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

Comments of Time Domain Corporation

In Response to the Request for Comments on
Test Data Submitted by NTIA Regarding
Potential Interference to Selected Federal Systems
from Ultra-Wideband Transmission Systems

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Executive Summary

NTIA's reports provide useful information for reaching rational decisions on the future of UWB and offer insight into the need to model carefully electromagnetic compatibility effects among systems. When analyzed in a "real-world" environment, the reports offer assurance that UWB can be implemented without undue risk of harmful interference and without unduly restricting the introduction of this new technology. This analysis, however, requires a careful review of what NTIA did, and what it did not do.

NTIA developed a very conservative model. Conservative analysis in the defense of safety of life systems critical to the nation's infrastructure is reasonable, but only if the model reflects reality. NTIA correctly noted – but did not apply – many real-world mitigation factors that show how UWB technology can be implemented under Part 15 while protecting Federal systems. If one applies NTIA's model without taking these mitigating factors into account, one ends up with results that are plainly unrealistic. Using NTIA's conservative assumptions, a typical baby monitor or cordless phone is predicted to be able to transmit information up to 300 km, which is clearly not the case in the real world.

Time Domain Corporation's ("TDC's") comments address "real-world" mitigating factors such as the existence of buildings, trees, and hills, and other matters such as measured urban ambient noise and operational factors that were not reflected in NTIA's analysis. Taking these relevant real-world factors into account would provide between 40 and 60 dB of additional signal margin for UWB. Incorporating these factors into NTIA's recommended separation distances between UWB and Federal Systems

would substantially reduce those distances. Consider, for example, the Airport Surveillance Radar (ASR-9), which operates between 2.7-2.9 GHz. NTIA's recommended separation distance for a UWB device is 0.8 to 1.5 kilometers. Given a 40 to 60 dB reduction, a 1 kilometer distance would be reduced to less than 25 meters. Clearly, incorporating these "real-world" factors has a major impact on NTIA's results.

Part 15 of the FCC's rules states that unlicensed device operation "is subject to the conditions that no harmful interference is caused." The term "harmful interference" has been part of the FCC and NTIA's spectrum management lexicon for decades. Harmful interference is defined by the FCC as "interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service." NTIA's own definition tracks closely this FCC definition. In addition, the glossary provided on the NTIA ITS website adds that harmful interference "must cause serious detrimental effects, such as circuit outages and message losses, as opposed to interference that is merely a nuisance or annoyance that can be overcome by appropriate measures." At no point in its report did NTIA attempt to determine whether UWB caused any adverse operational impact, let alone an operational impact that would fall under the definition of harmful interference, to any of the Federal systems it measured or modeled.

The Commission's decisions on the authorization of ultra-wideband (UWB) technology will not only impact the beneficial uses of UWB on an unlicensed basis. The technical choices to be made will also have far-reaching ramifications for other spectrum users. Setting unreasonably low levels based on ill-conceived information will obviously stifle UWB deployment. More importantly, taking this path will exact a high price to be paid by all current and future spectrum users.

Current Part 15 general limits effectively establish the lowest floor for unwanted emissions throughout the Commission's regulatory structure. Indeed, most FCC licensed services, including many that deploy ubiquitous transmitters, are allowed to generate unwanted emissions that are much higher than the general Part 15 limits. Most Federal systems are also allowed to suppress unwanted emissions to levels that are much higher than the general Part 15 limits. If the Commission errs by mandating emissions limits for UWB technology that are too low, it will have set the stage for a wholesale reexamination of all emission masks and limits pertaining not only to licensed services but to most unlicensed devices. Such an exercise could have enormous negative cost and operational implications for both current and future services, regardless of the success of UWB. Accordingly, any review of NTIA's reports on compatibility between UWB devices and selected Federal radio systems should be undertaken with the goal of reaching conclusions that lead to reasonable limits that protect against harmful interference. The imposition of undue cost or complexity, however, will impede the development not only of UWB but a host of other spectrum-based technologies and services both for government and non-government users.

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I. Introduction

A. *The NTIA Reports Show That UWB Operation Under Part 15 Can Adequately Protect Federal Systems.*

The power levels the FCC has proposed for UWB will be no higher than levels already authorized for millions of other Part 15 unlicensed devices and billions of digital devices. Unlicensed operations have evolved over the past 50 years so that today virtually every person utilizes a host of devices that generate emissions in all regions of the spectrum. TDC estimates that there are over five billion devices in the United States that operate under Part 15.

The Commission has a long and useful history with Part 15 of fostering innovation while protecting licensed users of the spectrum from harmful interference. Over twenty years ago, the Commission developed emissions limits for narrowband and broadband noise emanating from computers and other digital devices. In 1989, the Commission found that those limits could serve as the basis for new general limits for unlicensed devices. Since the inception of this proceeding, it has been TDC's position that the Commission should work with this successful background of general limits and alter the application of the limits only if testing and analysis clearly support such changes.

TDC is pleased that the reports presented to the Commission by NTIA recognize the current benefits and promise of UWB technology.[1] TDC is also pleased that the reports demonstrate that UWB operation under Part 15 is possible. Accordingly, as TDC explains in these comments, when the data are viewed in the context of real-world operating conditions, the conclusion reached shows that UWB poses no significant risk to Federal systems.

B. *What Part 15 Levels Really Mean*

This proceeding will set a number of precedents affecting whether future innovative technologies will be encouraged and developed. Findings herein of how to quantify "harmful interference" in the context of UWB will affect future Part 15 technologies, as well as other spectrum management efforts, such as increased sharing among licensed commercial and government users. Furthermore, the fundamental issue

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[1] NTIA Special Publication 01-43, Assessment of Compatibility Between Ultrawideband Devices and Selected Federal Systems (Jan. 2001) ("NTIA Report"); NTIA Report 01-383, The Temporal and Spectral Characteristics of Ultrawideband Signals (Jan. 2001) ("ITS Report").

of what constitutes reasonable levels of emissions outside of defined bands confronts the Commission every time a new licensed or unlicensed service is proposed. Such "emission mask" concerns will be impacted by the Commission's considerations of UWB signal levels. In a world of 3G spectrum demands, "spectrum drought," and incumbent relocation challenges, it would be particularly unfortunate to add new and unnecessary complexities to the Commission's spectrum management policies.

In almost every category of intentional radiator regulated under Part 15 since the 1989 rulemaking, the Commission has adopted a provision stipulating that spurious emissions and out-of-band emissions — the useless signals that are generated by innumerable electronic devices, such as two-way pagers and cell phones — do not require attenuation below the general Section 15.209 limits, the same limits that apply to emissions radiated by receivers and digital devices. Thus, essentially all devices regulated by Part 15 (*e.g.*, computers, peripherals, telephones, radio receivers, TV interface devices, cable converters, carrier current systems, security transmitters, wireless car door and garage door openers, cordless phones, unlicensed personal communications devices, U-NII devices, etc.) can radiate all or some of their emissions throughout the entire regulated spectrum, including the restricted bands, at levels equivalent to the Section 15.209 levels.[2] These levels effectively establish a floor below which unlicensed

[2] Unlicensed intentional radiators operated under Part 15 are currently permitted to place spurious emissions in these bands at the Section 15.209 levels. Such devices are usually allowed to generate fundamental emissions at levels much higher than those set forth in Section 15.209 provided that the fundamental emissions are in other parts of the spectrum. For example, devices authorized under Section 15.247 may operate with 4 watts EIRP – and in some cases more – so long as the unwanted emissions that fall within

devices are not required to suppress their emissions. These levels are the same levels that the Commission has proposed authorizing for UWB equipment.

C. *The Commission Has Carefully Crafted the Part 15 Rules.*

Today, billions of devices that comply with Part 15 emit radio noise, both intentionally and unintentionally, into the environment with minimal interference impact. Over its 50-year evolution, Part 15 has enabled the development and market introduction of countless innovative products. The fact that the FCC and NTIA are not overwhelmed with interference issues created by the billions of devices demonstrates the efficacy of Part 15. The continued successful and "interference-free" environment for licensed services shows that the Commission has succeeded in protecting against harmful interference despite the overlapping emissions from countless Part 15 devices, from licensed equipment, and from Federal systems.

While Part 15 has allowed development of pioneering communications applications, the Rule Part tightly circumscribes device operation. Part 15 devices are required to accept interference from other unlicensed and licensed equipment. Federal spectrum users and FCC licensees are generally authorized to operate on a primary basis, which means that they are protected against "harmful interference" caused by unlicensed and licensed equipment that place emissions into the licensed band. On the other hand,

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restricted bands do not exceed Section 15.209 levels. UWB technology, by its very nature does not lend itself to narrowly limited portions of the spectrum as do the intentional radiators heretofore authorized under Part 15. However, UWB holds the

Part 15 devices, such as UWB equipment, operate on a "permitted" basis with no protection from interference. More importantly, for the purposes of analyzing these test results, even devices that comply with Part 15 rules are not permitted to cause harmful interference to licensed services, and in many cases must carry a label stating this limitation. Furthermore, the operator is obligated to stop transmissions if interference is caused.[3]

The Commission has in place rules under Part 15 that provide adequate protection to both Federal systems and licensed services. The fact that the Commission has relied on Part 15 levels in innumerable proceedings when setting emissions limits testifies to the efficacy of the agency's regulatory framework.

D. *Emissions From Devices Operating in Compliance With Part 15 Have Never Been Found to Constitute Harmful Interference.*

As noted above, the general conditions for unlicensed operation under Part 15 are such that "no harmful interference" may be caused.[4] Both the FCC and NTIA agree that for an unwanted signal to cause harmful interference it must cause serious degradation,

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promise of performing very useful functions at signal levels previously regarded as appropriate only for noise.

[3] FCC rules require strict adherence to the authorization and certification procedures, and the Commission has extensive enforcement authority including assessment of substantial civil and criminal penalties. When the Commission authorizes UWB deployment and establishes its rules therefor, it has ongoing authority to enforce those rules to maintain compliance of UWB equipment and prevent UWB operations that cause harmful interference.

[4] 47 C.F.R. § 15.5(b).

obstruct, or repeatedly interrupt intended communications.[5] While the Commission has issued a number of rulings related to what constitutes "harmful interference," the FCC has never – to TDC's knowledge – found equipment operating in compliance with Part 15 limits to cause "harmful interference."

NTIA's Report does not address – or even mention – the term "harmful interference." In developing the test data that forms the basis for its report, NTIA chose to measure the impact that UWB signals have on the "noise floor" of a hypothetical victim receiver. NTIA determined whether UWB signal levels at a given distance cause a 1 dB, or in some cases a 0.5 dB, rise in the noise floor. The procedure used here by NTIA is based on the same criterion that was recently received and rejected by the Commission in the *700 MHz Report and Order*. In that proceeding, the FCC rejected an assertion from Motorola that harmful interference will result from a 1 dB increase in the noise floor.[6] In its decision, the Commission stated that "[w]e find Motorola's assumption that a 1 dB increase in the noise floor will result in objectionable interference to be unreasonable and overly restrictive."

TDC and other UWB developers are asking the Commission to authorize signal levels for UWB that are less than 50 billionths of a watt of power. The authorization of UWB signal levels up to Part 15 limits – signal levels not unlike those emitted both

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[5] *See* 47 C.F.R. § 2.1; NTIA Manual § 6.1.1.

[6] *See* Service Rules for the 746-764 and 776-794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, *Second Memorandum Opinion And Order*, WT Docket No. 99-168 at ¶ 6 (rel. Jan. 12, 2001) ("700 MHz Order").

intentionally and unintentionally by billions of electronic devices every second of every day – will enable a broad array of innovative applications, many heretofore unrealizable.

II. No Real World Operational Testing Was Conducted.

NTIA states unequivocally in a number of places throughout the report that interference from UWB equipment operating at Part 15 levels can have an impact on the actual operation of Federal systems[7] when, in fact, NTIA performed no UWB interference testing with live operational systems. At one point, NTIA remarkably states that UWB-generated noise "may result in the ship's captain … being unable to pilot the ship using radar as a guidance tool in inclement weather."[8] Other than the seven field measurements discussed at length below, NTIA documents no other field measurements it made to verify and/or supplement the data derived from its computer models. Moreover, NTIA did not consider the impact or measure the level of UWB signal power needed to "seriously degrade" or "repeatedly interrupt" operation of any Federal system analyzed, *i.e.*, the determination of whether UWB does, in fact, cause harmful interference. Instead, NTIA chose to quantify UWB interference potential by measuring the level at which UWB signal power exceeds "protection criteria."

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[7] NTIA Report at 4-6; ("UWB devices operating at that power level would add to the system noise, rendering the radar less capable of tracking and monitoring meteorological results.") *see also id.* at 4-11, 4-17; 4-34, 4-39 ("less capable of receiving distress alert transmissions from satellites relayed from maritime, aviation and land users"); *id.* at 4-43 & 4-48 ("For compatible operations this requires a lower permitted UWB EIRP and a longer separation distance than the Earth station and the UWB device coupling off axis.").

[8] *See* NTIA Report at 4-65.

While such an approach is a useful exercise, in order to properly interpret the test results one must recognize that the results cannot be correlated with any operational impact on the systems. Consequently, the results do not – on their face – yield sufficient information on what UWB signal levels would cause harmful interference to these systems. However, it is possible to extend the test results and calculations to better incorporate "real-world" factors that allow the FCC to determine that UWB at the power levels proposed will not pose any risk of harmful interference to Federal systems.[9]

A thorough analysis of the impact of UWB emissions on a particular radar system should include a determination of the likelihood that, for example, a noise signal will cause a false alarm. Rather than present a detailed system level analysis that attempted to correlate the presence of UWB signal with an operational impact on the radar receiver, NTIA solely considered the amount of noise power required to raise the output level of a radar receiver by 0.5 dB as its "analysis criterion." This criterion has little relationship with receiver performance in a live operational radar. Moreover, this criterion bears no relationship to harmful interference.

Integration of real-world factors is needed to develop a measure of whether, and to what degree, actual operational system performance would be affected. The test setup measured the level of UWB radio energy that exceeds the protection criteria as a function of distance from the victim system. Based on this approach, the only reliable statement that NTIA can, and indeed did make, was whether the stated protection criteria were

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[9] These factors are discussed at length in Section IV below.

exceeded (at a given range and power level). *See* NTIA Report at 4-51, 4-61. The operational impact statements made by NTIA go beyond the scope of the test's capabilities.[10] Given the number of real-world factors that NTIA's model did not account for, there is no sound basis for making these statements.

III. **<u>UWB Signal Levels in Excess of Stated "Protection Criteria" Do Not Constitute Harmful Interference.</u>**

General conditions of operation under Part 15 of the FCC's rules are such that unlicensed device operation "is subject to the conditions that no harmful interference is caused."[11] The term "harmful interference" has been part of the FCC and NTIA's spectrum management lexicon for decades. Harmful interference is defined by the FCC as "interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service."[12] NTIA's own definition tracks closely this FCC

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[10] Another - somewhat secondary but still troubling - aspect is that NTIA presents data that, by its stated terms, is unsupported by the model. After explaining that its model is not "generally accurate at ranges less than 200 meters due to uncertainties of near field, propagation and antenna gain" (*see* NTIA Report at vi n.5), NTIA presents data showing that the protection criteria are exceeded at distances of 20 meters for an Air Traffic Control Radio Beacon System (ATCRBS) Air Transponder Receiver (*see id. at* 4-22), 80 meters for a DME Interrogator (*see id. at* 4-24), and 70 to 160 meters for MLS (*see id. at* 4-27). An analysis based on a computer model that is not accurate within a particular range should not report data within that range.

[11] 47 C.F.R. §15.5(b).

[12] 47 C.F.R. § 2.1.

definition.[13] In addition, the glossary provided on the NTIA ITS website adds that harmful interference "must cause serious detrimental effects, such as circuit outages and message losses, as opposed to interference that is merely a nuisance or annoyance that can be overcome by appropriate measures."[14]

As noted above, NTIA conducted no testing to measure any operational impacts, and, in TDC's view, a properly conducted operational test would show that NTIA's measurement approach and underlying assumptions are exceedingly conservative. The NTIA Reports are based solely on "protection criteria" that are "exceeded" when a Part 15 device adds between 0.5 dB and 1.0 dB of signal to the noise floor within a victim receiver's pass band. This protection criteria is specified in a number of ITU Recommendations related to the particular service analyzed by NTIA.[15]

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13 NTIA Manual § 6.1.1 defines harmful interference as "interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with these Regulations."

14 http://www.its.bldrdoc.gov/fs-1037/dir-017/_2541.htm. The glossary is set to be approved in March 2001 by the American National Standards Institute.

15 *See generally* Appendix A of the NTIA Report. A 0.5 dB increase in the noise floor correlates to a protection criteria of –10 dB, and a 1.0 dB increase in the noise floor correlates to a protection criteria of –6 dB for the systems analyzed.

Past FCC Decisions Have Found That Harmful Interference Must Result in Serious Degradation of Service. This is Not What NTIA Tested, Nor is It What NTIA Found.

The Commission has specified what it considers to be harmful interference in some service-specific instances. With regard to cellular phone service, harmful interference has been defined as the "serious degradation, obstruction, or repeated interruption" of service."[16] In a case involving broadcast booster stations, the Commission defined the term based on the reception of interference by the public and stated that "harmful interference is deemed to occur where the Commission receives a significant number of complaints."[17]

As noted earlier in these comments, the FCC recently rejected Motorola's assertion that 700 MHz public safety services should be protected to the extent of prohibiting more than a 1 dB increase in the noise floor – the same level used by NTIA in its UWB analysis.[18] After finding Motorola's assertion that a 1 dB increase in the noise

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[16] Aircell, Inc. Petition, Pursuant to Section 7 of the Act, For a Waiver of the Airborne Cellular Rule, Or, in the Alternative, for a Declaratory Ruling, *Memorandum Opinion and Order*, 15 FCC Rcd 9622 (2000) (defined for the limited purposes of a conditioned authorization and waiver of § 22.925 to a modified cellular service).

[17] Amendment of Part 73 of the Commission's Rules Concerning FM Booster Stations and Television Booster Stations, *Report and Order*, 63 RR 2d 761, 2 FCC Rcd 4625 at ¶ 30 (1987); *see also* Valley Broadcasting, Inc. For Construction Permit for a New FM Booster Station on Channel 279 in Omaha, Nebraska, *Memorandum Opinion and Order*, 71 RR 2d 264, 7 FCC 4317 ¶ 24 (1992) (approving a booster station because the complaints raised were based only on "potential interference" to a sparsely populated area, as "actual interference" was lacking because there were no listener complaints.).

[18] *See* n.15, *supra*.

floor would result in objectionable interference to be "unreasonable and overly restrictive," the Commission went on to explain:

> [P]ublic safety systems are more likely to be designed so that an interfering signal greater than 10 dB above the noise floor would have to exist before a disruption to communications would occur. Specifically, public safety systems are likely to be designed so that a reliable, desired signal from a transmission at the fringe area of a system would be 10 dB above the weakest serviceable signal in the absence of interference, which we believe to be a signal that is 20 dB above the noise floor. To protect such a signal from interference, we determine that the interfering signal can be no more than 10 dB above the noise floor. Protecting against such an interference level, rather than the – 6 dB interference level employed in Motorola's calculation, reduces from 4.8 kilometers to 767 meters Motorola's estimate of the minimum distance that a commercial base transmitter would have to be from a public safety base receiver to avoid interference.[19]

The Commission also found Motorola's assertion that a quite minimal noise floor increment represents objectionable interference to be significantly more stringent than the level of protection to public safety services granted by the *700 MHz First Report and Order*.[20]

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[19] See 700 MHz Order at ¶ 6 (footnote omitted).

[20] *See* 700 MHz, *First Report and Order*, 15 FCC Rcd at 518-519. The Commission went on to attack the clutter factor proposed by Motorola: "[W]hile there may be instances where line-of-sight conditions could exist between a public safety and a commercial base station, thus yielding a 0 dB clutter factor, we believe that it is much more likely that very few such instances will occur – that is, we believe that in the vast majority of cases there *will* be intervening obstructions between public safety and commercial base stations, which will result in a clutter factor of greater than 0 dB. For public safety and commercial base stations that are located roughly 500 meters to 1000 meters apart, we would estimate a clutter factor of about 5 dB. If such a factor is assumed, then the previously-calculated 767 meter interference distance is further reduced to 432 meters. This result represents a considerably less serious interference scenario than suggested by Motorola. We therefore disagree with Motorola's across-the-

The Commission has offered sound guidance as to the contours of what is and what is not harmful interference. The Commission has also continually recognized that the Part 15 levels serve a critical role in defining spectrum policy. These levels, which work hand-in-hand with the guiding principle of "harmful interference," have increased the value of spectrum use by allowing overlapping signals and emissions from licensed and unlicensed devices to coexist peacefully.

IV. Many Real World Factors Were Not Modeled By NTIA.

NTIA explains that a number of "real-world" factors were not included in its computer modeling for both single entry and aggregate interference calculations.[21] As TDC explains in this Section, there are a number of additional relevant real-world factors that NTIA does not directly address. Had all of these real-world factors been accounted for, NTIA's presentation and conclusions would have been very different.

It is difficult to see how a single UWB device operating at less than 50 billionths of a watt of power can disrupt operations of an Air Route Surveillance Radar - 4 (ARSR-4) at 5.5 kilometers strains credulity, especially when there must already be numerous noise generating devices at closer range emitting signals in the ARSR-4 band both at and above Part 15 levels.[22] Indeed, if one were to apply the signal propagation model used by

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board assumption of a 0 dB clutter factor to describe the signal attenuation between commercial and public safety base operations. *See* 700 MHz Order at ¶ 10.

21 *See* NTIA Report at 5-25 to 5-34.

22 For example, in the NPRM, the FCC proposed defining the same limits for UWB that it adopted for Class B, *i.e.*, consumer-based, digital devices. There are also

NTIA to 49 MHz baby monitor or cordless phone transmissions, it would show that the signals emanated from the devices could be expected to be able to communicate over nearly 300 kilometers,[23] a value that is plainly unrealistic.

A. *Real-World Factors Noted In The Report – But Not Accounted For*

The real-world factors that NTIA explicitly acknowledges as missing from its model, would easily provide UWB signals with at least 30 to 40 dB of additional margin. Some of these factors are summarized in Table 1 below.

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commercial-based Class A limits, which are about three times greater than Class B limits. The Commission reasoned that the relaxation was appropriate because the harmful interference potential from Class A devices was perceived to be smaller, as such equipment would be located in industrial and commercial environments where existing ambient noise levels were already relatively high and they would be farther away from victim receivers. However, there likely will be many Class A devices near the actual installations of most of the Federal systems examined by NTIA. As shown in detail in Section IV, subsection B, the levels of ambient noise near Federal systems is, in fact, quite high.

[23] A baby monitor and a cordless phone can each transmit with an average EIRP of -15.23 dBm, and assuming a 20 kHz IF bandwidth and a temperature of 19°C, the receiver sensitivity would be -130.9 dBm. Based on this, each can then transmit over a distance that corresponds to a path loss of 115.67 dB. With a 0 dBi receive antenna and free-space attenuation, the transmit distance equates to 296 km according to NTIA's model.

"Real-World" Factor	**Additional Signal Loss**
Irregular Terrain	4.5 to 24.2 dB[24]
Urban / Suburban Environment[25]	20 dB Urban below 1 km 40 dB beyond 1 km 15 dB Suburban below 1 km 30 dB beyond 1 km
Building Penetration	9 dB[26]
Antenna Alignment	3+ dB
Foliage	10 dB[27]
Activity Factor	10 dB

Table 1. A Sample of the Real World Factors Not Included in NTIA's Analysis

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[24] at 2 GHz. *See* NTIA Report at 5-27.

[25] The commonly accepted Okumara-Hata (O-H) propagation model for urban and suburban environments incorporates the losses for foliage and natural and man-made structures. However, the model does not account for losses due to building penetration, for example.

[26] From 960 MHz to 3 GHz. *See* NTIA Report at 5-31. Note that NTIA Report 95-325, "Building Penetration Measurements From Low-height Base Stations At 912, 1920, and 5990 MHz" (Sept. 1995), contains "Mean NLOS Penetration Losses" that indicate that this number is conservative.

[27] at 869 MHz. *See* NTIA Report at 5-27. In their report, Julius Goldhirsh and Wolfhard J. Vogel, "Handbook of Propagation Effects for Vehicular and Personal Mobile Satellite Systems - Overview of Experimental and Modeling Results," A2A-98-U-0-021 (APL), EERL-98-12A (EERL) (Dec. 1998), present measurements and an analysis of foliage attenuation. The measurements at 870 MHz may be scaled to 1.5 GHz and 4 GHz. So, for a path elevation angle of 30 degrees, an attenuation due to foliage of 10 dB at 870 MHz scales to 13 dB at 1.5 GHz and 21 dB at 4 GHz. This attenuation factor is less at higher path angles and greater at lower path angles.

NTIA recognizes that its model is based on "ideal" conditions and lists a number of real-world factors that would have a major impact on the results it presented.[28] By omitting from its analysis these factors and a number of others as described below, NTIA presents, not a practical worst-case assessment, but an unrealistic worst-case assessment of the impact of UWB operations. Understanding each of these "real-world" factors – noted by NTIA but absent from its modeling – is crucial to understanding the true impact of NTIA's data and conclusions.

Irregular Terrain. NTIA used a "smooth Earth" signal propagation model.[29] While use of this model greatly simplifies computations, it is based on the unreal assumption that the Earth is a smooth sphere with no buildings, bridges, hills or valleys. NTIA correctly notes that the smooth Earth model will underestimate the actual propagation losses caused by these natural and man-made obstructions.[30] Another factor that must be accounted for in using the "smooth Earth" model is that, as NTIA mentions, "very few places in the United States, even in the Great Plains, include terrain that is effectively smooth."[31] NTIA quantifies this lack of smoothness with a factor, Δh, that would provide between 4.5 and 24.2 dB of additional propagation losses at 2 GHz.[32]

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[28] NTIA Report at 5-25 ("It is recognized that in most cases such ideal conditions will not exist, resulting in lower realized values of aggregate interference.")

[29] *See id.* at 5-25.

[30] *See id.* at 5-25 to 5-29.

[31] *See id.* at 5-27.

[32] *See id.* at 5-27.

Urban/Suburban Environment. Yet another factor is the propagation of radio signals in densely populated urban environments. Corrections to the "smooth Earth" model can be made through applying the Okumara-Hata (O-H) propagation model, which is generally accepted to represent losses in urban and suburban areas for signals between 30 MHz and 1.5 GHz.[33] The O-H propagation model illustrates that, for signals beyond 1 km, the predicted level of interference is reduced by 30 dB in suburban environments and by 40 dB in urban environments. For signals at distances less than 1 km, the predicted level is reduced by 15 dB and 20 dB in suburban and urban environments, respectively.[34] The O-H model only accurately represents signals up to 1.5 GHz. At higher frequencies, the predicted levels of interference would likely be reduced, because the propagation loss increases with frequency.

Building Penetration. NTIA reports that its models did not account for the losses due to building penetration. NTIA estimates the signal loss due to building penetration to be 9 dB in the frequency range from 960 MHz to 3 GHz.[35] In TDC's view,

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[33] The report states that the O-H model cannot be applied to airborne receivers. While the O-H model was developed from terrestrial measurements, it does not mean that a free space propagation model is applicable to an airborne receiver. NTIA notes that building penetration losses between 960 and 3000 MHz average 9 dB, so most signals reaching an airborne platform would experience building attenuation. Additional sources of attenuation are also likely, for example, from diffraction and foliage.

[34] Even applying a free space propagation model to automotive applications would be highly misleading, as this environment will scatter the signals creating multipath and Rayleigh fading. Also, the antennas will be directional (which reduces the total emitted power) and there will be obstructions. In addition, the center frequency of operation will more than likely be above 5 GHz because of the need for angular resolution.

[35] *See* NTIA Report at 5-31.

this is a conservative estimate (and note that the loss is will be even greater at higher frequencies).

Antenna Alignment. NTIA reports that "[a]ll of the analyses in this report assume a worst case situation wherein the maximum radiation from the UWB device is always pointing at the victim receiver."[36] It is highly unlikely that a UWB device would be present in the main beam of many Federal radar systems. Many of the antennas for these systems are mounted 25 to 75 feet off the ground and positioned upwards. It is difficult to imagine a situation in which signals from an outdoor UWB device would be present in the main beam of these Federal systems, and difficult to imagine further a situation in which a tall building containing a UWB device would be located adjacent to these Federal systems.

Foliage. These obstructions also include foliage, which, as NTIA notes, can be "especially significant" when UWB emitters are at low heights. NTIA reports that one measurement of signal loss at 869 MHz due to a single tree canopy was 10 dB.[37] Figure 1 shows the loss from forestation, as estimated by TDC.[38]

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[36] *See id.* at 5-31.

[37] *See id.* at 5-27.

[38] Internal TDC study based on foliage propagation literature.

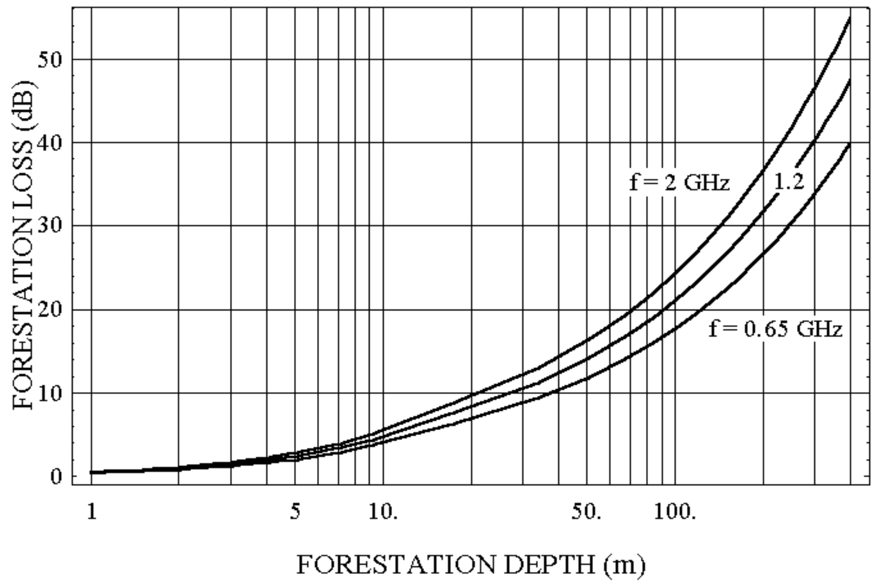

Figure 1. Forestation Loss vs. Forestation Depth at 650 MHz, 1.2 GHz, and 2 GHz as predicted by the modified exponential decay model.

Activity Factor. NTIA notes that its model does not account for the activity factor for UWB emitters that represent how often a UWB device will be transmitting. While NTIA acknowledges that, in many applications, UWB devices will not always be transmitting, NTIA's aggregate model assumes, nonetheless, that every modeled UWB device is transmitting continuously.[39]

In formulating a complete picture of UWB interference potential, every one of these "real-world" factors that was not incorporated into the NTIA model must be taken into account.[40] Based on the factors NTIA acknowledges as missing from its model, it is

39 *See id.* at 5-33.

40 Propagation between a device on a suburban or urban street involves a roof top diffraction for a large fraction of paths, even to aircraft and satellites. UWB devices will generally exist where people are, and people are typically located among the urban clutter. There is most often a limited view of the sky – that is, propagation from the ground to the sky is obscured. This is evident to the casual observer, and certainly

evident that a minimum of 30 to 40 dB of additional actual loss must be added to the result.

B. *Real-World Factors That NTIA Did Not Address*

NTIA's analysis ignores significant characteristics of all modern radar systems, which were not accounted for in the limited static testing procedures used. These factors are discussed here. In TDC's estimation, these factors would add an additional 10 to 20 dB of margin, at least, to the 30 to 40 dB that NTIA explicitly acknowledges. All totaled, NTIA's numbers must be adjusted by 40 to 60 dB to present some semblance of real-world operating conditions.

Ambient Noise. NTIA's models do not incorporate any external noise sources that are present in the real world. Spectrum Surveys conducted by NTIA in 1994 and 1995 suggest that radars operating in the 2.7 to 3.1 GHz band are not operating at their thermal noise floors. Nevertheless, the model used by NTIA in its UWB analysis assumed that all analyzed radars were operating at the thermal noise floor. NTIA's Spectrum Surveys show that (at the geographic points where the surveys were conducted) there are many overlapping radar signal skirts and that the signal levels at these locations

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impacts radio propagation strongly. Diffraction effects are well understood and documented today, and are incorporated in modern propagation models. *See, e.g.,* H. L. Bertoni, RADIO PROPAGATION FOR MODERN WIRELESS SYSTEMS, Prentice Hall PTR (2000) Figure 7-4. One text on the subject shows that the fields 1.8 m above ground level are approximately 25 dB below the roof top level fields in a typical suburban setting. The propagation models used by NTIA may be adequate to describe the rooftop level fields only, but and additional 25 dB loss attenuation must be taken into account when a are well above threshold levels (approximately 60 dB) used by the NTIA for its UWB assessment. These data suggest that ambient levels may be equal to or larger than thermal levels. If ambient levels were only equal to the thermal noise floor of the radars, then the true noise floor would be 3 dB above the thermal noise floor. Were ambient noise levels greater than thermal noise, they would become dominant and, thus, become the noise floor. More importantly, this suggests that the systems could tolerate much more UWB signal than projected by the NTIA's criteria.

Figures 2 to 9 were taken from spectrum surveys conducted by NTIA in 1994 and 1995.[41] These figures show signal levels in the 2.7 to 3.1 GHz band, one of the restricted radar bands of concern to NTIA, in four cities: Denver, Los Angeles, San Diego and San Francisco. In no case is the average signal level in the band below -100 dBm/MHz, and it is often closer to -80 dBm/MHz.

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roof top diffraction is involved in the path. Losses due to diffraction in urban areas are greater and occur more often.

[41] NTIA report numbers: 95-321 (Denver), 97-336 (Los Angeles), 97-334 (San Diego), and 99-367 (San Francisco).

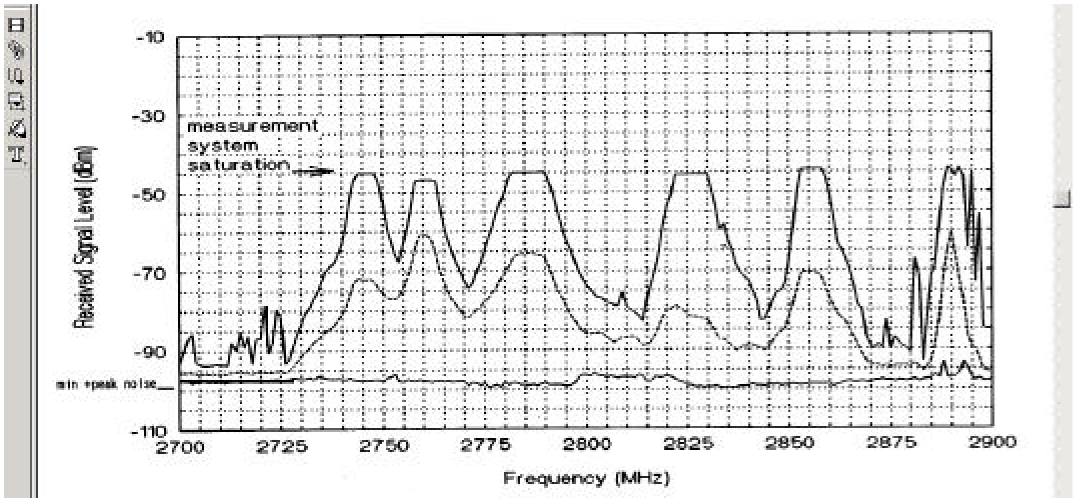

Figure 2. NTIA Spectrum Survey of Denver, Colorado (2.7 to 2.9 GHz, 1 MHz resolution bandwidth).[42]

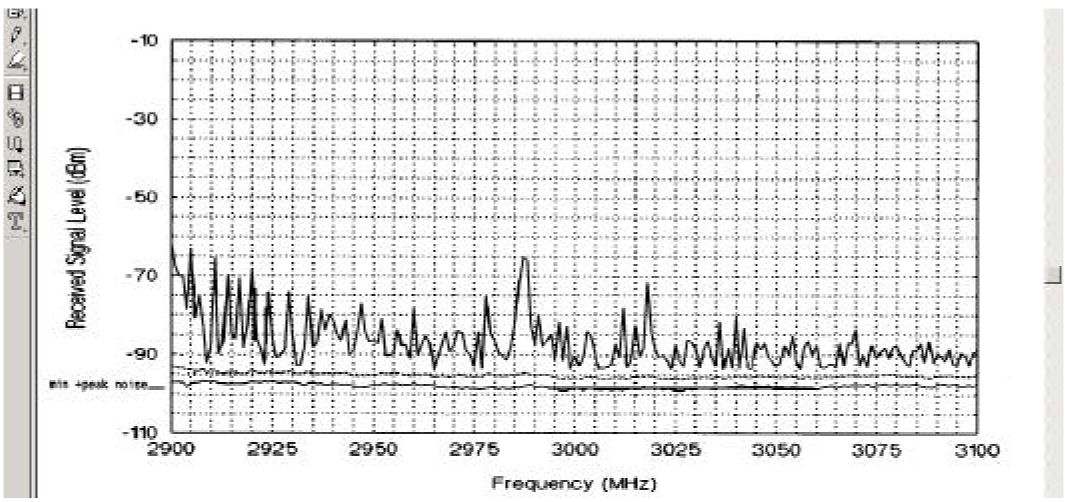

Figure 3. NTIA Spectrum Survey of Denver, Colorado (2.9 to 3.1 GHz, 1 MHz resolution bandwidth).

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[42] Each of the NTIA spectrum survey figures has three traces. The top trace represents the peak level measured; the middle trace represents the average measured level; and the lowest trace represents the minimum level measured. The spectrum analyzer used a peak-detector mode and the average level represents the average dBm level over a large number of scans.

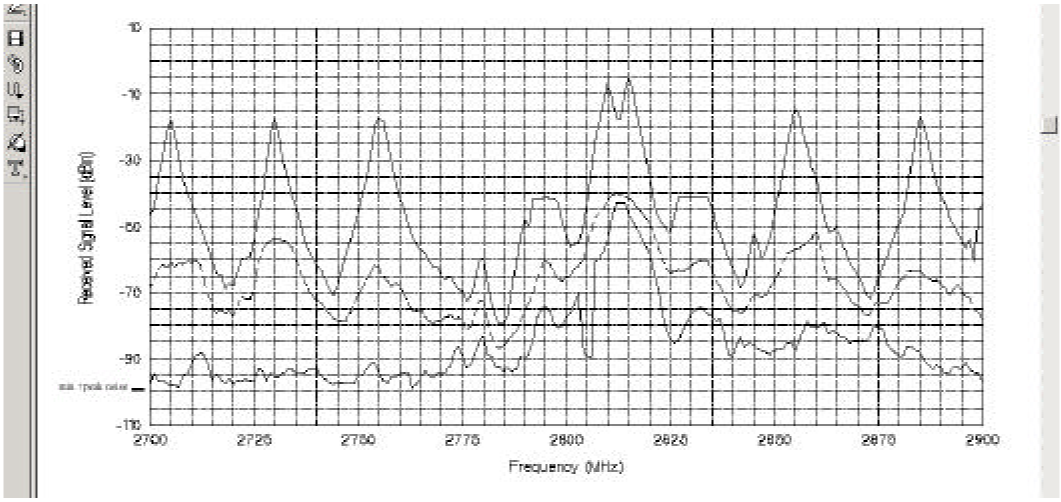

Figure 4. NTIA Spectrum Survey of Los Angeles (2.7 to 2.9 GHz, 1 MHz resolution bandwidth).

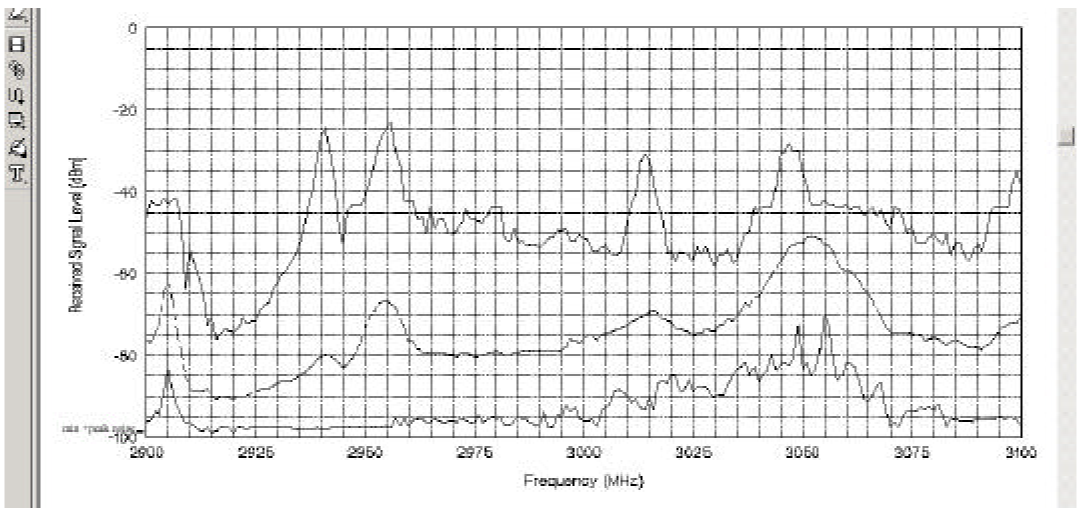

Figure 5. NTIA Spectrum Survey of Los Angeles (2.9 to 3.1 GHz, 1 MHz resolution bandwidth).

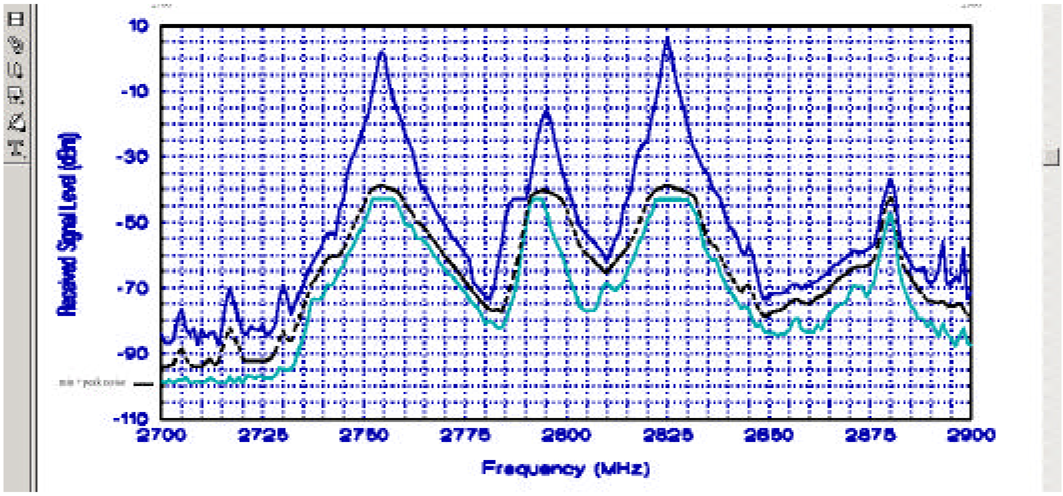

Figure 6. NTIA Spectrum Survey of San Diego (2.7 to 2.9 GHz, 1 MHz resolution bandwidth).

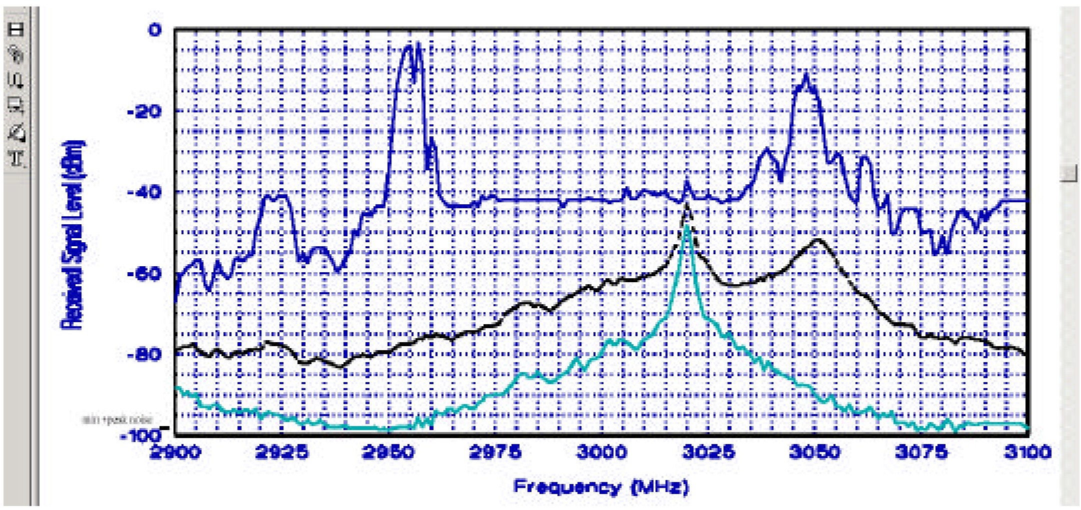

Figure 7. NTIA Spectrum Survey of San Diego (2.9 to 3.1 GHz, 1 MHz resolution bandwidth).

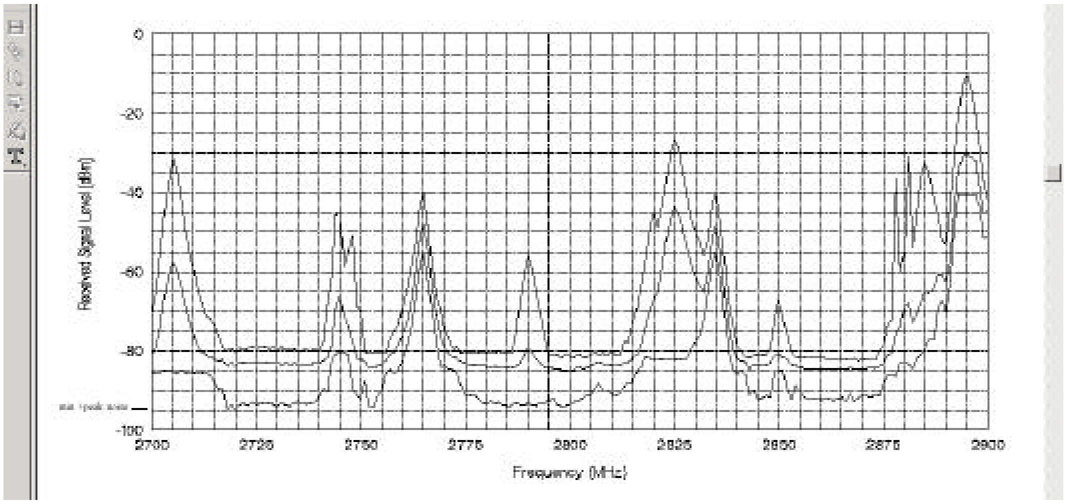

Figure 8. NTIA Spectrum Survey of San Francisco (2.7 to 2.9 GHz, 1 MHz resolution bandwidth).

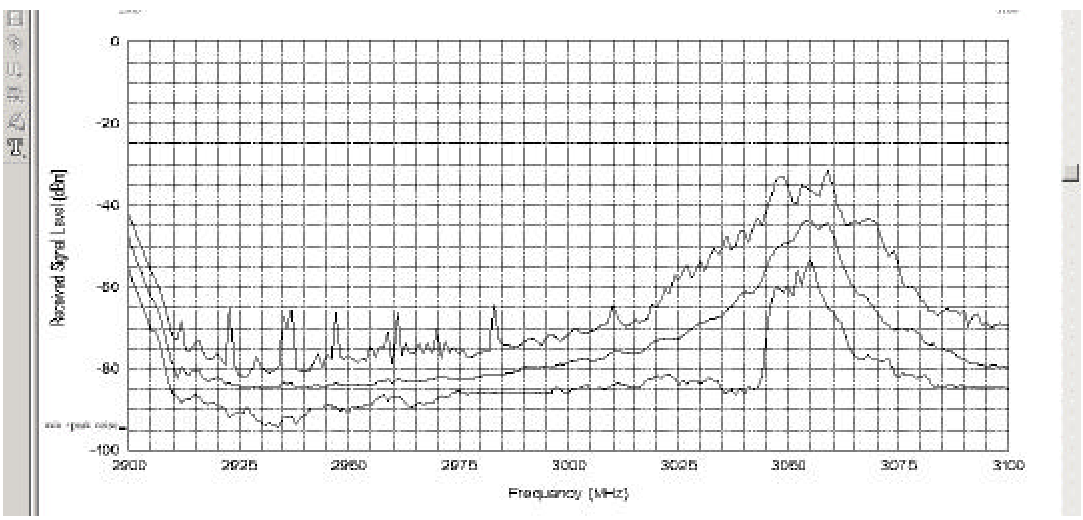

Figure 9. NTIA Spectrum Survey of San Francisco (2.9 to 3.1 GHz, 1 MHz resolution bandwidth)

While these data do not prove that the noise levels in the bands of operation at every radar site exceed thermal limits, they certainly suggest that most, if not all, radars in these cities are not operating at thermal noise limits because the noise floors at the measurement sites appear to be around –80 to –100 dBm/MHz. NTIA's implied threshold levels for a UWB emissions in the radar bands are around –140 dBm/MHz.[43] This 40 to 60 dB difference is significant and not only strongly suggests that the radars are operating at levels much higher than their thermal noise floor limits without experiencing adverse operational impacts, but also that NTIA's conclusions as to the likely impact of UWB on the radars are overstated.

Digital Signal Processing. Most of the Federal radar systems used for air traffic control and weather detection have advanced digital signal processing ("DSP") capabilities that allow these systems to operate properly in the presence of noise well in excess of the Part 15 levels. In a footnote to an Appendix of its report, NTIA implicitly acknowledges that factors such as error-control coding and bit interleaving - which make a digital modulated system more robust to interference - "need to be considered."[44] NTIA's model does not account for these factors. NTIA's model also does not appear to address system processing gain, which further contributes to making many radiocommunications systems less susceptible to interference.

Beam Shape Losses. Beam shape losses result from the normal scanning of the radar and reduce the sensitivity of radars to point sources of noise. NTIA's analysis also ignores this significant source of noise, which is found in all radar systems, but is not present in the static testing conducted by the NTIA. NTIA assumed the radar was not in a scanning mode. Rather, NTIA's radar model assumed that the Federal system's

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[43] The implied level is below kTB (*i.e.*, the thermal noise floor) because the radar systems have high gain antennas.

[44] *See* NTIA Report at A-21, n.73.

antenna was pointing in one static direction, and the UWB device was placed within the radar's main beam.

Beam shape losses raise the level of noise in a typical radar receiver by at least 1.6 dB above thermal noise and possibly as high as 3 dB. Had these noise sources been considered, UWB signal margin could be raised by 10 dB above the levels the NTIA characterized as acceptable.

Because the antenna's main lobe is actually tapered, the response signals being integrated cannot have the UWB transmitter fixed at the maximum of the lobe; instead, it is smeared over the beamwidth.[45] NTIA's tests assume the beam of the antenna is not moving when in reality the antenna is scanning and integrating signals over the full curve of the beam. When a large number of integrations is used, a system scanning with a pencil beam incurs a target signal loss of 3.2 dB. Systems with relatively low integration are likely to experience even higher beam shape losses. The radar design already accounts for these losses for target detection but they are not accounted for by NTIA in analyzing the UWB signal. Beam shape losses would reduce the impact of a point noise source by half the value of the beam shape loss. Thus, beam shape losses would reduce the impact of an UWB emission by at least 1.6 dB and probably closer to 3 dB.

Localization of Degradation. Even if UWB were to have the effect predicted by the model, the impact would be fleeting and hardly noticeable. The protection criteria

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[45] This phenomenon is described in Skolnik, M. I., INTRODUCTION TO RADAR SYSTEMS, 58-59 (1980).

used by NTIA is an interference to noise ratio of -10dB, which is equivalent to degrading the system's noise figure by 0.5 dB. For example, degrading a radar's noise figure by 0.5 dB may only `increase the probability of false alarms from 10^{-8} to 10^{-7}, which would occur during the entire scan as it completed the frame. However, a UWB emitter would not increase the noise throughout the entire frame of the radar but only for a small portion of the volume being monitored by the radar. As can be seen in Figure 10, the zone of degradation is very small in comparison to the volume of coverage; consequently, the aircraft radar target is likely to occupy the degraded region for only a very short period of time. UWB emissions can only cause degradation in the specific sector in which the receiver's antenna main beam intercepted it at the fringe of the radar's performance. It is improbable that the aircraft would remain, as defined in terms of range, azimuth, and elevation, in the fringe of detection within the narrow beam occupied simultaneously by the UWB transmitter.

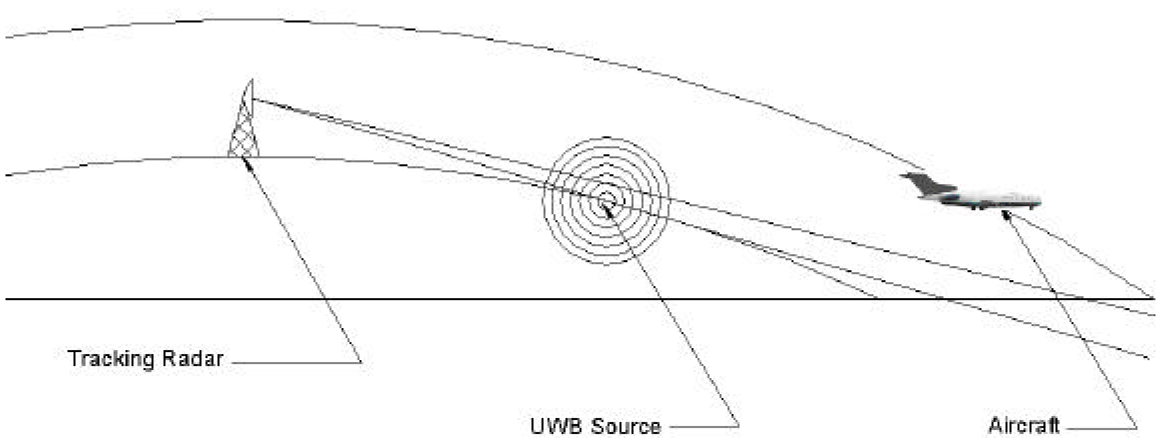

Figure 10. Radars Have a Limited Zone of Degradation

0.5 dB Increase in Noise Floor Power with UWB_{pwr} = -41.3 dBm/MHz	
	$10Log(UWB_{pwr}/Noise_{pwr})$
NTIA Model { $RCVR_{NoisePwr}$ = KTB; $Ambient_{NoisePwr}$ = 0; Propagation Loss = 0 dB	-9.14 dB
Scenario 1 { $RCVR_{NoisePwr}$ = KTB; $Ambient_{NoisePwr}$ = KTB; Propagation Loss = 0 dB	-6.13 dB
Scenario 2 { $RCVR_{NoisePwr}$ = KTB; $Ambient_{NoisePwr}$ = 2KTB; Propagation Loss = 0 dB	-4.37 dB
Scenario 3 { $RCVR_{NoisePwr}$ = KTB; $Ambient_{NoisePwr}$ = 3KTB; Propagation Loss = 0 dB	-3.12 dB
Scenario 4 { $RCVR_{NoisePwr}$ = KTB; $Ambient_{NoisePwr}$ = 0; Propagation Loss = 10 dB	0.86 dB
Scenario 5 { $RCVR_{NoisePwr}$ = KTB; $Ambient_{NoisePwr}$ = 0; Propagation Loss = 20 dB	10.86 dB
Scenario 6 { $RCVR_{NoisePwr}$ = KTB; $Ambient_{NoisePwr}$ = 0; Propagation Loss = 30 dB	20.86 dB
Scenario 7 { $RCVR_{NoisePwr}$ = KTB; $Ambient_{NoisePwr}$ = KTB; Propagation Loss = 20 dB	13.87 dB

Propagation losses = Foilage Loss + Beam Steering Loss + Building Loss + Terrain Loss + Building Defraction Loss

$Noise_{pwr}$ = RCVR Noise + Ambient Noise

Table 2. Impact of Real World Factors

Table 2 shows the impact of the assumptions that NTIA made in their report, *i.e.*, that UWB emissions would be the only in-band emission as well as the impacts of the various factors not included by the NTIA in its assumptions. Incorporating realistic assumptions would clearly have changed the estimated impact of UWB emissions.

NTIA's Ambient Noise Data Coupled to NTIA's Model Indicates That One Government Radar System Could Render Another Government System Inoperable. The survey data illustrates that radar emissions from one radar overlap with the band used by another at the geographic point where the measurements were taken. Thus, the radars themselves are likely sources of in-band noise.[46] For example, the Denver survey shows approximately six radar signatures with overlapping skirts. This conclusion is supported by an NTIA report on the spectral characteristics of radars.[47] Figure 11, which was taken from that report, shows that radars have very broad emissions. Figure 12, from a more recent NTIA report,[48] shows an emission spectrum for a long-range air search radar. The emissions span from 1.2 GHz to 4 GHz and are quite high.

These data clearly suggest that radars do not operate at thermal noise limits, as the measured noise floor appears to be around -80 dBm/MHz. For if the ambient levels were equal to the thermal noise floor of the radars, the true noise floor would be 3 dB above the thermal noise floor, as two signals with equal strength is equal to a 3 dB rise in the noise floor. If, on the other hand, the ambient level is much greater than the thermal level, then the ambient level becomes the noise floor, which would obviously be greater

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[46] Suppression of unwanted levels by at least 80 dB below the carrier level is now typical for government fixed radars. With high-powered radars, this level of suppression still results in undesired emissions far in excess of the Part 15 general levels. NTIA Manual, § 5.5; *See also*, NTIA Report 94-313, *Analysis of Electromagnetic Compatibility Between Radar Stations and 4 GHz Fixed Satellite Earth Stations*, at 8.

[47] NTIA Report 82-92, Output Tube Emission Characteristics of Operational Radars (Jan. 1982).

[48] NTIA Report 94-313, Analysis of Electromagnetic Compatibility Between Radar Stations and 4 GHz Fixed Satellite Earth Stations (July 1994) at 29.

than -140 dBm/MHz (*i.e.*, -80 dBm/MHz). The NTIA Spectrum Surveys strongly imply that many of these radars are operating with noise floors set by the ambient levels. However, NTIA's implied levels for a UWB emission in the radar bands is close to -140 dBm/MHz.

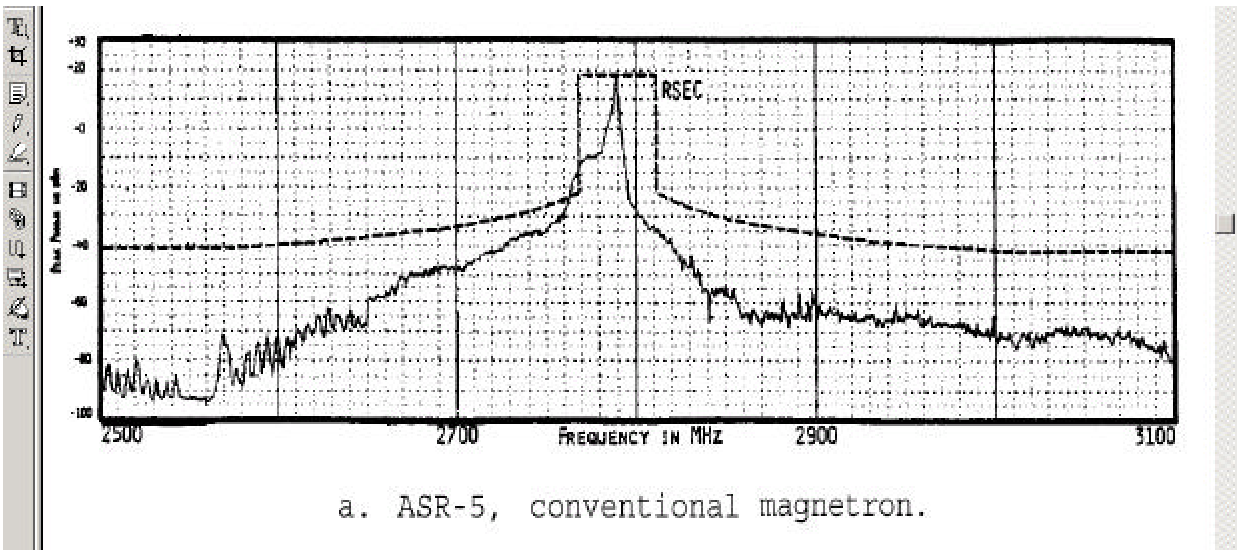

Figure 11. Output Emissions from an ASR-5 Radar as Measured by the NTIA in 1982. (The vertical axis extends from +30 dBm to –100 dBm.)

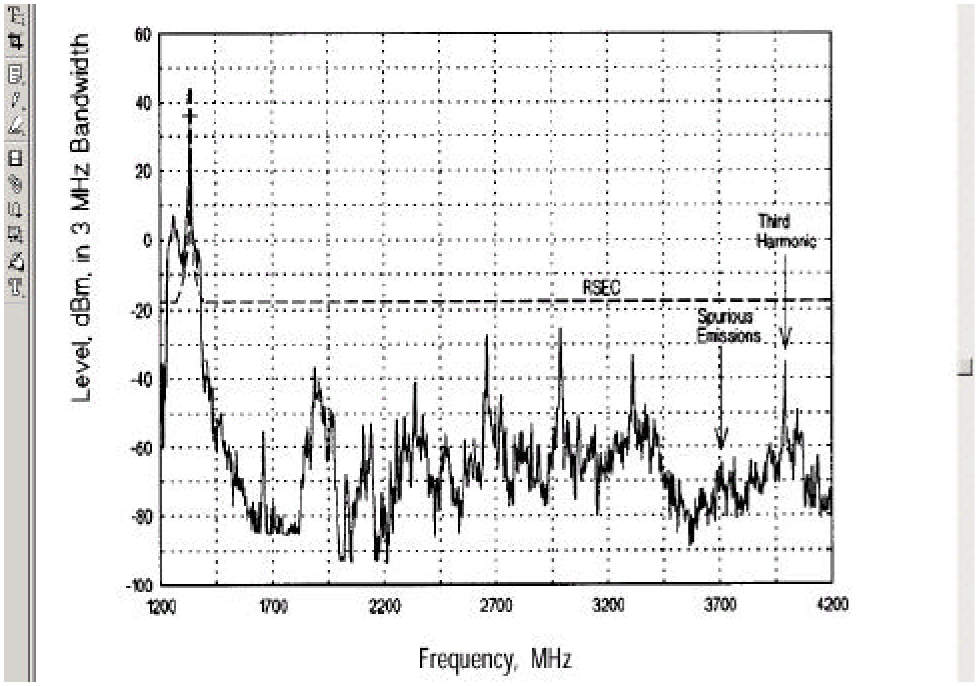

Figure 12. Emissions Spectrum of a Long-Range Air Search Radar from a 1994 NTIA report.

Section 4.12 of the NTIA report analyzes the impact of a single UWB emitter operating in the maritime radionavigation radar band. The analysis indicates that the minimum separation distance for a UWB emitter at this power level is between 600 and 1200 meters. Figure 5, Figure 7, and Figure 9 show traces that were taken in cities with major port facilities (Los Angeles, San Diego, and San Francisco). The figures strongly suggest that emissions from shipborne radars raise the noise floor for other shipborne radars to levels well above thermal limits, such as would be the case with two ships passing each other in a river. Presumably this is not currently resulting in catastrophic failures of these systems, and as such, it can be safely concluded that the NTIA proposed power levels and separation distances for UWB devices are extremely conservative.

C. *The Seven Field Measurements Made By NTIA Must Be Viewed in the Context of a Real-World Environment.*

NTIA explained away the difference between the "field" and "calculated" results by noting: (1) that the calculated does not taken into consideration exact terrain variations and (2) that the radar antenna elevation pattern used in the calculated analytical model may not accurately represent the antenna gain in the direction of the UWB device.[49] The nearly 9 dB variation between the field data (an uncertainty factor of 8) based on a sample of only seven data points calls into question the accuracy of NTIA's computer modeling and the accuracy of NTIA's measurement technique.[50]

The NTIA data also suggest that the measurements were indeed "worst-case". Figure 13 was taken from the ITS report.[51] The figure shows that the apparent antenna pattern is like a comb with respect to distance with the tops of the comb lines 30 to 40 dB above the valleys. The measurements made by NTIA engineers were made at or near locations where there were signal peaks.[52] Clearly, if measurements were made at or near the locations of the valleys, then they would not have recorded any increase in the radar receivers' noise floors, as these would have to be reduced by 30 to 40 dB.

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49 *See* NTIA Report at 3-18.

50 Regardless of the modeling anomalies, the limited measurements show that NTIA was able to create a direct line-of-sight, bore-sight to bore-sight path using a stationary radar antenna and a UWB device held aloft 4 meters above ground aligned precisely with the radar antenna.

51 ITS Report, Figure 7.2 at 7-5.

52 NTIA Report at 7-4.

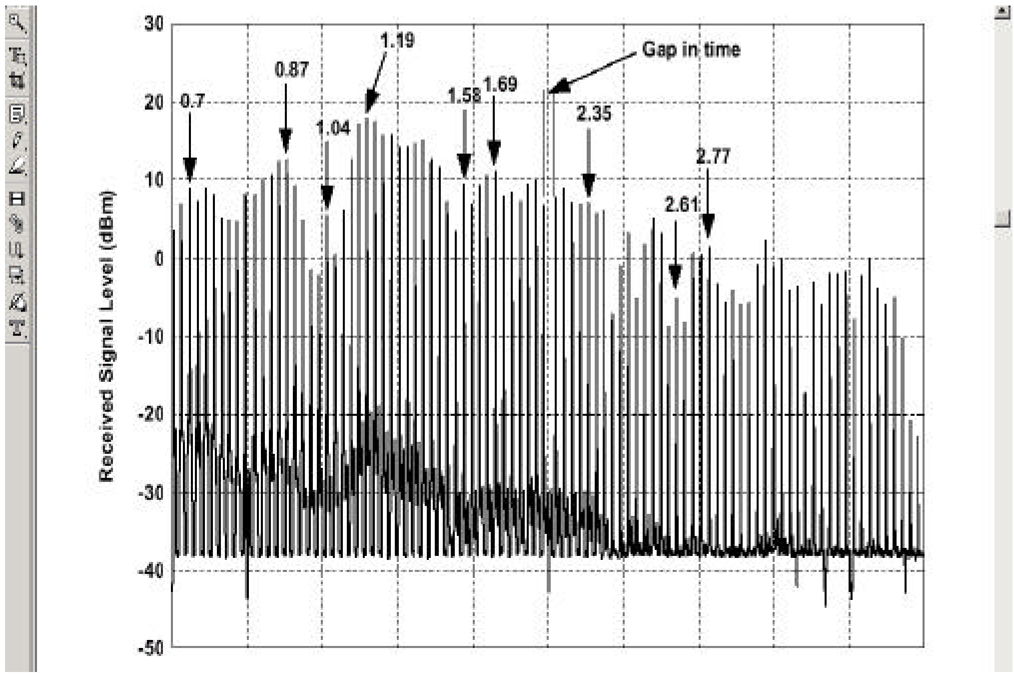

Figure 13. NTIA Measurement of ARSR-4 Emissions Taken from a Vehicle Moving Away From the Radar. (The horizontal axis appears to be related to distance.)[53]

Unfortunately, the data presented by the NTIA do not show what the impact would have been if the antenna had been actually rotating and scanning. It is clearly possible that the peaks and nulls shown in Figure 13 would move. If this were so, then the emissions of UWB signal would have been "averaged" over the peaks and nulls of the antenna and, as a result, would be significantly reduced on average.

In short, NTIA's field measurements produced more questions about the validity of the NTIA model instead of confirming its accuracy.

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53 The NTIA report shows similar graphs for the ASR 8.

V. The Aggregate Analysis Is in Conflict with NTIA's Own Measurements.

NTIA's ambient emissions analysis used an ideal propagation model, and like other aggregate analyses, chose to add UWB signal power linearly – which the government agency confirmed was a valid approach based on the measurement of two UWB signal sources. NTIA noted, however, that its estimated aggregate signal levels would be significantly lower if urban and suburban propagation models were used instead. TDC believes that such models are necessary to accurately portray the aggregate effects of UWB devices. This is not only because many of the proposed applications of UWB devices are for indoor usage (and will likely be concentrated in urban and suburban environments), but also because an ideal propagation environment is only found in outer space.

A. *NTIA's Studies of Emissions from Microwave Ovens Point out the Flaws in its Aggregate Model.*

Microwave ovens can serve as a useful example of the cumulative impact of RF emitters. Millions of microwave ovens are in use and distributed widely throughout the U.S. Relating the results from NTIA's Spectrum Surveys to the power levels proposed for UWB emitters suggests that there will not be a measurable aggregate effect, and that NTIA's model for aggregate emissions greatly overstates the actual measured emissions.

In 1994, NTIA measured and documented the emissions from 13 new microwave ovens.[54] That report demonstrated that the second harmonic emissions at 4.9 GHz were nearly equal to the levels proposed for UWB (and probably several decibels higher). Figure 14 shows the spectrum survey results made from a mountain at 3800 feet overlooking Los Angeles, and Figure 15 shows the spectrum survey for Denver. The NTIA Spectrum Surveys for 4.8 to 5.0 GHz in Los Angeles, San Francisco, and Denver did not show an increase in the noise floor at 4.9 GHz.[55] This would not have been the case had aggregate emissions from microwave ovens added in the manner predicted by NTIA's model, and suggests that UWB aggregate emissions at the proposed power levels would not cause a measurable increase in the noise floor – unlike the results NTIA just presented to the FCC.

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[54] NTIA Report 94-303-1 and 2, "Radio Spectrum Measurements of Individual Microwave Ovens (March 1994).

[55] The San Diego survey cannot be used because there was some other system using that band.

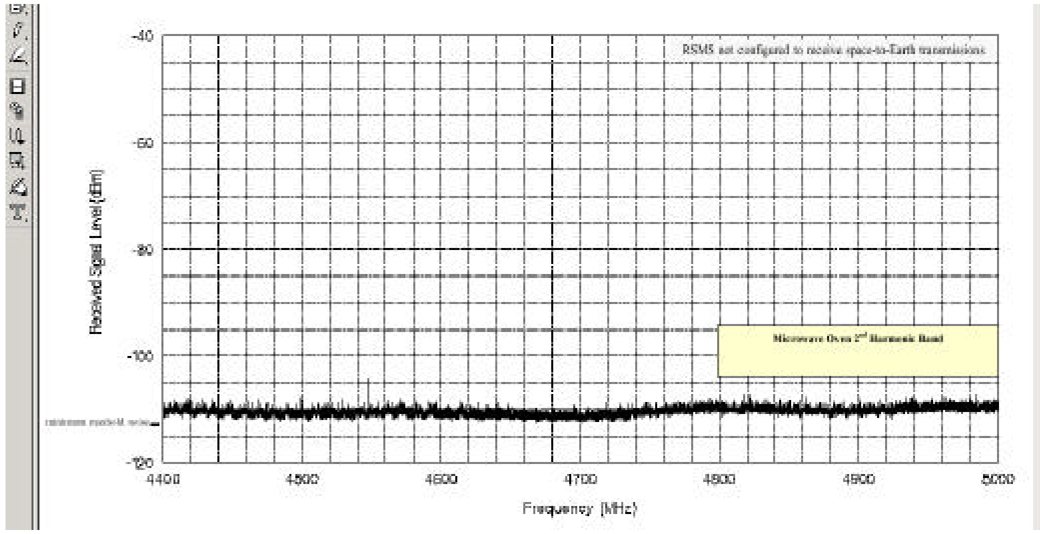

Figure 14. NTIA Spectrum Survey of the 4.4 to 5.0 GHz Band in Los Angeles Taken in 1995.

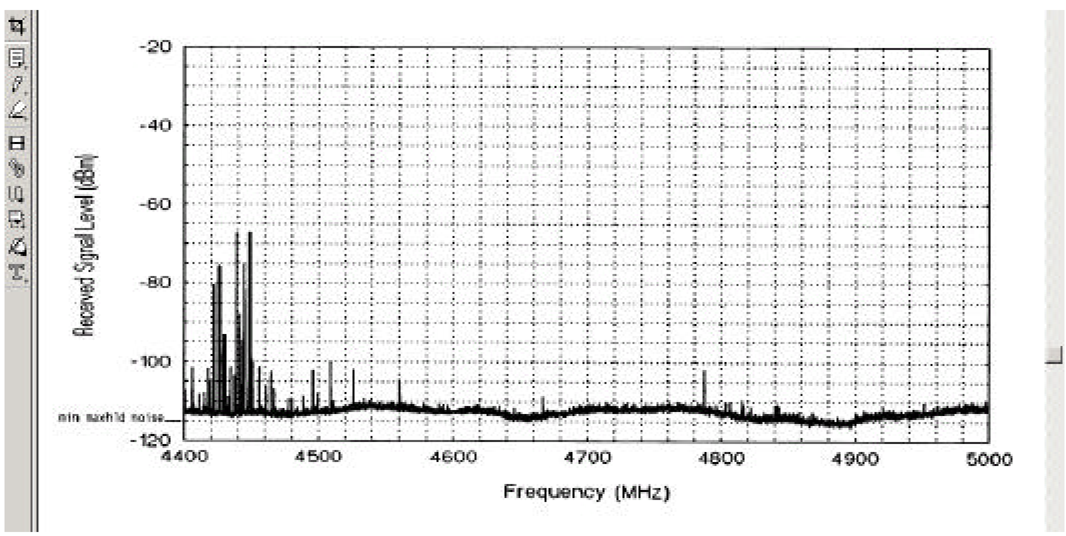

Figure 15. NTIA Spectrum Survey of the 4.4 to 5.0 GHz Band in Denver Taken in 1993.

B. *NTIA Did Not Use a Realistic Propagation Model.*

NTIA's aggregate analysis is flawed because it does not incorporate reasonable propagation models that would have provided UWB devices with up to an additional 40 dB of margin. NTIA used extremely conservative assumptions about propagation.

Essentially, NTIA chose to use models that are little more than free space,[56] even while recognizing that UWB technology will be used in consumer applications and that such applications are dominantly in urban and suburban areas and mostly indoors.[57]

Applying free space for most analyses will overstate the impact of UWB emissions significantly. The NTIA report discusses terrain irregularities, foliage, urban and suburban propagation impacts, building penetration losses, and antenna directivity (though it misses polarization misalignments), but they were not incorporated into its aggregate analyses. Given this, and given that it would apply to the emissions from microwave ovens in the same manner as it does for UWB, it is no wonder that NTIA found no measurable rise in the noise floor at 4.9 GHz, despite what its aggregate model might have predicted.

Any rational assessment of UWB device distribution must account for a significant fraction of UWB devices located inside buildings. Another text on the subject shows that the median penetration losses for residential buildings is about 7.5 dB in the frequency range of interest.[58] This loss adds directly to the roof top diffraction losses for

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[56] NTIA report, section 5.6.1. "The results above clearly indicate that under somewhat ideal conditions used for these aggregate interference analyses, aggregate interference can indeed result in levels that exceed the established interference criteria. It is recognized that in most cases such ideal conditions will not exist, resulting in lower realized values of aggregate interference."

[57] See especially NTIA report, Table 5-11, page 5-34.

[58] K. Siwiak, RADIOWAVE PROPAGATION AND ANTENNAS FOR PERSONAL COMMUNICATIONS, 2d Ed. (1998), Figure 7.16.

UWB units located inside residences. Median losses into urban buildings are 15 to 18 dB in the frequency range of interest.

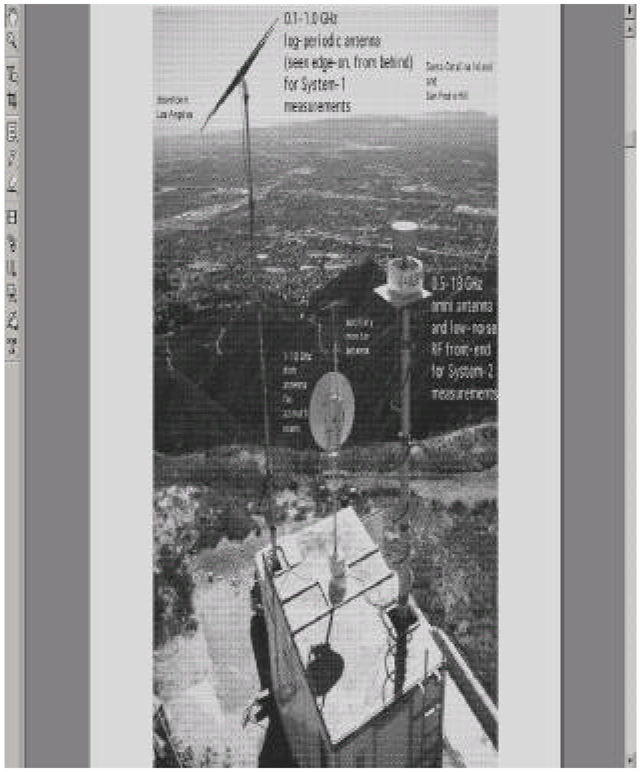

Figure 16. View Overlooking Los Angeles from which the NTIA Made its Spectrum Survey in 1995 (south view from an altitude of 1260 meters above mean sea level).

Figure 16 is a photograph from NTIA's Los Angeles spectrum survey report. It shows the panoramic view of Los Angeles from the location where the NTIA survey team made their measurements. This is essentially the view an aircraft would have from 3,800 feet above Los Angeles. As shown in Figure 14 the survey made from this vantage point did not detect second harmonic signal levels from microwave ovens. Thus, NTIA's own real-world measurements strongly suggest that their theoretical aggregate model is excessively conservative even for airborne receivers.

VI. Conclusion

Harmful interference is the result of interfering signals in the passband of a victim receiver that "seriously degrades, obstructs, or repeatedly interrupts [the] radiocommunications service." The Commission's experience shows that the general Part 15 limits, which were based on the digital device limits, have worked particularly well in preventing harmful interference. When read with an understanding of the relevant mitigation factors, NTIA's Federal Systems Test Report offers the basis for authorization of UWB operations on a Part 15 basis.

Respectfully,

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