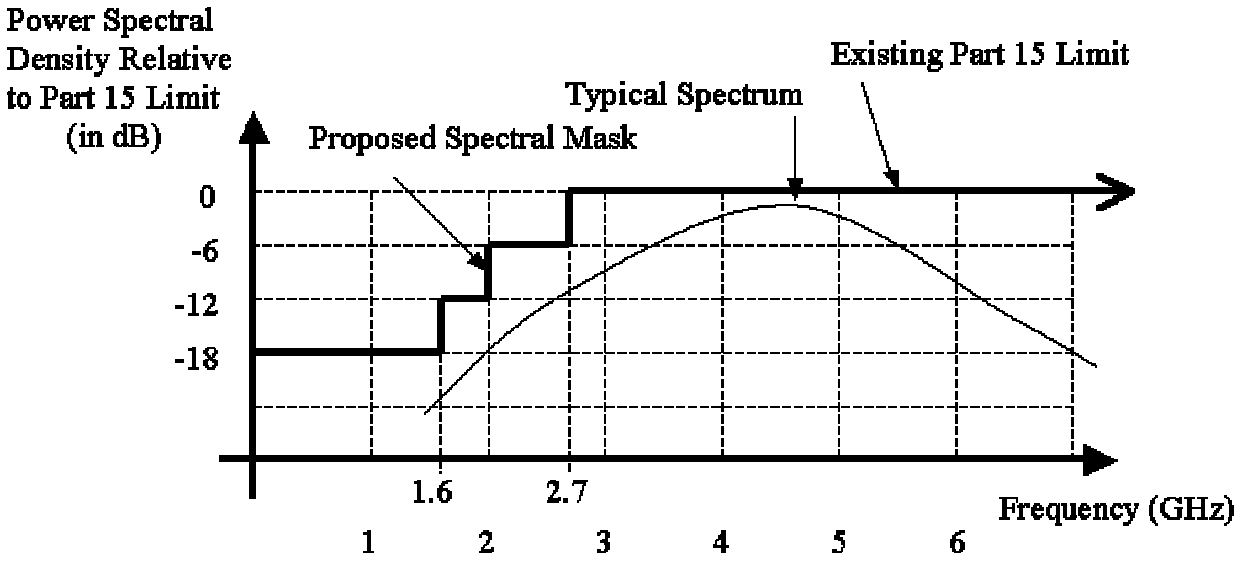

Figure 1: Proposed spectral mask for UWB operations under modified Part 15 rules.

2. Neither the GPS nor the PCS frequency bands are within the principal spectral regions proposed for UWB emissions

Many of the comments filed in response to the GPS reports indicate that existing Part 15 rules would be inadequate to protect GPS. But the FCC in the original NPRM and XtremeSpectrum in subsequent comments have proposed that UWB emissions at lower frequencies be permitted only at significantly reduced levels for roll-off, much as many existing systems do outside of their primary bands. The proposed levels for UWB emissions in the GPS band are 18 dB lower than existing Part 15 limits and in the 1.9 GHz PCS band they are 12 dB lower than existing Part 15 limits. Given the spectral mask proposed in the NPRM and in slightly modified form by XtremeSpectrum, most of UWB power for a typical system is likely to be emitted in frequency bands hundreds or thousands of MHz away from the GPS and PCS bands as shown in Figure 1.

3. Potential UWB interference to GPS receivers is well understood based on the results of the recent reports

A number of comments still indicate some confusion with regard to various UWB signal parameters and their effects on GPS.[5] The recent documents report on extensive studies of UWB effects on GPS receivers and provide enough information to understand the potential interference issues. These reports have identified two interference mechanisms that are consistently seen to completely characterize UWB interference on GPS. Because of these studies, it is now understood that UWB interference depends on two specific, measurable properties:

1. The power spectral density of noise-like UWB signals, and

2. The presence or absence of spectral lines in the GPS L1 band

[5] See comments by Boeing dated April 23, 2001, and Lockheed Martin and Motorola, dated April 25, 2001.

For noise-like UWB signals, GPS interference has been shown to be much like the well-understood and relatively benign effects caused by random broadband noise. This interference mechanism is well understood and well characterized. XtremeSpectrum's previous comments have shown that proposed spectral mask for average power providing 18 dB attenuation below existing Part 15 levels is sufficient to prevent harmful interference to GPS from noise-like signals in any reasonable situation. [6]

The various reports also demonstrate that some GPS receivers are up to 15 dB more sensitive to spectral line emissions in the L1 band than to the noise-like interference levels discussed above. This effect is reported to be a result of interactions between the spectral lines of the GPS C/A codes and spectral lines present in some UWB signals.[7] This interaction can be prevented by stipulating that any UWB signals which do contain spectral lines in the L1 band be required to attenuation such lines an additional 15 dB below the spectral mask (that is in addition to the 18 dB attenuation below Part 15 limits required by the average power limits). To this end, XtremeSpectrum has proposed a specific test to detect spectral lines in the GPS L1 band that is described in previous comments.[8] The combined limitation on noise-like power and spectral line power is sufficient to provide complete protection of GPS receivers against UWB interference. This conclusion follows directly from the measured interference thresholds for noise-like and CW-like interference.[9] No other interference mechanisms were reported in the different GPS interference studies.

Discussions about UWB transmitter PRF and modulation format are not directly relevant to the rule making process because these issues are addressed effectively by the proposed tests for broadband average power and allowable spectral line amplitude in the L1 band. These restrictions afford the UWB designer maximum flexibility in achieving optimal system design, while simultaneously providing the needed protection for GPS, PCS and other systems.

4. Comments on the effect of UWB operation on CDMA PCS Networks

4.1 The Qualcomm report does not demonstrate that UWB devices will cause harmful interference to PCS networks

In comments on the Qualcomm report, some parties claim that the report demonstrates that UWB devices "will have harmful impact on the normal operation of CDMA wireless devices in the voice, data and GPS modes" and that the report is an independent confirmation of the Sprint PCS/Time Domain tests submitted earlier in the proceedings.[10]

The Qualcomm report, however, contains unrealistic assumptions about UWB emission levels, path loss figures and interference thresholds for PCS receivers. XtremeSpectrum demonstrated that when the original Qualcomm analysis is adjusted to include more realistic assumptions, the clear result is that harmful UWB interference to a PCS receiver is extremely unlikely.[11] In

[6] See XtremeSpectrum comments dated March 12 and April 25, 2001.
[7] See, for example, the discussion on spectral line alignment in NTIA 01-384, page 4-8.
[8] See XtremeSpectrum comments dated April 25, 2001.
[9] The NTIA Special Publication 01-45 reports these measured interference thresholds for both noise-like and CW-like UWB signals in numerous places, including Tables 1-4.
[10] See comments by Sprint PCS dated April 25, 2001.
[11] See XtremeSpectrum comments dated April 25, 2001.

previous comments we demonstrated that the analyses and tests presented by Qualcomm contained several specific problems that led to unrealistic results:

1. The original QUALCOMM analysis assumed that the 1.9 GHz PCS band would be a *principal* spectral region for UWB emissions. Actually, both XtremeSpectrum and the FCC have proposed that emissions in this band only be permitted at levels *12 dB below* Part 15 general emission limits for communications systems.

2. Much of the original analysis in the report assumes only free-space propagation losses, even to distances of hundreds of feet, with no account for non-line-of-sight effects. More realistic models demonstrate significantly lower interference and reduce the potential range for UWB interaction predicted by using the Qualcomm model.[11] Even this revised analysis did no take into account additional factors noted by Sprint PCS in their laboratory testing that might lead to even greater losses relative to free-space propagation.[12]

3. The original analysis assumes a very conservative value for the threshold of harmful interference due to UWB emissions (6 dB below the thermal noise floor). Both the analytical expressions and laboratory results presented by Qualcomm show that this threshold is too conservative, and computations using a more realistic level remove any concern about harmful interference.

After careful examination of the test results and analyses in the Qualcomm report, it becomes clear that no harmful interference in PCS systems will result from UWB operation under Part 15 rules when emissions in the 1.9 GHz PCS band are limited to 12 dB below current Part 15 levels. When the original analyses of the report were modified to include the 12 dB reduced emission limits and more realistic assumptions for propagation losses, the indicated minimum separation distances were significantly reduced. With a further modification to incorporate a more realistic level for PCS receiver interference threshold, which is supported by Qualcomm's own test results, the conclusion is that there is little likelihood of UWB devices causing any interference to PCS receivers even in close proximity.

4.2 The Sprint PCS testing and analysis demonstrate that UWB devices will not cause substantial harmful interference to PCS networks

In a number of different comments submitted by Sprint PCS, the claim is made that test data and analysis confirm that "UWB devices will cause harmful interference to PCS CDMA networks, even at the more stringent –53.2 dBm/MHz average power level discussed in the NPRM."[13]

The Sprint PCS tests and analysis have been referenced numerous times in these proceeding as proof that significant interference to PCS networks will result from UWB devices. However, this claim is based on numerous unrealistic assumptions and conflicting results. Because of the

[12] In the PCS-UWB interference tests reported by Sprint PCS in Attachment 2 of their comments dated September 12, 2000, the report indicates that PCS handset antenna polarization effects caused a variation of 1.5 to 2.5 dB in received power levels and that losses due to line-of-sight blockage by the PCS user's head or body caused an additional 12-15 dB of variation.

[13] See, for example, Sprint PCS comments dated April 25, 2001, page 2.

continued confusion concerning the reported tests and models, we wish review the actual testing and the implications of the results.

4.3 The co-sponsor of the testing, Time Domain, disagrees with many of the test conclusions reported by Sprint PCS

Time Domain, a co-sponsor of the study used as a basis for the Sprint PCS claims, submitted a response disagreeing with a number of the key conclusions made by Sprint PCS. In this response, Time Domain indicates that they disagree with Sprint PCS on the following points:[14]

- The claim that CDMA signal levels below –95 dBm are sufficiently reliable to constitute a useful coverage area;
- The assumption in the model that all UWB transmitters emit UWB signals continuously when most of the applications that have been identified for UWB are likely to be highly intermittent (e.g., packet radio wireless LANs);
- The belief that UWB causes loss of cell capacity; and
- The claim that an aggregation of TM-UWB units will significantly increase the probability of harmful interference.

We agree with Time Domain that many UWB applications will typically transmit only on an intermittent basis. Furthermore, based on our own analysis and that of others, including the NTIA, it is clear that the aggregate effect of multiple UWB emitters is typically dominated by those emitters closest to any given receiver.[15] This belief does not contradict the principle that independent noise-like RF signals are additive in their effects, but rather it indicates that propagation effects in real-world environments are such that the effects of distant emitters are attenuated to a degree that nearby emitters will dominate any interference effect seen by a victim receiver.

Time Domain also indicated that they felt that the "results from real-world testing differed dramatically from the model's predictions."[16] They stated that they felt the model should incorporate more real-world effects such as CDMA Rayleigh fading and other sources of noise.

4.4 The limited laboratory testing reported by Sprint PCS demonstrates that UWB devices will not cause harmful interference

The test results reported for this study indicate that only two limited tests for UWB interference were conducted. Specific tests reported as part of these proceedings are:

Over-the-air tests in an anechoic chamber using a base station simulator: The brief statement of the findings presented in the report for this test is summarized below.[17]

[14] See Time Domain comments dated October 27, 2000, Appendix A, page 1.
[15] This dominating effect of nearby UWB emitters is described in the NPRM (paragraph 46) as a baseline conclusion. XtremeSpectrum comments dated April 25, 2001 also demonstrate that this effect is also clearly supported by the simulation results presented in NTIA report 01-43.
[16] Ibid, Appendix A, page 2.
[17] The original statement of these finding is found on page 2 of Attachment 2 to Sprint PCS comments dated September 12, 2000.

- The testing verified that free-space path loss is a valid model inside 2 meters.
- The testing indicated that the PCS handset antenna had a measured gain of –4.6 dBi for the receive frequency band.
- The RSSI measured by handset was 3 dB different from computed values.
- The measured E_b/N_0 for onset of frame errors was 5 dB, consistent with expectations.
- The indicated received handset power varied by 1.5 to 2.5 dB because of handset antenna polarization and by 12 to15 dB due to "head loss" of the handset user.
- The effect of UWB interference on a PCS handset appears to be the same as equivalent levels of Gaussian noise.

It is important to note that the anechoic chamber effectively eliminated all external RF noise and any potential interference effects due to other CDMA cells or multi-path interference. It has already been noted in these proceedings that these effects are perhaps the most important factors in understanding the potential for UWB interference on a real PCS network.[18] There is no indication in the report provided by Sprint PCS of measurements made to determine whether any real PCS network would experience either a decrease in capacity or an increase in blocked calls due UWB device emissions as a part of these tests. Based on the results of these tests it is not reasonable to claim that they demonstrate substantial harmful interference to a PCS network from UWB devices.

Tests on a live system test-bed: This testing was carried out at an outdoor Sprint PCS test facility. Because much of the data from these tests was apparently lost, the only result reported in the Sprint PCS comments is for a single test run in which a PCS handset exhibited a rise in traffic channel power and then a dropped call only when a UWB emitter was moved to *within one foot* of the handset. It was stated in the report that this result seemed consistent with expectations based on the earlier anechoic room testing. However XSI contends that testing at greater distances, 1 and 3 meters, did not produce the expected rise in traffic channel power, presumably because other interference presented by the real world dominated the environment.[19] It is also useful to note here that the report does not indicate the transmit power level of the UWB device in this live test. If it was the same power as that of the device used in the anechoic chamber test (above), then the UWB output power for this test was –49.1 dBm (i.e. more than 3 dB higher than the emission limit of –53.2 dBm/MHz+10Log(1.25)= -52.2 dBm proposed in the NPRM).

We see from these results that the actual testing reported by Sprint PCS in no way verifies any of the claims made about the effects of UWB devices on a PCS network. There is no report of testing to demonstrate the loss of capacity in a network due to UWB devices at 2 meters range, and there is no verification of the claims that UWB devices at three meters range or more will result in additional blocked calls in the network. In short, there is no report of any tests that demonstrate that any CDMA network will experience "substantial harmful interference" from UWB devices in any reasonable situation under the limits proposed in the NPRM.

[18] See comments of the study co-sponsors, Time Domain, dated October 27, 2000, page A-3.
[19] This is the same conclusion reached by Time Domain in their comments dated October 27, 2000.

4.5 The interference model submitted by Sprint PCS contains many unrealistic assumptions that prevent accurate prediction of interference effects

The analytical model developed by Telcordia Technologies for Sprint PCS is an excellent theoretical analysis. While it can provide valuable insight on the general effects of UWB devices in a PCS network, it cannot predict real-world performance, because the model contains too many idealized assumptions to produce realistic results.

This model is the basis for a number of different figures that Sprint PCS has provided as part of their claim that UWB devices will definitely cause substantial harmful interference to a PCS network. In several comments submitted to the FCC, Sprint PCS claims that its model demonstrates that UWB devices operating 12 dB below the Part 15 limits will lead to reduced network capacity and additional blocked calls of up to 8 percent for their network.[20]

To understand why these claims represent a very exaggerated picture of UWB interference potential, it is helpful to review some of the assumptions made in the analytical model with regard to real-world effects. These assumptions are all well documented in the original model description, but it seems that sometimes these underlying assumptions were not included when predictions of the model were presented in later submissions. Some of these assumptions are summarized below.

- **The model does not consider for non-line-of-sight propagation effects**. Free space propagation is assumed for all UWB devices. There are many environmental factors that can cause attenuation of RF signals, even in indoor environments at ranges less than 10 meters, but no account for such propagation factors is made.[21]

- **No allowance is made for interference from other PCS base stations, although this effect is shown to be significant.** In the annex to the report, the interference effect of other base stations is shown to cause as much as a 5 dB rise in effective noise floor. This is particularly the case at the fringe regions of the cells, which is the region of greatest concern for UWB interference because of lower PCS forward link power levels.[22]

- **No allowance is made for ambient RF noise or interference.** The model indicates that external ambient noise can affect the noise floor assumed in the model. It indicated that such an effect could easily be incorporated in to the calculations, but it is not.[23] This is particularly relevant since recent NTIA ITS surveys in three major

[20] See Sprint comments dated October 6, 2000 (page 4-5), comments dated February 21, 2001 (page 2), comments dated April 6, 2001 (page 2), and comments dated April 25, 2001 (page 2).
[21] See Sprint comments dated September 12, 2000, Attachment 2, page 3. Even the companion report for the Telcordia analytical study presents results of laboratory testing that indicate a significant variation of path loss (12-15 dB) simply due to blockage of the line-of-sight by the body or head of the PCS user. There are many references available that provide specific measured values for path loss due to items such as interior walls, partitions, furniture, etc. One text that provides a good discussion and bibliography on this subject is by Theodore Rappaport, Wireless Communications: Principles and Practice, Prentice Hall, 1996.
[22] Sprint comments dated September 12, 2000, Attachment 1, page 24.
[23] Sprint comments dated September 12, 2000, Attachment 1, page 9.

metropolitan areas have indicated ambient noise levels of no less than 12 dB above thermal levels in the 1.9 GHz band.[24]

- **UWB device densities assumed in the model are extraordinarily high relative to other studies in these proceedings.** The NTIA report used a range of 1 to 10,000 active UWB devices per km^2 for its aggregation analysis because the authors believed that actual values could potentially be as high as be hundreds or thousands of devices per km^2.[25] The density values assumed in the Telcordia analysis are significantly higher than this range. In the Telcordia model, the figure used for a "very low" density equates to 5000 active devices per km^2 (0.005 per m^2) and the "relatively high" density value equates to 100,000 active devices per km^2 (0.1 per m^2).[26] The density values used to demonstrate claims of interference in Sprint PCS comments (i.e. where one in five or one in twenty PCS phones is exposed to a UWB device at 3 meters)[20] are equivalent to between 2000 and 30,000 active UWB devices per km^2, depending on the assumed device distribution pattern.[27]

- **No account is taken in the Sprint PCS analysis of UWB device activity factor**, although it is indicated in the model description that such a factor is essential for understanding the interference effect of UWB devices.[28] One of the co-sponsors of the study, Time Domain, indicated this omission as a major point of disagreement with the findings of the analytical study.[29] XtremeSpectrum in previous comments has pointed out that high UWB emitter densities (see above) and high activity factors for each emitter are incompatible because of the ensuing UWB-on-UWB interference.[30]

- **No account is taken of potential UWB power derating.** The model includes suggested corrections to account for a potential *de facto* derating of the UWB power measured as well as 1-2 dB potential cable and calibration losses. These factors are included in many plots and results in the original Telcordia report, but are not included in results reported by Sprint in any submitted comments.[31]

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[24] See Time Domain comments, dated Oct. 27, 2000, Appendix A, note 7.
[25] NTIA report 01-43, pages 5.1-5.2.
[26] Sprint comments dated September 12, 2000, Attachment 1, page 10.
[27] The model describes several possible distributions for UWB devices in a PCS cell. One typical density value used widely in the model report was 0.1 active emitters per m^2 (equivalent to 100,000 active emitters per km^2). This density would result in a 90% probability that any PCS phone would be with 3 meters of an active UWB device. The values of 1-in-5 or 1-in-20 for the number of PCS phones exposed to a UWB emitter at 3 meters can be converted to equivalent densities using the equations in Table 2 of the model description (Attachment 1, page 6) and then to density values in terms of emitters per km^2.
[28] Sprint comments dated September 12, 2000, Attachment 1, page 5.
[29] Time Domain submitted comments (October 27, 2000) documenting that activity factors for one primary UWB application (wireless local area networks) will likely be much lower than 100%. Other potential applications will likely also have very low activity factors, as noted in the NTIA Special Publication 01-43, page 5-34.
[30] XtremeSpectrum comments dated April 25, 2001. Because UWB devices share a common RF channel, the density of active emitters is inherently self-limiting. Any cluster of devices must reduce activity factor, power or both to prevent excessive UWB-on-UWB interference.
[31] The effects of the derating of UWB transmission power and other effects are described in the Telcordia model where an effective limit of –60 dBm/Mhz is suggested to account for these effects. Basically, this derating effect is

As can be seen from this list, there are numerous real-world phenomena that are not directly included in the application of the Telcordia model.This lack is very significant- so much so that conclusions drawn about the feasibility of UWB operations based on predictions of this model are irrelevant.

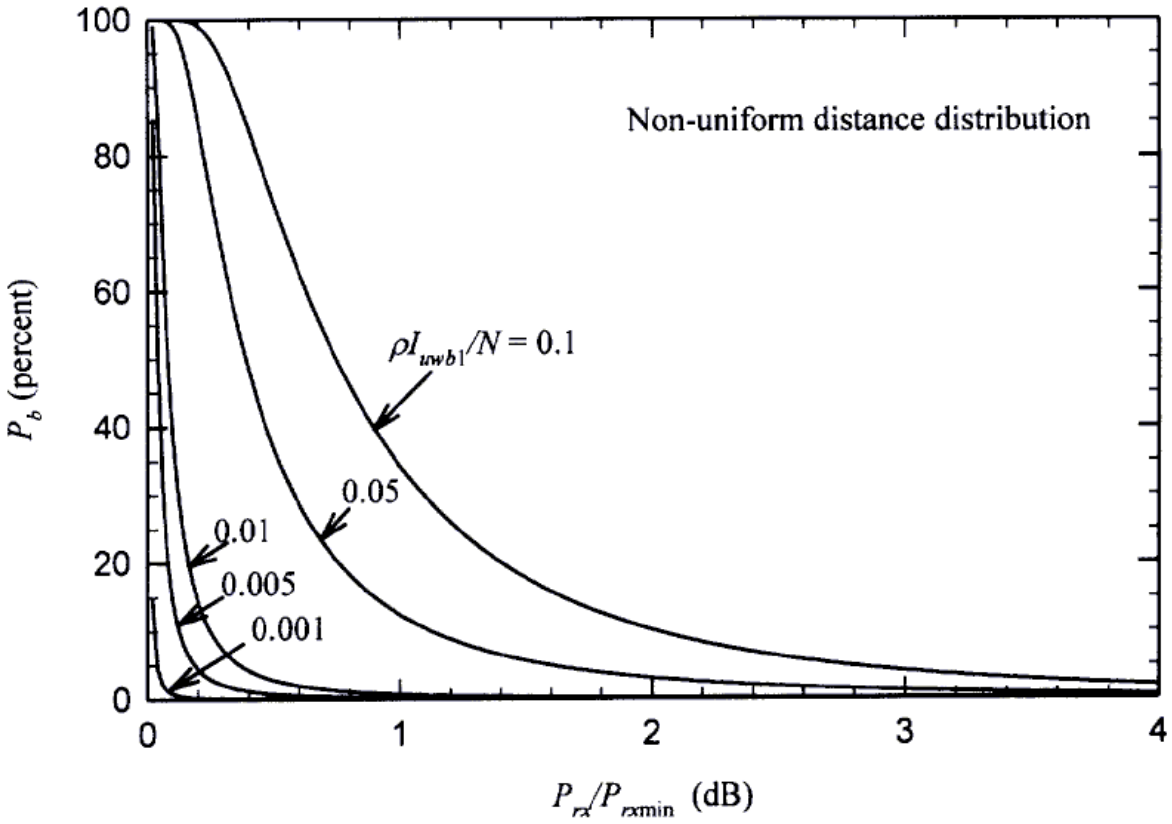

Figure 2: Plot of blocking probability, P_b, versus margin of total receiver power, P_{rx}/P_{rxmin} (reproduced from original Telcordia model description, Figure 5).

4.6 Projections using more realistic assumptions demonstrate that UWB devices will not result in harmful interference to PCS networks

Because the analytical model contains general results for wide ranges of some parameters, it is possible to see the effects of modifying some of the specific assumptions noted above. Figure 5 in the model description provides an example. This figure (reproduced here as Figure 2) shows the probability of call blocking (P_b) versus the ratio of received power to minimum received power (P_{rx}/P_{rxmin}). We can use this plot to show that for reasonable UWB device densities the probability of blocking is quite small. For examples, with a density of 1000 active UWB emitters per km^2 (equivalent to the $\rho I_{uwb1}/N = 0.001$ active devices/m^2 in Figure 2, since $I_{uwb1}/N \approx 0$dB) the additional probability of blocking due to UWB emissions only becomes non-zero when P_{rx}/P_{rxmin} is a small fraction of a decibel, that is, when the received signal power is essentially at the minimum value for which the PCS handset could possibly operate in the absence of all

caused by a need to compensate for positive reinforcement of UWB signals due to ground plane effects during the measurement process. Although these effects are included in many of the analyses and results in the Telcordia model report, they are not included in any results reported by Sprint PCS in subsequent comments.

interference.[32] In light of the live test reported results, it seems that the occurrence of any UWB interference is unlikely even when the PCS receiver is operated at the extreme margin of the received power range.[33]

To further understand the specific effects of the unrealistic assumptions made in the Sprint PCS interference model, Table 1 presents the results of analysis that incorporates a number of more realistic assumptions about real-world effects into the Telcordia model. In this table, the original projections presented by Sprint PCS in several different submissions are reproduced along with the results of additional analysis. For each of the three model adjustments indicated in the table, the blocking probability is reported for three different assumed UWB emitter densities. This analysis includes a third density value (1 in 100 PCS phones exposed to UWB emitter at 3 meters) to provide an indication of what the effect would be if the density is about 350 active emitters/km^2.[34]

Range of UWB Device	UWB device at 4 m			UWB device at 3 m			UWB device at 2 m		
Proportion of PCS phones exposed	**1/100**	**1/20**	**1/5**	**1/100**	**1/20**	**1/5**	**1/100**	**1/20**	**1/5**
Original values given in Sprint PCS report	-	0.8 %	3.1 %	-	1.2 %	4.8 %	-	2.0 %	7.9 %
After adjustment to account for propagation loss of 10 dB	0.0 %	0.1 %	0.4 %	0.0 %	0.2 %	0.7 %	0.1 %	0.4 %	1.4 %
After adjustment to include effects of other cells, ambient noise and 2 dB antenna polarization loss	0.0 %	0.1 %	0.5 %	0.0 %	0.2 %	0.9 %	0.1 %	0.5 %	1.9 %
After adjustment to account for derated NPRM power limit as suggested by the model	0.0 %	0.2 %	0.8 %	0.1 %	0.3 %	1.3 %	0.1 %	0.7 %	2.6 %
After adjustment to include all three of the effects described above	**0.0 %**	**0.0 %**	**0.0 %**	**0.0 %**	**0.0 %**	**0.0 %**	**0.0 %**	**0.0 %**	**0.0 %**

Table 1: Results of additional analysis to incorporate more realistic assumptions about propagation losses, interference and noise levels into the Telcordia UWB-PCS interference model.

Table 1 demonstrates the influence of real-world effects, but is not intended to be an accurate prediction of call blocking. The first modification demonstrates the changes that result with non-

[32] The figure originally appears on page 11of attachment 1 to Sprint comments dated September 12, 2000. The definitions of the specific variables are found on page 2 and in equation (15).

[33] The live tests at the Sprint test range indicated that the PCS handset received power fluctuated over a 5 dB range even with a clear line of sight to the base station tower and no UWB interference present. In their own conclusions about the Sprint PCS/Time Domain field tests, Time Domain indicates that environmental factors such as multi-path fading, ambient RF noise and other interference masked any observable effect due to UWB interference at ranges greater than one foot, even at PCS forward link signal levels of -94dBm.

[34] This density of 350 active emitters/km^2 would be equivalent to about 2000 *total* emitters/km^2 using an activity factor of about 1/6 and also equates to about one PCS phone out of every 100 being exposed to a 100% active UWB device at 3 meters range.

ideal propagation losses between the UWB device and the PCS handset. In an indoor environment at ranges of up to 4 meters it is realistic to expect some obstructions and blockage of the line-of-sight.[35] These obstructions may be walls, furniture, or even the PCS user's head. Laboratory testing reported by Sprint PCS showed a variation of 12-15 dB in received power simply due to the head or body of the PCS user and suggested that "head loss" is a "significant factor with respect to interference received from a nearby UWB transmitter."[36] The second modification in Table 1 shows the effect of including interference from other CDMA cell base stations and external noise. Also, included is a 2 dB factor to model a lower antenna coupling between the UWB device and the PCS handset due to antenna polarization.[37] A third modification to the original model is to include the effect of a potential *de facto* derating of the UWB power due to propagation effects during equipment certification. Also included is 1-2 dB margin for uncertainties in calibration and cable losses.[38] The final row in Table 1 reports the result of including all three of the above independent effects in the modified analysis.

The results of this extended analysis shows that the original projections of the model reported by Sprint PCS (the top row) are overly pessimistic. The results in Table 1 show that a vast majority of the cases only indicate a fraction of a percent for blocking probability at these close ranges and at lower (more realistic) emitter densities—in fact the model often predicts no blocking at all. Although the final row is perhaps not completely realistic because it combines all three effects simultaneously, it does indicate how multiple real-world effects can compound and lead to elimination of potential for harmful interference.

It is important to note that this compounding of real-world effects is not an exaggeration, but agrees with the actual testing results reported by Sprint PCS. The live testing showed that real-world effects such as interference, noise and Rayleigh fading were severe enough to mask any effects predicted by the analytical model until the UWB interferer was moved to within one foot of the PCS handset.[39] All of the real-world factors noted above are also relevant to the forward link power computations. Because these real-world effects will result in lower UWB interference as well as masking potential UWB/PCS interactions, it is clear that those values predicted by the model based on overly simplified assumptions are also exaggerated.

Sprint PCS indicated in their comments that third generation CDMA systems will likely experience similar effects from UWB[40]. It is reasonable to conclude that current and future

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[35] Although such propagation effects could affect the desired signal as well as the interferer, the model already uses a propagation loss for the *desired PCS signal* proportional to $1/R^{3.5}$, whereas the loss for the *interfering signal* is computed using $1/R^2$. See equation (23) in Sprint comments dated September 12, 2000 and notes for the table in Attachment A of Sprint comments dated October 6, 2000.

[36] See Sprint comments dated September 12, 2000, Attachment 2, page 9.

[37] The combined effects of other cell interference and external RF noise is modeled as a 6.6 dB rise in the effective noise floor. The report on Sprint PCS tests indicated a variation of 1.5 to 2.5 dB between UWB devices and PCS handset because of handset orientation (Attachment 2, page 9).

[38] The effects of the derating of UWB transmission power and other effects are described in the Telcordia model where an effective limit of –60 dBm/Mhz is suggested to account for these effects. Although these effects are included in many of the analyses and results in the Telcordia model report, they are not included in any results reported by Sprint PCS in subsequent comments.

[39] See note 15 above.

[40] See Sprint PCS comments dated October 2, 2000, page 13-14: "The precise impact of UWB devices on these 3G technologies is not known. However, reasonable predictions can be made because the underlying technology in 2G and 3G CDMA systems is the same. For example, it is reasonable to assume that to the extent that UWB transmitters interfere with 2G systems, their interference impacts on 3G systems will be similar."

CDMA systems will be more limited by real-world interference and propagation issues, than by any interference due to low-level UWB emissions. Reasonable calculations show there will be no noticeable effect on either PCS network capacity or on call blocking under any reasonable circumstances from UWB operations.

5. Conclusion

When all of these results are taken together only one conclusion can be reached: the proposed 12 dB attenuation below Part 15 levels for UWB emissions in the PCS band will provide ample protection against any possible harmful interference.

Respectfully submitted,

Matthew L. Welborn, PhD

Senior Design Engineer
XtremeSpectrum, Inc.
8133 Leesburg Pike, Suite 700
Vienna, VA 22182
(730) 269-3000

SERVICE LIST

Chairman Michael Powell
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Commissioner Harold Furchtgott-Roth
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Commissioner Susan Ness
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Commissioner Gloria Tristani
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Bruce Franca, Acting Chief
Office of Engineering and Technology
Federal Communications Commission
445 12th Street, S.W., Room 7C-155
Washington, D.C. 20554

Dr. Michael Marcus
Associate Chief of Technology
Office of Engineering & Technology
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Julius P. Knapp, Chief
Policy & Rules Division
Federal Communications Commission
445 12th Street, S.W., Room 7B-133
Washington, D.C. 20554

Karen E. Rackley, Chief
Technical Rules Branch
Federal Communications Commission
445 12th Street, S.W., Room 7A-161
Washington, D.C. 20554

John A. Reed
Senior Engineer
Technical Rules Branch
Office of Engineering and Technology
Federal communications Commission
445 12th Street, S.W., Room 7A-140
Washington, DC 20554