

**Before the
Federal Communications Commission
Washington, DC 20554**

In the Matter of

Revision of Part 15 of the FCC's
Rules Regarding Ultra-wideband
Transmission Systems

ET Docket 98-153

Reply Comments of Time Domain Corporation

In Response to the Request for Comments on
Five Reports Addressing Potential Interference from
Ultra-Wideband Transmission Systems
in Public Notice DA 01-753, March 26, 2001

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May 10, 2001

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Executive Summary

The Commission's experience shows that the general Part 15 limits have worked quite well in preventing harmful interference to licensed services. Throughout this proceeding, TDC has demonstrated that in order to determine the presence of harmful interference caused by UWB operations, the test data must be read with an understanding of the real-world signal propagation and other environmental factors. In so doing, all of the reports demonstrate that UWB operations may be safely authorized on a Part 15 basis.

The actual power levels being debated in this proceeding must be kept in perspective. The maximum level under consideration by the FCC is less than one ten-thousandth of a milliwatt per megahertz (*i.e.*, one-hundred billionths of a watt per megahertz). For purposes of comparison, typical cordless telephones transmit between one and 100 milliwatts, wireless local area networks transmit at 100 milliwatts, and cellphones transmit up to 500 milliwatts. These electronic devices – and countless others – are currently permitted to generate useless out-of-band emissions at levels equal to or greater than the proposed levels that UWB devices use to support numerous innovative – and life-saving – applications. Making such use of these exceedingly low signal levels has been heretofore impossible.

* * *

Well over 200 parties have participated in this proceeding, and a number of entities have provided the Commission with useful test data and analysis. The Commission now possesses a solid record on which to base UWB regulations.

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I. Introduction

Time Domain Corporation (TDC) respectfully submits these reply comments in response to the FCC Request for Comments on five reports assessing the potential for Ultra-Wideband (UWB) systems to cause harmful interference to Global Positioning System (GPS) receivers and Personal Communications Services (PCS) telephones.¹ TDC uses these reply comments to respond to the demand by a number of UWB opponents for a Further Notice of Proposed Rulemaking (FNPRM) before the Commission authorizes UWB operations. In reply, TDC explains that the Commission has a strong record on which to base regulatory decisions and demonstrates that the notice provided by the

¹ See Comments Requested on Reports Addressing Potential Interference from Ultra-Wideband Transmission Systems, DA 01-753, ET Docket No. 98-153 (Mar. 26, 2001).

Commission in its UWB NPRM provides a legally sufficient foundation on which to promulgate regulations. TDC also takes this opportunity to respond to a number of the technical positions put forth in the opening comments on the five reports.

The FCC's proceeding on UWB has elicited considerable criticism from many within the GPS and aviation industries. Unfortunately, much of this criticism is based on misunderstandings. One misunderstanding is that UWB emissions can somehow propagate farther than narrowband RF signals; in fact, UWB signals are limited by the same laws of physics that apply to other RF systems. The other misunderstanding is that the power levels proposed by the FCC are large relative to signal levels already allowed and encountered today. It must be remembered that, in the NPRM, the FCC proposed that below 2 GHz the power allowed would be 12 dB below today's Part 15 Class B general limits (*i.e.*, a reduction of 94%). This is less than 1/100,000,000 of a watt per megahertz – a level significantly lower than the limits that today's designers of unintentional radiator devices, *e.g.*, digital devices, struggle not to exceed.

UWB signals have been in use for years without raising controversy. As numerous *ex parte* filings attest, ground penetrating UWB radars are an important tool of geophysicists and have been in use for decades.² Many of these UWB radar devices are used regularly in and around airports. The military, both here and abroad, has also been using UWB equipment for quite some time, as have other U.S. government agencies. In fact, many of these ground penetrating radars (GPRs) and military systems use power

levels well above what the FCC has proposed. Most importantly, not a single instance of harmful interference caused by these devices has appeared in the record of this proceeding and, to our knowledge, neither the FCC nor NTIA has received any complaints of interference from these devices.

II. A Further Notice of Proposed Rulemaking Is Not Necessary.

A. The Commission Has Now an Ample Record on Which to Base UWB Regulations.

The Commission has structured this proceeding into well-defined stages. The Commission's approach has been well-reasoned and carefully planned.³ In September 1998, the FCC issued its Notice of Inquiry ("NOI") to gather basic information about UWB systems. Then – more than 21 months later – in May 2000, the agency released its Notice of Proposed Rulemaking ("NPRM") based firmly upon the issues relevant to defining rules to allow UWB equipment to be deployed in a timely and appropriate manner. The NPRM contained numerous recommendations regarding regulations for UWB equipment including the applications and general characteristics, the frequency band(s) of operation and the corresponding emissions limits, measurement procedures,

² See, e.g., the filing of the Common Ground Alliance (May 3, 2001).

³ See, e.g., *ex parte* filing by Siemens Aktiengesellschaft (Apr. 14, 2001) responding to Joint Opposition Letter (*see* n.8, *infra*) (providing a description of the FCC's meticulous course to date in handling the authorization of UWB equipment).

and noted the critical input the Commission would receive from the many testing programs⁴ and related follow-on comments.

The NPRM provided clear and sound guidance to NTIA, Stanford University and the Department of Transportation, and the University of Texas Advanced Research Laboratory (UTARL) enabling them to build – and complete – detailed testing programs to measure the interaction between UWB and GPS. The NPRM also provided clear and sound guidance to a number of other parties who have conducted UWB testing, including – but not limited to – Sprint, Qualcomm and TDC. The Commission expected these testing programs to provide useful input and they have. In its NPRM, the FCC announced that it would request comment on each of the testing programs and related data.⁵ This latest round of comments should comprise the final pieces of the Commission’s carefully crafted rulemaking process.

The Commission’s staff has been monitoring the progress of the tests and has been closely interfacing with many of the parties who have conducted testing. The fruits of this effort are clearly evidenced. The Commission’s record of involvement and oversight of the testing programs has provided it with a solid and complete record – generated in response to multiple calls for public comment – upon which to base sound regulatory decisions.

⁴ The Commission even extended the deadline for which it would accept test results from the original date of October 30, 2000, so that more thorough testing and analysis could be performed.

⁵ See NPRM at ¶ 31.

Accordingly, a Further Notice of Proposed Rulemaking is not necessary, and continued calls in the record for an FNPRM and additional tests⁶ are nothing more than an attempt to delay this proceeding and to further delay introducing the benefits of UWB technology.

The UWB devices used by the NTIA implemented a variety of modulation techniques, and, as a result, allowed NTIA to test a variety of UWB signal structures. Some modes tested by NTIA were not noise-coded, while others were noise-coded. As NTIA noted in its Federal Systems and GPS test reports, it used these devices to test their effect on a variety of narrowband systems. As TDC explained in its comments,⁷ NTIA was only able to make claims that UWB would cause interference by using unrealistic criteria and computer simulations that ignored many real-world factors. In so doing, NTIA was still unable to show that UWB at the general Part 15 limits causes *harmful interference*. Moreover, NTIA found that signals from noise-coded UWB systems were

⁶ See, e.g., Comments of Conexant Systems, Inc. (Apr. 25, 2001) at 1; see also Comments of ARRL, the National Association for Amateur Radio (Apr. 25, 2001) at 3-4 (asking the Commission to wait “several months” before issuing regulations so that testing with amateur systems having limited funding, limited personnel, and limited access to facilities can be completed). ARRL also mistakenly argues that the NPRM proposed no rules or parameters, and notes that this “omission” makes it difficult to conduct testing. TDC finds ARRL’s statement curious, given the number of detailed and successfully completed testing programs (conducted by NTIA, Stanford/DoT, and UTARL/JHUAPL, to only name a few), which form an integral part of this docket. The U.S. GPS Industry Council (GPSIC) also argues that “[n]o specific rule proposals were made in the NPRM.” See Comments of GPSIC (Apr. 25, 2001) at 9. The Commission’s NPRM proves that GPSIC and ARRL are both wrong.

⁷ See TDC Comments (Feb. 23, 2001), Reply Comments (Mar. 12, 2001) and Comments (Apr. 25, 2001, as revised May 7, 2001).

similar to that of white noise signals when compared against the numerous victim receivers that were tested. Because the impact of white-noise is well understood, further testing is, therefore, unnecessary.

B. The Commission is Not Required to Include the Text of Proposed Rules in its NPRM.

A number of UWB opponents have expressed the view that the Commission should issue an FNPRM with the text of proposed rules and urge further comment.⁸ This is necessary, in the view of these UWB opponents, so that they will have adequate notice and a full opportunity to participate in the rulemaking as required by the Administrative Procedures Act (“APA”).⁹

These UWB opponents are mistaken. As TDC has explained in the section above, the Commission has provided adequate notice in this proceeding and these opponents have had and continue to have the opportunity to fully participate in this rulemaking process. This is clearly evidenced by the fact that so many of these parties have actively participated in this proceeding having submitted comments at the many stages in this rulemaking as structured by the Commission.¹⁰

⁸ See Joint Letter submitted by Air Transport Assoc. of America, Inc., et al. in ET Docket 98-153 (Mar. 27, 2001) (“Joint Opposition Letter”); see also Comments of Motorola, Inc. (Apr. 25, 2001) at 2.

⁹ See 5 U.S.C. §§ 551-702.

¹⁰ A number of these parties have also been actively meeting with Commission staff as evidenced by their *ex parte* notice filings.

As a legal matter, these UWB opponents are clearly wrong. It is well established that where courts have overturned an administrative regulation due to inadequate notice, the agency either gave no notice at all or there were major substantive differences between the proposed rule and the rules as adopted.¹¹ Neither of those situations applies in this proceeding. First, notice was given to interested parties in the UWB NPRM.¹² Second, even though the final rules have yet to be announced, the Commission may promulgate rules based on the full record as long as their scope is consistent with the NPRM.

The UWB opponents also base their demand for an additional comment period on the allegation that the Commission has violated the APA in failing to include the text of the proposed rule in the NPRM. Contrary to what these opponents would like the statute to say, the APA does not require an administrative agency to publish the text of a proposed rule in an NPRM.¹³ An administrative agency may include in the NPRM “either the terms or substance of the proposed rules *or* a description of the subjects involved.”¹⁴ Furthermore, an agency is not required to give notice to the parties of every precise

¹¹ See *Chrysler Corporation v. Department of Transportation*, 515 F.2d 1053, 1061 (6th Cir. 1975).

¹² Notice was also given to interested parties in the Notice of Inquiry: *Revision of Part 15 of the Commission’s rules Ultra-Wideband Transmission Systems*, 13 FCC Rcd 16376 (1998).

¹³ It is unclear what additional information the UWB critics would have wanted included in the NPRM. The NPRM already included a discussion of the relevant changes that would be made to Part 15 to permit the use of UWB devices. If the UWB critics seek a reprint in the notice of the Part 15 rules in their entirety, including the proposed changes, then they are simply placing form over substance.

proposal that the agency might adopt; the agency only needs to be descriptive enough of the subjects and issues involved in the proceeding to afford interested parties a “reasonable opportunity to participate” in the rulemaking.¹⁵ Despite the allegations of the UWB critics, the courts and the Commission have concluded in other rulemakings that similarly worded NPRMs were adequate, and have allowed the interested parties to participate fully in a meaningful and informed manner.¹⁶ Indeed, in this proceeding, the Commission provided extensive proposals in its 30 plus page NPRM, as noted above. Clearly, the Commission’s directive was complete enough for the testing parties to design and carry out the detailed testing programs that form an integral part of this docket.

¹⁴ See 5 U.S.C. § 553(b)(3) (emphasis supplied).

¹⁵ See *Trans-Pacific Freight Conference of Japan/Korea v. Federal Maritime Commission*, 650 F.2d 1235, 1248 (D.C. Cir. 1980); *California Citizens Band Association v. United States*, 375 F.2d 43, 49 (9th Cir. 1967).

¹⁶ Amendment to Parts 2, 15, and 97 of the Commission's Rules To Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications; International Harmonization of Frequency Bands Above 40 GHz; Petition of Sky Station International, Inc., For Amendment of the Commission's Rules To Establish Requirements for a Global Stratospheric Telecommunications Service in the 47.2-47.5 GHz and 47.9-48.2 GHz Frequency Bands; Amendment to Part 27 of the Commission's Rules To Revise Rules for Services in the 2.3 GHz Band and To Include Licensing of Services In the 47 GHz Band, *Memorandum Opinion and Order on Reconsideration and Notice of Proposed Rulemaking*, 13 FCC Rcd 16947, ¶ 47 (1998). (The Commission concluded that the Millimeter Wave Notice provided adequate notice by specifically inviting suggestions for rules “that would enhance the use of specific bands for particular services,” and stating that the “frequency bands proposed for commercial use and their technical standards might be altered in the final rules” to allow for the commercial development of ‘short range wireless radio systems.’) *State of New York Department of Social Services v. Shalala*, 21 F.3d 485, 495 (2d Cir. 1994). (The court concluded that HHS had given adequate notice in its rulemaking on Medicaid’s transition funding policy; the notice included a summary of the transition funding policy coupled with a request for comments “on all of Part 11 of the SMM [State Medicaid Manual].”)

The courts have held that to satisfy the notice requirements of the APA an agency's final rule must simply be a "logical outgrowth" of the notice provided.¹⁷ This means that, after reviewing an agency's NPRM, an interested party "should have anticipated such a requirement might be imposed" in the final rules.¹⁸ It is therefore legally acceptable where the party first encounters the final format of a rule when it is announced, as long as that rule is a logical outgrowth of the NPRM. Accordingly, at this juncture in the rulemaking process, it is premature for the UWB critics to raise this complaint. Once the Commission announces the final rules, the UWB opponents will have a full opportunity to seek reconsideration. Indeed, the adequacy of the Commission's notice and whether the final rules are a logical outgrowth of the NPRM cannot be determined until the final rules are promulgated.¹⁹

The UWB critics in their Joint Opposition Letter also assert that the NPRM failed to indicate the possible impact its NPRM would have on some parties (consumer groups and state agencies) who lacked the specialized expertise to realize the full import of the FCC's notice. It is well settled that the relevant inquiry is whether potential

¹⁷ *United Steel Workers of America v. Marshall*, 647 F.2d 1189, 1221 (D.C. Cir. 1980); *American Iron & Steel Institute v. EPA*, 568 F.2d 284, 293 (The court must ask whether the agency's notice would fairly apprise interested persons of the subjects and issues of the rulemaking).

¹⁸ *Aeronautical Radio v. FCC*, 928 F.2d 428 (D.C. Cir. 1991); *Small Refiner Lead Phase-Down Task Force v. United States EPA*, 705 F.2d 506, 549 (D.C. Cir. 1983) ("[T]he test, imperfectly captured in the phrase 'logical outgrowth,' is whether [the party], ex ante, should have anticipated that such a requirement might be imposed.")

commentators would have known based on the notice if an issue in which they were interested would be addressed in the final rule.²⁰ The FCC in the UWB NPRM clearly stated that the intent of the rulemaking was to “amend Part 15 of the Commission’s rules to pave the way for new types of products incorporating UWB technology.”²¹ Furthermore, well over 200 parties – including consumer groups and state agencies – have commented in this proceeding. The FCC provided proper notice in this rulemaking.

The UWB critics have cited *Wagner Electric Corp v. Volpe*, 466 F.2d 1013 (3d Cir. 1972), in support of their proposition that not all parties were made aware of the impact of the UWB NPRM. This case is inapposite. The *Wagner* NPRM stated an intent to change the rules related to vehicular hazard warning signal flashers by altering the test sampling provisions. The NPRM did not make reference to any other changes; however, the final rules included changes in the performance criteria for flashers. While the court concluded that interested parties were not given proper notice of the proposed change, it is important to note that – unlike in the UWB proceeding – the agency did not seek

¹⁹ “A determination of whether notice [is] adequate... turns, then, on an examination of the notice... provided in relation to the final rule which it ultimately adopts.” *AFL-CIO v. Donovan*, 757 F.2d 330, 338-39 (D.C. Cir. 1985).

²⁰ *American Medical Ass’n v. U.S.*, 887 F.2d 760, 768 (7th Cir. 1989) (articulating the standard as “whether or not potential commentators would have known that an issue in which they were interested was ‘on the table’ and was to be addressed by the final rule”); *Spartan Radiocasting Company v. FCC*, 619 F.2d 314, 321 (4th Cir. 1980). (“Unfairness results unless persons are ‘sufficiently alerted to likely alternatives’ so that they know their interests are ‘at stake.’”)

²¹ See NPRM at ¶ 1.

comment on the entire subject matter of the flashers.²² Moreover, the agency in Wagner had even conceded during the proceeding that its notice was not adequate.

In other cases, courts have found notice to be inadequate where the agency's notice does not include any reference to a rulemaking,²³ or if a proposed rulemaking is hidden in the text of a notice.²⁴ The instances where the notice was found to be inadequate bear no relation whatsoever to the current situation. The UWB NPRM sought "broad comment" on its proposed revisions to Part 15; commentators were not encouraged to limit their remarks to any specific portion of Part 15, and the fact that the rulemaking was for UWB devices operating under Part 15 of the Commission's rules is clear from the caption of the original NPRM and each subsequent notice requesting public comment.

In their Joint Opposition Letter, the UWB critics also expressed the view that by not including the text of the proposed rule in the NPRM, the Commission has damaged the rulemaking process by limiting the specificity of responding commentators. As discussed above, the UWB NPRM is specific enough to give interested parties a

²² See *Wagner*, at 1019.

²³ In *National Tour Brokers Association v. U.S.*, 591 F.2d 896 (D.C. Cir. 1978), the court struck down rules changing tour brokers' licensing requirements under the ICC because the notice did not mention any proposed rule changes; the notice only stated that the ICC was initiating a proceeding to determine the need for a legislative amendment to the Interstate Commerce Act.

²⁴ In *MCI Telecommunications Corp. v. FCC*, 57 F.3d 1136, 1142 (D.C. Cir. 1995), notice of a potential rule change was only contained in a single footnote. The court held that "an agency may not turn the provision of notice into a bureaucratic game of hide and seek."

reasonable opportunity to participate in the rulemaking. The UWB critics simply want to delay this proceeding indefinitely by requesting another round of comments in order to comment on the final rules. An agency cannot be forced to issue a new NPRM every time it validly alters its proposed rule by taking into account the comments filed in that proceeding.²⁵ If that were the case, rulemakings could become never ending processes and the agencies, in an effort to avoid further comment rounds, would be given the incentive to ignore the suggestions of the public thereby thwarting the principle behind the NPRM.²⁶

It is vital for the public and interested parties to be given an opportunity to comment on proposed agency rules, but once the public has had that opportunity, the relative public interest in another round of public comment must be balanced with the

²⁵ See *National Cable Television Ass'n v. FCC*, 747 F.2d 1503, 1507 (D.C. Cir. 1984), quoted in *Transmission Access Policy Study Group v. FERC*, 225 F.3d 667, 729 (D.C. Cir. 2000) (“An agency ... must be free to adopt a final rule not described in the [NPRM] where the difference is sufficiently minor, or agencies could not change a rule in response to valid comments without beginning the rulemaking anew.”); *International Harvester Co. v. Ruckelshaus*, 478 F.2d 615, 632 (D.C. Cir. 1973) (“the requirement of submission of a proposed rule for comment does not automatically generate a new opportunity for comment merely because the rule promulgated by the agency differs from the rule it proposed.”).

²⁶ The APA cannot be construed to place agencies in the dilemma of either ignoring substantive comments or modifying its proposals in response to comments, thus triggering another round of comments. *American Medical Ass'n v. U.S.*, 887 F.2d 760, 768 (7th Cir. 1989); *Trans-Pacific Freight Conference*, at 1249.

public interest in finality and timely action.²⁷ These latter factors could not be any more consequential than they are for UWB authorization.

The attempt by these UWB opponents to push the Commission into another time-intensive round of additional comments in the UWB proceeding is not only premature, but unnecessary. The UWB NPRM was detailed enough to allow all interested parties to know that their interests were at stake and be able to offer meaningful comment. The Commission should now be in a position to promulgate final rules that are consistent with its NPRM.

Because the initial notice was adequate and the final rules will in all likelihood be a logical outgrowth of that notice, there is no justification for an additional round of comment. Thus, a Report and Order would be an appropriate next order of course for the Commission.

III. What Part 15 Power Levels Really Mean

It is worth remembering the actual power levels being debated in this proceeding. The maximum level under consideration by the FCC is less than -41 dBm per megahertz. This is less than one ten-thousandth of a milliwatt per megahertz. Even taking into account the bandwidth of UWB systems, the total power level is still well under a milliwatt, one thousandth of a watt. Typical cordless telephones transmit between one

²⁷ See *Small Refinery* at 547 (noting that the agencies and the courts must balance the value of notice and that of expedition and finality.)

and 100 milliwatts, portable cellphones transmit up to 500 milliwatts, and wireless local area networks transmit at 100 milliwatts. Each of these devices – and countless other electronic devices – are allowed to generate out-of-band noise at levels equal to or greater than the levels proposed to be used by UWB devices.

Prior to the advent of modern UWB technologies, devices emitting a few milliwatts were considered low power devices and devices emitting microwatts of power had no conceivable value for high performance communications applications. As a testament to the minuscule nature of this power level, prior to this proceeding, Part 15 Class B emissions levels were known almost exclusively to digital device manufacturers who were finding that with ever increasing clock rates, compliance with the limits required painstaking design and manufacturing.

UWB has redefined extremely low power communications equipment because its huge operating bandwidth is a better match to the cluttered environment in which people live and work, thereby allowing it to utilize signals with extraordinarily low power spectral densities. In fact, as numerous parties have noted throughout this proceeding, UWB technology has been implemented – for years – by the U.S. Government, in form of GPR systems, dozens of contracts and STAs, and in a variety of “sensitive” locations, including in and around airports. The fact that there have been no documented reports of interference from these UWB operations – some at power levels in excess of the levels the Commission is considering authorizing – speaks volumes about the exceedingly low probability of UWB-induced harmful interference at the Part 15 general limits.

The comparison with other communications technologies reveals the technology's radical potential. Powers of 0 dBm to 21 dBm as measured within one MHz of bandwidth are common today for many unlicensed devices (including other wireless technologies such as Bluetooth and 802.11). While some of the current techniques hold the promise of data rates on the order of what can be expected from early UWB devices, none of the narrowband technology systems can integrate precision geo-positioning and radar sensing, for use in and around buildings. UWB, however, offers a fused communications, positioning and radar capability. There will continue to be a need for narrowband systems. However, as the spectrum becomes more crowded and additional capabilities such as tracking and positioning become increasingly critical, UWB offers a viable option without effectively dedicating spectrum to unlicensed operations.

IV. Response to Issues Raised in Opening Comments on the GPS Reports

A. GPSIC's Attempts to Distort the Record

Contrary to statements made by U.S. GPS Industry Council (GPSIC), there was testing of multiple UWB emitters.²⁸ Testing conducted by the University of Texas Applied Research Laboratory (UTARL) and analyzed by the Johns Hopkins University Applied Physics Laboratory (JHUAPL) included up to 16 simultaneously transmitting UWB emitters. NTIA also conducted testing with multiple emitters. The results from these tests are clear: the emissions of multiple noise-coded UWB emitters add like

²⁸ See GPSIC Comments at 7.

emissions from an equal number of white noise sources. Knowing that UWB emissions are white-noise-like makes it relatively easy to model the emissions and to therefore determine the impact on other systems.

GPSIC is also wrong in stating that the NTIA operational scenarios improperly favored the UWB community.²⁹ In fact, NTIA's scenarios were mostly based on information submitted by GPSIC, which was represented at all of NTIA's open meetings. (The other scenarios used by the NTIA came from other GPS users, such as the US Geological Survey and the Coast Guard.) In fact, TDC's only request – that all scenarios be analyzed relative to real-world performance criteria – was rejected by NTIA. NTIA's analysis effectively assumed that GPS would work 100% of the time no matter the environment and, therefore, any and all degradation to GPS receiver performance was attributable to UWB emissions.

B. White-Noise-Like UWB Signals Can Coexist with Existing Operations.

The NTIA, JHUAPL, and Stanford GPS/UWB compatibility studies all indicated that the worst effects on GPS C/A code receivers are from CW-like spectral emissions that are aligned with the GPS C/A code spectral lines. According to Stanford, CW-like emissions cause the same GPS performance degradation as do white-noise-like emissions that are up to 17 dB higher than CW-like emissions.³⁰ The frequency spectrum of a randomly dithered Pulse Position Modulation (PPM) UWB emission appears white-

²⁹ See *id.* at 1, 3-4, 10.

noise-like or pulse-like depending on the intercepting bandwidth, pulse repetition frequency (PRF), code length, and modulation type.

For UWB signals with PRFs of 1 MHz and above, a general test to determine whether a UWB signal is white-noise-like would be: (1) to measure the average power using a RMS detector in a 1 MHz RBW at the peak frequency; (2) then measure the average power at the same peak frequency using a noise marker measurement; and (3) then add 60 dB to the noise marker value. This technique should result in a sum that is within 3 dB of the measured power in the 1 MHz RBW for a white-noise-like UWB signal. This technique will assure that the UWB signal is white-noise-like across its entire frequency bandwidth, and not just at a single frequency such as the GPS L1 band.

Any measurement technique intended to determine whether a particular UWB implementation is white-noise-like should not unnecessarily impose a requirement for an additional reduction in power. Consider, for example, the test for white-noise-like emissions suggested by XtremeSpectrum. When combined with XtremeSpectrum's proposed emissions mask, their approach would require that UWB signals be attenuated in the GPS L1 band by 33 dB³¹ – a level that TDC does not believe can even be reliably measured using currently available technology. While TDC agrees with the conclusions made by JHUAPL, NTIA and Stanford that for high PRF systems, white noise-like UWB signals have the least impact on GPS C/A code receivers – and does not object to a

³⁰ See Stanford Report at 2, bullet one.

³¹ See GPS Comments of XtremeSpectrum (Apr. 25, 2001).

requirement that UWB signals to be designed to be white noise-like – TDC does not believe that any of the data or analysis in the record supports the need for a 33 dB attenuation of UWB power, regardless of whether the UWB signal is white noise-like or CW-like. TDC believes that the method outlined in the preceding paragraph is adequate for ensuring that UWB emissions are sufficiently noise-like.

C. Absolute Peak Limit

TDC has already suggested the elimination of the absolute (or total) peak limit because there is no data that links the instantaneous time domain peak electric field voltage to degradation in the victim receiver's performance.³² In other words, no direct relationship between the value of the peak electric field voltage and harmful interference (or any operational impact to a receiver, for that matter) has been established.

Several other parties have suggested a power ratio measurement and calculation of the absolute peak power. However, the NPRM has proposed measuring the absolute peak electric field in terms of instantaneous peak voltage - not power. While TDC continues to believe that the absolute peak limit is unnecessary, TDC has proposed an absolute peak electric field strength measurement technique that correlates the instantaneous peak electric field voltage to the standard FCC class B average electric field strength limit of

³² See Reply Comments of TDC (Oct. 27, 2000) at 52.

54 dB μ V/m at 3m.³³ TDC believes that this was the intent of the Commission as stated in its NPRM.

D. Band Limited Peak to Average Limit

TDC previously submitted comments and recommendations to the FCC concerning the 50 MHz band-limited peak limit for UWB emissions.³⁴ TDC has recommended, in the reply comments concerning NTIA's report on UWB and selected federal systems electromagnetic compatibility, that the existing 50 MHz band-limited time domain peak-to-average proposal be changed from the present limit of 20 dB to 41 dB in light of TDC's showing that the higher value would allow realization of the full potential of UWB technology without posing any added risk of harmful interference.³⁵ Based on NTIA's own data (with reasonable corrections based on real-world scenarios), TDC has shown that a 41 dB peak-to-average ratio at PRFs of 1 MHz and above will meet NTIA's protection criteria of a 1 dB increase in the system IF noise floor when the antenna is boresighted in a stationary position directly at the UWB source. (TDC has taken, and continues to take, issue with the manner in which the NTIA analysis was performed and with the use of a 1 dB increase in the system IF noise floor as a metric for harmful interference. Note that higher PRF systems will be limited by the average power

³³ See TDC Filing (Feb. 20, 2001).

³⁴ See *id.*

³⁵ See Reply Comments of TDC (Mar. 12, 2001) at 18.

limit that must also be met, which forces these systems to actually have a peak-to-average ratio much less than 41 dB).

The GPS test reports prepared by NTIA, JHUAPL, and Stanford provide further evidence that supports increasing the band-limited peak-to-average ratio. All UWB emissions look pulse-like for PRFs that are smaller than the victim receiver bandwidth, and appear as either CW-like or white-noise-like for PRFs that are larger than the victim receiver bandwidth. TDC's UWB signals utilize a randomly dithered Pulse Position Modulation technique, which has been classified in all three reports as pulse-like (for low PRFs) or white-noise-like (for higher PRFs).

All three reports show that C/A code receivers are actually more robust against pulse-like UWB emissions than against white-noise-like UWB emissions,³⁶ while white-noise-like UWB emissions are shown to affect GPS receivers much like other white noise-like signals, which include a number of other devices regulated under Part 15 of the FCC's rules. In other words, UWB systems that appear white-noise-like have a similar impact on a GPS receiver as do other Part 15 devices (*e.g.*, computers) while UWB systems that appear pulse-like have less of an impact than a source of white noise.

Pulse-like UWB emissions occur at PRFs that are lower than 0.66 of the intercepting bandwidth. The FCC has chosen to consider a representative victim receiver bandwidth of 50 MHz, so pulse-like UWB emissions will appear at PRFs that are less

³⁶ See Section on Classification of UWB Emissions in TDC's May 7, 2001 Filing, beginning on page 11.

than approximately 33 MHz. Since all three reports scale UWB emissions with different PRFs to the same average power, the UWB emissions with lower PRFs (which appear pulse-like to the GPS receivers) have much higher bandlimited peak-to-average ratios than UWB emissions with higher PRFs (which appear white-noise-like to the GPS receivers). Even though all UWB emissions were related to the same EIRP, the test results revealed that the C/A code GPS receivers can withstand higher UWB signal to GPS signal (J/S) ratios from pulse-like UWB emissions than from any other type of UWB emission. In other words, NTIA found that the same performance degradation (such as dropping lock on a single satellite or an increase in satellite reacquisition time) will occur at a higher UWB power level for pulse-like emitters than for CW-like or white-noise-like emitters.

The peak-to-average UWB band-limited emission limit for a given PRF can be calculated from the peak-to-average ratio relative to the EIRP of -41.3 dBm/MHz and from the difference between the white-noise-like J/S and the pulse-like J/S ratios. TDC will only consider randomly dithered PPM UWB emissions, which appear white-noise-like to a representative 50 MHz victim receiver bandwidth when the average PRF is greater than 33 MHz, and pulse-like when the PRF is less than or equal to 33 MHz. The lowest PRF that TDC will consider is 1 MHz, which equates to a band-limited peak-to-average ratio of 37.2 dB for a 1.5 ns wide pulse at a peak amplitude of 2.3 Vpk at 1 m measured through a 50 MHz Bessel filter (which is the measurement technique proposed by TDC in Appendix C of its October 27, 2000, filing and in its February 20, 2001, filing). The minimum difference between the J/S ratio of a randomly dithered 1 MHz

PRF PPM UWB emission that appears pulse-like to a C/A code receiver and the J/S ratio of a white-noise-like UWB emission is approximately 6 dB according to Table 2-1 of NTIA Report 01-45.³⁷ The total band-limited peak-to-average ratio for a 1 MHz PRF randomly dithered PPM UWB emission is therefore 37.2 dB (as calculated above for a 50 MHz bandwidth victim receiver) plus 6 dB (to account for the difference between a pulse-like and white-noise-like emission) for a total of 43.2 dB. This provides additional margin beyond the 41 dB peak-to-average level that TDC has suggested.

Higher PRF systems with the same average EIRP of -41.3 dBm/MHz will have a smaller band-limited peak-to-average ratio in order to comply with the average electric field strength limits. Since the GPS receivers examined by NTIA could tolerate a larger J/S ratio from the 1 MHz pulse-like emission with a high bandlimited peak-to-average ratio than a higher PRF UWB white-noise-like emission with a much smaller bandlimited peak-to average ratio, adoption of a peak-to-average limit of 41 dB would be sufficiently protective of GPS receivers.

³⁷ See Table 2.1 of NTIA Report 01-45. NTIA considered UWB emissions with 1 MHz PRFs, 2 % relative dithering and 100% gating factors to be pulse-like, and UWB emissions with 5 MHz and 20 MHz PRFs, 2% relative and 50% absolute dithering, and 100% gating factor to be noise-like. The average injected level of a 1MHz PRF 2% relative dithering, 100% gated system is -88 dBm/20 MHz for a given performance degradation. The average injected level for 5 and 20 MHz PRF systems with 2% relative and 50% absolute dithering and 100% gating is the average of $(-93.5 + -95 + -94 + -93)$ dBm/20 MHz to obtain about a 6 dB increased tolerance to pulse-like UWB emissions.

V. Conclusion

The Commission's experience shows that the general Part 15 limits, which are based on the prevailing digital device limits, have worked particularly well in preventing harmful interference to licensed services. TDC has shown throughout this proceeding that when the test reports are read with an appreciation of the real-world signal propagation and environmental factors – a critical component of determining the presence of harmful interference – they demonstrate that UWB operations may be safely authorized on a Part 15 basis.

Respectfully,

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