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

In The Matter Of Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems	)	ET Docket No. 98-153

REPLY COMMENTS OF QUALCOMM INCORPORATED

Dr. Samir S. Soliman
Vice President- Technology
QUALCOMM Incorporated
5775 Morehouse Drive
San Diego, CA 92121-1714
(858) 658-2916

Dean R. Brenner
Crispin & Brenner, P.L.L.C.
1156 15th Street, N.W.
Suite 1105
Washington, D.C. 20005
(202) 828-0155

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Executive Summary

QUALCOMM Incorporated (QUALCOMM) herein files its Reply Comments in response to the Federal Communications Commission (Commission or FCC) Public Notice issued on March 23, 2001 in the above referenced proceeding.[1] These Reply Comments address the Comments provided to the FCC under this docket by Time Domain Corporation (TDC or Time Domain).[2] In its Comments, TDC addressed the recent tests and detailed reports submitted by QUALCOMM, the University of Texas/Johns Hopkins University, the National Telecommunications and Information Administration, and the Department of Transportation/Stanford University. The QUALCOMM Report,[3] providing PCS test results, was submitted as part of the record to help the Commission in its difficult task of considering revision to Part 15 rules to accommodate UWB devices.

The recent tests and detailed reports provided the Commission with important data and analysis for the Commission's eventual decision in the matter of Revision of Part 15 of the Commission's rules regarding Ultra-wideband transmission systems. The overwhelming consensus of the various comments received by the Commission is that certain types of UWB devices will cause interference with licensed receivers, especially cellular, broadband PCS, certain specialized mobile radio, and GPS. All the tests demonstrate that UWB devices can significantly interfere with both GPS and PCS systems depending upon the UWB signal characteristics and the victim receiver type.

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[1] *See* FCC Public Notice, DA 01-753 (released March 23, 2001, revised March 26, 2001) "Comments Requested on Reports Addressing Potential Interference from Ultra-wideband Transmission Systems."

[2] *See* Time Domain Corporation, ET Docket No. 98-153 (April 26, 2001), "GPS Comments – ET Docket No. 98-153" and Errata to GPS Comments (April 26, 2001) *Errata to GPS Comments* – ET Docket No. 98-153, Section VIII, "PCS and UWB", p. 83.

In its Comments,[4] Sirius Satellite Radio (Sirius) points out that the QUALCOMM Report is of "great interest as it is one of the few that addresses the measurement of interference from UWB devices into non-GPS receivers." Furthermore, Sirius states unequivocally that "the conclusions of the [QUALCOMM] report are absolutely clear: UWB devices operating in accordance with the Commission's proposed technical parameters would cause harmful interference to PCS handsets." Further, "the QUALCOMM report shows that UWB devices would cause harmful interference even when operating at significant distances from PCS receivers." A Sprint Spectrum, L.P. (Sprint) analysis[5] regarding interference to PCS systems confirms that UWB devices are unable to share spectrum, especially in restricted bands with licensed services on a non-interference basis. One major impact of UWB interference is loss of PCS network capacity. Sprint PCS, in its Comments, stated that at -52.3 dBm/MHz emissions level and a fair signal (-90 dBm RSSI), a PCS handset will require 8% more forward link power when exposed to a UWB device 2 meters away. At a marginal signal (-100 dBm RSSI), the handset will require 50% more forward link power. Thus, a forward link capacity loss could be significant if several PCS users are near active UWB devices.

With respect to UWB interference with GPS, Sirius, the U.S. GPS Industry Council, Aeronautical Radio, Inc. (ARINC), and the Air Transport Association of America, Inc. (ATA),[6] as well as a host of others, all concur beyond question that the introduction of UWB transmission systems into GPS receivers will cause harmful interference to virtually every GPS receiver.

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[3] *See* QUALCOMM Incorporated, ET Docket No. 98-153 (March 5, 2001) "Report of QUALCOMM Incorporated."
[4] *See* Sirius Satellite Radio, Inc., ET Docket No. 98-153 (April 25, 2001), "Comments of Sirius Satellite Radio Inc."
[5] *See* Sprint PCS, ET Docket No. 98-153 (October 6, 2001), Supplemental Comments.
[6] *See* Sirius, "Executive Summary"; U.S. GPS Industry Council, ET Docket No. 98-153 (April 25, 2001), "Comments of the U.S. GPS Industry Council on Test Data Regarding Potential Interference From Ultra-wideband Transmission Systems"; and ARINC and ATA , ET Docket No. 98-153, (April 25, 2001) "Comments of ARINC and ATA on Test Reports Addressing Potential Interference from Ultra-wideband Transmission systems."

Based on the test results already submitted, ARINC and ATA urge the Commission to "preclude unlicensed UWB operations entirely."[7]

QUALCOMM recommends that the FCC take a reasonably conservative approach in deciding whether to permit the deployment of ultra-wideband (UWB) devices on an unlicensed basis under its Part 15 rules. The set of tests and analyses conducted by QUALCOMM and reported to the FCC in the captioned proceeding indicate that UWB proliferation will severely impact the performance of cellular licensees, broadband PCS licensees, certain specialized mobile radios (SMR), and enhanced GPS operation for safety-of-life applications.

[7] *See* Aeronautical Radio, Inc. and the Air Transport Association of America, "Summary".

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QUALCOMM Incorporated ("QUALCOMM"), pursuant to the Commission's Public Notice DA 01-753, released March 26, 2001, hereby submits its Reply Comments. These Reply Comments address the Comments provided to the FCC under this docket by Time Domain Corporation (TDC or Time Domain).[8] In its Comments, TDC addressed the recent tests and detailed reports submitted by QUALCOMM, the University of Texas/Johns Hopkins University, the National Telecommunications and Information Administration, and the Department of Transportation/Stanford University.

1. Introduction

QUALCOMM is a worldwide leader in developing and delivering innovative digital wireless communications products and services based on the Company's Code Division Multiple Access (CDMA) digital technology. Its corporate goal is to maintain the voice quality superiority and the spectral efficiency advantages of the CDMA products. QUALCOMM joins others in their

[8] *See* Time Domain Corporation, ET Docket No. 98-153 (April 26, 2001), "GPS Comments – ET Docket No. 98-153" and Errata to GPS Comments (April 26, 2001) *Errata to GPS Comments* – ET Docket No. 98-153, Section VIII, "PCS and UWB", p. 83.

considerable concern for the integrity of existing and licensed communications and navigation systems in cases where UWB devices are allowed to co-exist. Many communication and navigation systems, (including vital safety-of-life systems), depend upon the detection of weak signals for their operation. Test after test (even those sponsored by Time Domain) have substantiated beyond doubt that UWB will cause significant harmful interference to cellular, broadband PCS, certain specialized mobile radio, conventional and enhanced GPS systems.

TDC addresses the QUALCOMM Report in the last section of its Comments.[9] TDC has made several erroneous statements, starting with the first paragraph of the introduction to that last section. Indeed, the very first sentence is incorrect when it states that the QUALCOMM Report "does not add any new or substantive information to the UWB docket." In contrast to Time Domain's statement, Sirius Satellite Radio[10] declares that the QUALCOMM report is "one of few that addresses the measurement of interference from UWB devices into non-GPS receivers." The ARINC/ATA Comments include several references to the QUALCOMM Report including this quote: "The proposed UWB rule....will have harmful impact on the normal operation of CDMA wireless devices in voice, data, and GPS modes."[11] In addition, ARINC and ATA, in Footnote 5 of their Comments, state that "there has been a limited number of non-GPS systems tested, [but] the potential for interference to existing authorized radio operations appears sufficiently great ...to warrant the FCC proceeding extremely cautiously." Continuing, ARINC and ATA note that, "to date, the QUALCOMM Study is the only measurement campaign that characterizes the degradation in frame error rate (FER) of PCS phone in voice mode as a function of UWB power, pulse repetition frequency (PRF) and CDMA received power."

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[9] *See* Time Domain, Part VIII, p. 83.
[10] See Sirius Radio, Comments.
[11] *See* Aeronautical Radio, Inc. and the Air Transport Association of America, Inc. ET Docket No. 98-153 (April 25, 2001) "Comments of Aeronautical Radio, Inc.", and the Air Transport Association of American, Inc., "Test Reports Addressing Potential Interference from Ultra-wideband Transmission systems."

In that same first paragraph of the section of its Comments addressing the QUALCOMM report, Time Domain now disputes the results of its very own sponsored study by Dr. Padgett of Telcordia. On September 12, 2000, Sprint PCS and Time Domain jointly submitted two documents in this ultra-wideband rulemaking proceeding[12]. The first document is a model that Telcordia Technologies developed, with substantial consultation with Sprint PCS and Time Domain, to analyze the impact of UWB transmitters on the forward link of a code-division multiple access (CDMA) PCS network.[13] The model developed by Dr. Padgett, presents an exhaustive model of the theoretical response of a CDMA PCS system to time modulated UWB signals.

Dr. Padgett in his summary[14] affirmed "...as expected, adherence to the free-space path loss vs. distance relationship was observed; i.e., the path loss at 2 GHz, in dB, is $L = 38 + 20 \log (d)$ where d is the separation between the transmitter and receiver, in meters. This is a good model for the path loss between the UWB device and PCS handset, which normally must be fairly close together for an interference effect to occur."

A second document summarized the tests that Sprint PCS, Time Domain, and Telcordia conducted to better understand the effect of a UWB transmitter on a PCS handset under controlled conditions.[15] These tests included laboratory bench tests with conducted RF paths, over-the-air tests in an anechoic (RF absorber-lined) chamber, and field tests at the Sprint PCS laboratory. Sprint PCS summarized the practical effects of this model and these tests in

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[12] *See* Letter from Charles W. McKee, Sprint PCS, to Magalie roman Salas, FCC Secretary, ET Docket No. 98-153 (September 12, 2000), and Letter from Jeffrey S. Ross, Time Domain, to Magalie Roman Salas, FCC Secretary, ET Docket No. 98-153 (September 12, 2000).

[13] *See* Dr. Jay Padgett, Senior Research Scientist, Telcordia Technologies, "A Model for Calculating the Effect of UWB Interference on a CDMA PCS System (September 12, 2000), *appended* as Attachment 1 to the September 12, 2000 Spring PCS and Time Domain letters.

[14] *See* Sprint/TDC Joint Filing, (September 12, 2000), attachment 2 page 2.

[15] Dr. Jay Padgett, "Summary of Testing Performed by Sprint PCS and Time Domain to Characterize the Effect of Ultra-wideband (UWB) Devices on an Is-95 PCS System" (September 12, 2000), *appended as* Attachment 2 to the September 12, 2000 Sprint PCS and Time Domain letters.

supplemental comments filed October 6, 2000[16]. The data confirmed that UWB devices would cause harmful interference to PCS CDMA networks even at the more stringent –53.2 dBm/MHz average power level discussed in the NPRM[17].

Now, TDC disagrees with the very Telcordia scientist that it sponsored to conduct the tests. TDC contends that the document submitted to the Commission "shows that this theoretical model does not accurately describe the results of real world, open field testing." It is interesting to note that, of the over three-dozen Reply Comments filed which commented on the Sprint PCS/Time Domain/Telcordia model, only two parties—namely Time Domain and XtremeSpectrum—chose to question the conclusions Sprint PCS drew from the data. However, neither Time Domain nor XtremeSpectrum has presented proof which would undermine the most reasonable conclusions that can be drawn from the Time Domain/Sprint PCS/Telcordia model and testing—namely that UWB devices will cause significant harmful interference to CDMA PCS networks. Time Domain is effectively arguing that it seems unlikely that UWB interference will be harmful to PCS networks, but the Commission certainly cannot approve UWB based on such speculative, baseless assertions.

In the same first paragraph, Time Domain also claims[18] "...at separation distance of less than 1 meter, it was not possible to reliably detect the presence of an UWB emitter." In fact, however, at a separation distance of 1 meter, the path loss is 38 dB[19] and the power received from a Class B Part 15 Device in 1.25 MHz is then –78.2 (-41.2 –38 + 10log(1.25)). No one in the wireless community who is familiar with the interference model would make such a statement and characterize this level of interference as "not possible to reliably detect." QUALCOMM would

[16] *See* Sprint, ET Docket No. 98-153 (October 6, 2000) "PCS Supplemental Comments."
[17] *See UWB NPRM*, ET Docket No. 98-153, FCC 00-163, 15 FCC Rcd 12086 (May 11, 2000).
[18] *See* Time Domain (April 26, 2001), p. 83.
[19] Dr. Jay Padgett, "Summary of Testing Performed by Sprint PCS and Time Domain to Characterize the Effect of Ultra-wideband (UWB) Devices on an Is-95 PCS System" (September 12, 2000), *appended as* Attachment 2 to the September 12, 2000 Sprint PCS and Time Domain letters.

like to emphasize that a 1-meter separation is a very realistic distance, given the applications promoted by UWB proponents such as home entertainment, office and automotive applications.

Next, TDC implies, if not outright states, that QUALCOMM misunderstands UWB transmission technology. Time Domain spends much time and effort disputing the test results (NTIA, DOT/Stanford, and QUALCOMM) which all show that UWB transmissions pose a substantial threat of harmful interference to GPS operations. Earlier studies by the NTIA regarding interference to federal non-GPS systems[20] and the Sprint analysis regarding interference to PCS systems show the inability of unlicensed UWB devices to share spectrum, especially in restricted bands, without interfering to existing licensed services. ARINC and ATA[21] go so far as to urge the Commission, based on the test results already submitted, "to preclude unlicensed UWB operation entirely." According to ARINC and ATA, the data support only one rational answer to the question of whether UWB operations can cause harmful interference to GPS and other existing services. The answer is yes.

QUALCOMM takes an opposite approach from TDC. Rather than existing licensed services and safety-of-life services having to prove that UWB has real potential for harm, QUALCOMM strongly believes that the burden of proof is on TDC and the other UWB proponents to prove that there will not be any harmful interference either to GPS or to existing licensed services. To date, Time Domain has not positively proved that its version of UWB does not cause harmful interference to PCS and 3G phones, as well as to GPS.

In paragraph 2 of the introduction to Section VIII of its Comments, TDC claims that the testing described in the QUALCOMM Report "suffers from weaknesses common to misunderstandings

[20] *See* NTIA Special Publication 01-43, "Assessment of Compatibility between Ultra-wideband Devices and Selected Federal Systems," Lawrence K. Brunson, ET Docket No. 98-153 al. (January 2001).
[21] *See* Aeronautical Radio, Inc. and the Air Transport Association of America, Inc, ET Docket No. 98-153 (April 25, 2001), "Comments of Aeronautical Radio, Inc. and the Air Transport Association of America, Inc. on Test Reports Addressing Potential Interference From Ultra-wideband Transmission Systems."

about UWB and the Part 15 general limits." On the contrary, Time Domain demonstrates its misunderstanding of how commercial CDMA receivers work. For commercial CDMA receivers, it does not matter if the in-band noise in 1.2288 MHz bandwidth has spectral lines or white spectrum. What matters is the total power in 1.2288 MHz. In the following section, QUALCOMM addresses TDC's specific comments on the QUALCOMM Report in more detail.

2. QUALCOMM's Response to Specific Comments

A- 1 dB Increase in the Receiver Noise Floor Is Not Harmful Interference

According to TDC, QUALCOMM confused a 1 dB increase in a receiver's noise floor with harmful interference.[22] TDC claims that QUALCOMM is using a "harmful interference" definition that has been "rejected by the Commission in the 700 MHZ Report and Order."[23]

TDC is very selective with its definition of "harmful interference." It partially quotes the FCC and NTIA's definition of "harmful interference." According to TDC at page 84 of its Comments, both definitions state that for something to be considered harmful interference, "it must cause serious degradation, obstruct or repeatedly interrupt intended communications." However, NTIA's[24] entire definition of harmful interference is "**interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication services operating in accordance with these Regulations** (emphasis added)." The Commission's Rules[25] define harmful interference as "**Any emission, radiation or induction that endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunications service operating in accordance with this chapter.**"

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[22] *See* QUALCOMM, p. at 7.
[23] *See* FCC Second Memorandum Opinion and Order, (released January 21, 2001).
[24] See NTIA Manual § 6.1.1.
[25] *See* 47 CFR 15.3 (m) (emphasis added). *See also* 47 C.F.R. 2.1, 21.2.

Again, Time Domain wants to pick and choose the parts of a sentence that it wants to use, but ignores the parts which disprove its argument. In criticizing QUALCOMM for supposedly confusing a 1 dB increase in a receiver's noise floor with "harmful interference," TDC conveniently left off the parts of the FCC and NTIA's definitions of "harmful interference" which include "interference which endangers the functioning of a radionavigation service or of other safety services..." (NTIA) and "(a)ny emission, radiation or induction that endangers the functioning of a radionavigation service or of other safety services..." (FCC).

QUALCOMM used the 1 dB degradation in the noise figure as a criterion to calculate the minimum separation distance between a single UWB device and a general receiver. The calculation presented[26] indicated that the minimum separation is 24 meters (after correcting the error in the propagation model). At a three-meters separation, the UWB signal level is 17.3 dB above the noise floor of a CDMA handset receiver. This corresponds to degradation in the noise figure by 17.3 dB! No current commercial receiver can withstand this level of degradation.

In order to negate the interference impact of UWB devices on a PCS phone, one needs to improve the noise figure of existing phones. For a PCS phone with 8 dB noise figure, an improvement of 1.3 dB is required to negate a one dB degradation in noise figure. Similarly, an improvement of 3.8 dB in noise figure is need to negate a two dB degradation due to interference from UWB devices. Finally, it is theoretically impossible to negate the effect of 2.66 dB or higher noise figure degradation.

The noise figure of a CDMA phone is predominately set by the noise figure of the first Low Noise Amplifier (LNA), the insertion loss of the duplexer, and the insertion loss of the receive RF filter. The loss due to the duplexer is dominated by size and comes from the current density in the cavity walls. The larger the resonator, the lower the current densities and hence, lower

[26] *See* QUALCOMM, p. 8.

loss. Thus allowing a lower loss in the duplexer would potentially result in a much larger duplexer. A larger duplexer size is more expensive and requires a larger phone form factor.

Similarly, reducing the insertion loss of the receive RF filter implies increasing the size of the filter, hence the phone form factor. Currently, phones designers use RFIC LNAs. It is difficult to improve on existing noise figure without sacrificing the yield of production of these LNAs. The other option is use discrete implementation, which results in higher costs and again larger form factor. All these technical facts lead to the conclusions that improving the noise figure to compensate for the degradation due to interference form UWB is a costly and unacceptable proposal.

The Commission's rejection of Motorola's criterion[27] regarding the 1 dB noise figure degradation in the 700 MHz proceeding applies to base stations, not to handsets. It may be possible, although expensive, to compensate for the degradation in the noise figure of the base stations by improving the designed noise figure because the form factor of base stations is not a constraint. Also, the cost of improving the noise figure of one base station is usually divided by the number of subscribers served by that base station.

On the handset side, both the form factor and the cost of improving the design noise figure are expensive considerations in a highly competitive market place. One important consideration the Commission must keep in mind is that there are millions of CDMA legacy handsets already deployed.

Cellular, broadband PCS, and certain specialized mobile radio licensees have spent huge amounts of time and resources to reduce the form factor of the phones. If UWB were allowed to

[27] *See Service Rules for the 746-764 and 776-794 MHz Bands,* FCC Second Memorandum Opinion and Order, p. 4.

co-exist in the licensed spectrum, licensed users would be forced to spend more money per phone and change the phone form factor just to maintain the same noise figure in the presence of UWB interference.

It would be unjust to ask the existing licensees to redesign their systems. In Sprint's Comments relating to UWB interference to CDMA PCS networks,[28] Sprint is dismayed that Time Domain suggests Sprint PCS must redesign its networks to –95 dBm to allow for UWB interference. Even Time Domain concedes that a massive PCS network redesign would not eliminate UWB interference, but only reduce its level.

B- The Signal Type Used by QUALCOMM Included Harmful Spectral Features Instead of Using PPM to Ensure the Signal is White Noise-Like

In raising this objection, Time Domain demonstrates its misunderstanding of how commercial CDMA receivers work. For commercial CDMA receivers, it does not matter if the in-band noise has spectral lines or white spectrum. Unlike GPS receivers, the power spectrum of commercial CDMA signals do not contain spectral lines separated by 1 KHz. What matters is the total power in 1.2288 MHz. If all UWB devices used the noise whitening technique proposed by Time Domain, will the total noise power in 1 MHz be less than –41.2 dBm? In QUALCOMM's view, using a whitening technique will not reduce the power per MHz, which is an important parameter for operators and users of CDMA PCS systems.

As stated above, QUALCOMM would have preferred to test PCS interference using a UWB device provided by Time Domain or another UWB provider. As reported in the Comments,[29] QUALCOMM contacted several UWB companies in order to buy or borrow an UWB pulse

[28] *See* Sprint PCS, ET Docket No. 98-153 (February 21, 2001), "Written Ex Parte Presentation, UWB Interference to CDMA PCS Networks."
[29] *See* QUALCOMM, page 14.

generator module. All the companies contacted declined the request "due to lack of resources." Specifically, QUALCOMM contacted Time Domain several times. TDC claimed that they didn't have any UWB devices to loan or for sale. Therefore, because of the urgency of the timing and the importance of the testing to the FCC, emergency E911, and the PCS/cellular community, QUALCOMM subsequently decided to use the HL9200 pulse generator module in its testing program. QUALCOMM went to great lengths to replicate the signals that could be generated by potential UWB devices. QUALCOMM took into consideration that not all UWB device manufacturers will use the same exact whitening technique proposed by Time Domain for all applications.

C- Contrary to What QUALCOMM Argues, the Analyzed UWB Signals Did Not Exhibit A Large Peak-To-Average Ratio.

Time Domain claims that the joint testing conducted by Time Domain and Sprint PCS showed that time modulated UWB was white noise-like in the PCS receiver bandwidths and thus did not exhibit a large peak-to-average ratio. QUALCOMM examined carefully the Time Domain Report[30] and did not find any reference or mention of peak-to-average ratio.

The UWB module used by QUALCOMM exhibited relatively large peak-to-average ratios depending on the pulse repetition frequency. It is QUALCOMM's view that some UWB implementations will have large peak-to-average ratio as part of its inherent characteristics.

Time Domain also assumed that the UWB signal source used by QUALCOMM had 5 MHZ pulse repetition frequency (PRF). For the record, QUALCOMM did not use a 5 MHz PRF. QUALCOMM used the signal generator to vary the PRF between 10 MHz and 17.5 MHz. This is a reasonable range of PRF for a device used to communicate at 1 Mbps and uses 10-20 pulses

[30] *See* Sprint/TDC Joint Filing, (September 12, 2000).

per bit for coherent integration. Again, QUALCOMM doesn't anticipate that every UWB device manufacturer will use the same whitening technique, hence the peak-to-average ratio can be significant.

D- The Device Modeled by QUALCOMM Probably Emitted More Power Than the FCC Would Allow.

Here, Time Domain claims that QUALCOMM calculated the field strength based on a reading of the Part 15 Class B rules, but did not use a device that had undergone FCC laboratory certification testing. In addition, TDC assumes that the device probably emitted more power than would be certifiable (if the UWB signal generator was an unintentional emitter).

When Time Domain makes the statement that the QUALCOMM device "probably emitted more power" than would be certifiable, it is being disingenuous and highly misleading. To QUALCOMM's knowledge, UWB Part 15 FCC laboratory certified devices do not exist. Time Domain is completely ignoring the objective of QUALCOMM's testing. As stated in the Executive Summary of QUALCOMM's Report, the series of laboratory tests were conducted to assess the impact of ultra-wideband emissions on PCS phones. The investigation focused on assessing UWB proponents' claims that the technology is able to share the spectrum with existing users with no or minimal interference. Therefore, it does not matter how much power the UWB device used in the test emitted; what matters is the total power in 1.2288 MHz of bandwidth at the CDMA receiver input.

QUALCOMM's Report went to great length in calibrating the power at each point in the test set up.[31] Figure 5.1 depicted the huge degradation in Frame Error Rate (FER) as a function of the power received at the PCS phone input in 1.2288 MHz. For example, if the CDMA received

[31] *See* QUALCOMM, page 18, Figures 4.4, 4.5 and 4.6.

power from the BS simulator was –87 dBm, a UWB input power of –92 dBm degraded the FER to 5%. PCS carriers design their network to work at an average FER of 2%. At 5% FER voice is unintelligible and the service is considered unacceptable for commercial purposes. The path loss (isolation) required to achieve –92 dBm of interference power from a Class B Part 15 device (with output power in 1.2288 MHz =-41.2 + 10log(1.2288)) is 51.8 dB. This isolation corresponds to a separation distance of 4.9 meters. This separation distance is impractical in office, home or automobile environments. PCS carriers go through rigorous and costly testing and optimization procedures in order to achieve this level of performance. It would be unfair to subject them to any type of interference that degrades the service quality to unacceptable levels.

E- QUALCOMM Used an Unrealistic Propagation Model.

Time Domain asserts, "QUALCOMM used an unrealistic propagation model."[32] Again, Time Domain is being selective in quoting technical facts. QUALCOMM would like to underscore the study of Dr. Jay Padgett (sponsored by Time Domain) where he developed a model to analyze the impact of UWB interference on a CDMA PCS system[33]. The model assumed free space propagation. In the analysis section, Dr. Padgett summarized his findings by saying[34] "As expected, adherence to the free-space path loss vs. distance relationship was observed; i.e., the path loss at 2 GHz, in dB, is L = 38 + 20 log (d) where d is the separation between the transmitter and receiver, in meters. This is a good model for the path loss between the UWB device and PCS handset, which normally must be fairly close together for an interference effect to occur."

[32] *See* Time Domain, page 87.
[33] *See* Sprint, Attachment 1, page 1.
[34] *See* Sprint, Attachment 2, page 2.

F- QUALCOMM Used Unrealistic PCS Signal Levels.

As usual, and over and over again, Time Domain quotes QUALCOMM's work out of context. The minimum CDMA received signal level used in the test is –97 dBm. This is reasonable signal level since carriers use –100 dBm as a rule of thumb to define edge of coverage in CDMA. If Time Domain engineers carefully read the text, they would have recognized (and hopefully understood) that the calculated distance in the analysis part is the minimum separation required to degrade the noise figure of a CDMA phone by 1 dB. This type of calculation depends on the receiver sensitivity of the phone. In addition, a set of charts were provided to depict the degradation in noise figure as a function of the separation distance. The noise figure of commercial CDMA phones is 8 dB. This is equivalent to receiver sensitivity of –105 dBm. Again, the noise figure is a very important specification to the carriers. They go to great lengths to factory test the phones to ensure that the measured noise figure meets the requirements. Those phones that do not meet the requirements are rejected. Degradation in noise figure is equivalent to more transmit power from the base station, hence a loss in system capacity. As is evident from the Sprint PCS filing[35] the test conducted in the presence of UWB devices indicated that as much as 50% more power for the PCS phone is needed. The loss in network capacity could be considerable if several PCS customers are near active UWB devices.

QUALCOMM agrees that there was an error in Equation (3.9) in their report. The correct equation should have read $L_p = 20 \log(d) + 20\log(f) + 32.4 + L_{adjust}$. The error was also repeated in Table 3.1 and resulted in an error in calculating the minimum separation distance. The correct minimum separation distance in Table 3.1 should be 24 meters instead of 35 meters.

[35] *See* Sprint, ET Docket No. 98-153 (April 25, 2001), "Sprint Corporation Comments", page 2.

QUALCOMM, in its report, has stated that UWB interference mechanism is dependent on the UWB parameters, UWB deployment scenario, the characteristics of the victim receiver, and the deployment of the victimized service. The same conclusions have been shared with the Commission by many other contributions to the captioned proceeding.

3. Conclusions

QUALCOMM is concerned that the unrestricted deployment of UWB devices poses a demonstrated threat to existing and future licensed services. It is clear from all the test results submitted so far in the captioned proceeding that UWB RF interference impacts the performance of cellular, broadband PCS, certain specialized mobile services, and safety-of-life systems such as enhanced GPS receivers. More importantly, the impact is not as negligible as some UWB proponents claim.

In recent testimony to a Congressional Subcommittee, Time Domain touted the idea that "UWB operates in Part 15 of the spectrum where common digital devices such as laptop computers, palm pilots, and pocket computers place their unintended emissions."[36] The fact of the matter is UWB devices do not operate only in Part 15 of the spectrum. UWB devices emit interference over a very wide band of the spectrum covering not only the Part 15 sub-band, but other licensed sub-bands as well. The Part 15 unlicensed band is only 110 MHz wide. The UWB devices that Time Domain is promoting have multiple GHz of bandwidth.

[36] Time Domain testimony, House Armed Services Military Research and Development Subcommittee, Hearing on Innovative Research Companies, March 22, 2001.

In the same testimony, Time Domain claimed that "UWB exhibits incredible spectral efficiency that takes advantage of underutilized spectrum, effectively creating "new" spectrum for future and existing services by making productive use of "noise floor," where emissions from common household devices reside. Today, there are no services offered in this part of the spectrum and UWB provides an opportunity to use this spectrum productively." Stephen Fenichell, in an article he wrote for Discover Magazine[37], concluded after his interview with Larry Fullerton of Time Domain, that "A vast new spectrum for wireless communications could be available for use by everyday devices like cell phones. Best of all, if approved by the Federal Communications Commission, the Technology would not require the huge expense of purchasing the right to broadcast on a licensed frequency."

Both Time Domain's statements and the reporter's conclusions are inaccurate and misleading. It is well known in the UWB community that UWB is not an efficient way of utilizing spectrum. This can be demonstrated by comparing the data rates UWB devices deliver to the bandwidth used. The attractiveness of UWB is that it takes advantage of the ultra-wide bandwidth to hide the signal making it less prone to interception. This low probability of intercept feature is at the expense of spectral efficiency as known in the digital communications literature. In addition, much of the federal and commercial use of spectrum occurs below the 3.1 GHz. Many portions of this spectrum have been placed on the Part 15 restricted bands list, and for good reasons. Time Domain is advocating that UWB can superimpose its emissions on existing services without interference thereby "creating spectrum." Such statements are not factual and without basis. As a matter of fact, all the tests conducted so far show some level of interference. There are several

[37] *See* Discover Magazine, Vol 22, No. 5 (May 2001), "Radio Flyer: Can a tenacious lone inventor revolutionize wireless communications with a chip he invented in his garage?", Stephen Fenischell.

systems operating in these lower frequency bands that need to, and typically do, operate near the thermal noise floor including radio astronomy, weak signal amateur radio operations, CDMA cellular and PCS licensed systems and, more importantly, for safety-of-life GPS. In addition, companies who operate systems in these licensed bands have already paid huge sums to the FCC for ***exclusive*** licenses in order to use these frequencies free from interference and have invested billions of dollars in equipment, advertising, and market building.

QUALCOMM concurs with the statements presented in the Joint Industry *Ex Parte* submittal[38] that "any final action by the FCC on the current record would be seriously premature … especially because UWB proponents seek unprecedented changes in the way the FCC manages the spectrum and because of the potentially adverse impact those changes may have on broad array of licensed services." The UWB licensees, if any, should be held fully financially responsible for any damage they cause. The burden of proof for immunity to such damage claims should rest fully on their shoulders.

QUALCOMM trusts that the above information, along with the substantial information on this subject received by the Commission, will help in assessing the impact of UWB technology on licensed services. The FCC should take a cautious and reasonably conservative approach in this proceeding until all the facts regarding potential RF interference are collected, scrutinized, and digested by all concerned parties.

[38] Joint Industry *Ex Parte*, page 2.

Respectfully submitted,

Dr. Samir S. Soliman
QUALCOMM Incorporated
Vice President-Technology
5775 Morehouse Drive
San Diego, CA 92121-1714
(858) 658-2916

By: _____

Dean R. Brenner
Crispin & Brenner, P.L.L.C.
1156 15th Street, N.W.
Suite 1105
Washington, DC 20005
(202) 828-0155
Atttorney for QUALCOMM Incorporated

Dated: May 10, 2001

CERTIFICATE OF SERVICE

I, Dean R. Brenner, do hereby certify that on this 10th day of May, 2001, a copy of the foregoing Reply Comments was served by U.S. mail on:

Honorable Michael Powell
Chairman
FCC
445 12th Street, S.W.
Washington, DC 20554

Honorable Susan Ness
Commissioner
FCC
445 12th Street, S.W.
Washington, DC 20554

Honorable Harold Furchtgott-Roth
Commissioner
FCC
445 12th Street, S.W.
Washington, DC 20554

Honorable Gloria Tristani
Commissioner
FCC
445 12th Street, S.W.
Washington, DC 20554

Bruce Franca
Acting Chief
Office of Engineering & Technology
FCC
445 12th Street, S.W.
Washington, DC 20554

Rebecca Dorch
Deputy Chief
Office of Engineering & Technology
FCC
445 12th Street, S.W.
Washington, DC 20554

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

Julius Knapp
Chief, Policy & Rules Division
Office of Engineering & Technology
FCC
445 12th Street, S.W.
Washington, D.C. 20554

Karen Rackley
Chief, Technical Rules Branch
Office of Engineering & Technology
FCC
445 12th Street, S.W.
Washington, DC 20554

John A. Reed
Senior Engineer
Office of Engineering & Technology
FCC
445 12th Street, S.W.
Washington, DC 20554

Lisa Gaisford
Office of Engineering & Technology
FCC
445 12th Street, S.W.
Washington, DC 20554

Ron Chase
Office of Engineering & Technology
FCC
445 12th Street, S.W.
Washington, DC 20554

Mitchell Lazarus
Fletcher Heald & Hildreth, P.L.C.
1300 North 17th Street
11th Floor
Arlington, VA 22209
Counsel for Xtreme Spectrum, Inc.

Raul R. Rodriquez
Leventhal Senter & Lerman, P.L.L.C.
2000 K Street, N.W.
Suite 600
Washington, DC 20006
Counsel for The U.S. GPS Industry Council

Nicholas W. Allard
Latham & Watkins
555 Eleventh Street, N.W.
Suite 1000
Washington, DC 20004
Counsel for Sirius Satellite Radio, Inc.

Christopher D. Imlay
Booth Freret Imlay & Tepper, P.C.
5101 Wisconsin Ave., N.W.
Suite 307
Washington, DC 20016
Counsel for ARRL, the National Association for Amateur Radio

Paul Withington
Vice President
Time Domain Corporation
Cummings Research Park
7057 Old Madison Pike
Huntsville, AL 35806

David E. Hilliard
Wiley Rein & Fielding
1776 K Street, N.W.
Washington, DC 20006
Counsel for Time Domain Corporation

Edward A. Yorkgitis, Jr.
Kelley Drye & Warren, L.L.P.
1200 19th Street, N.W.
Suite 500
Washington, D.C. 20036
Counsel for Aeronautical Radio, Inc. & the Air Transport Association of America, Inc.

Vaidhyanathan Arunachalum
Conexant Systems, Inc.
4311 Jamboree Road
Newport Beach, CA 92660

Gerald Musarra
Vice President, Trade & Regulatory Affairs
Lockheed Martin Corporation
1725 Jefferson Davis Highway
Suite 403
Arlington, VA 22202

Steve B. Sharkey
Director, Telecommunications Regulation & Policy
Motorola, Inc.
1350 I Street, N.W.
Suite 400
Washington, DC 20005

Kathy D. Smith
Chief Counsel
U.S. Department of Commerce
National Telecommunications & Information Administration
Washington, DC 20230

Ben K. Sternberg
Professor & Director
Laboratory for Advanced Subsurface Imaging
University of Arizona
1235 E. North Campus Dr.
Tucson, AZ 85721

Professor Don Sinott
CEO
Centre for Sensor Signal & Information Processing
SPRI Building
Mawson Lakes Boulevard
Mawson Lakes, S.A. 5095
AUSTRAILIA

Dennis J. Johnson
President
Geological Survey Systems, Inc.
13 Klein Drive
North Salem, NH 03073

Sheldon R. Bentley
The Boeing Company
PO Box 3707
Mail Code 3U-AJ
Seattle, WA 98124

David L. Wright
Crustal Imaging & Characterization Team
USGS
Box 25046, Federal Center
Denver, CO 80225

Robert J. Fontana
President
Multispectral Solutions, Inc.
20300 Century Boulevard
Germantown, MD 20874

Luisa Lancetti
Rikke Davis
Sprint PCS
401 9th Street, N.W.
Suite 400
Washington, DC 20004

Charles McKee
Sprint PCS
6160 Sprint Parkway
KSOPHI0414-4A325
Overland Park, KS 66251

Lee D. Slater
Dept. of Geosciences
University of Missouri-Kansas City
Kansas City, MO 64110

Richard C. Benson
President
Technos, Inc.
3333 NW 21st St.
Miami, FL 33142

Jeffrey J. Daniels
Dept. of Geological Sciences
Ohio State University
Columbus, OH 43210

Dwain K. Butler
US Army Corps of Engineers
3909 Halls Ferry Rd.
Vicksburg, MS 39180-6199

Gary R. Olhoeft
Professor of Geophysics
Colorado School of Mines
1500 Illinois Street
Golden, CO 80401-1887

Dean R. Brenner