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BEFORE THE

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Federal Communications Commission

WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's Rules	)	ET Docket 98-153
Regarding Ultra-Wideband Transmission Systems	)	

To: The Commission

REPLY COMMENTS OF THE U.S. GPS INDUSTRY COUNCIL

THE U.S. GPS INDUSTRY COUNCIL

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SUMMARY

The U.S. GPS Industry Council ("the Council"), by its attorneys, hereby submits its Reply Comments in connection with the Commission's Notice of Proposed Rule Making ("*NPRM*") in its rulemaking proceeding in ET Docket No. 98-153 concerning the possible revision of Part 15 of the Commission's Rules regarding ultra-wideband ("UWB") transmission systems. The positions taken in many of the more than 130 comments that were filed in response to the *NPRM* confirm the Council's assessment that the instant proceeding is of critical importance to the future of the nation's information/technology ("IT") infrastructure, and that the Commission can take no action to permit the operation of devices containing UWB technology until the basic science of UWB transmissions is understood and reflected in rules that ensure the protection of the radio services that operate and will operate in the frequency bands that would be impacted by UWB transmissions.

It is clear from the comments that those interested in providing and/or using UWB technology envision a technology that would be employed in communications and radar applications that would be ubiquitously deployed, indoors and out of doors. This is a very problematic development for users of the Global Positioning System. GPS is currently incorporated in millions of receivers that are themselves ubiquitously deployed in hundreds of different applications. The incompatibility of communications signals and GPS signals has been the subject of recent studies in the International Telecommunication Union, which concluded that such shared use of spectrum is infeasible. Moreover, the ubiquity of GPS and the intended ubiquity of UWB devices require that compatibility be tested based on a collocation scenario, where the interfering UWB devices are located within two meters of victim GPS receivers.

Unfortunately, the ongoing testing efforts – including those of the National Telecommunications and Information Administration ("NTIA") and Stanford University – are focusing on single UWB emitters and are not addressing the multipath and pulse aggregation effects

of UWB, which pose the problem of virtually unlimited radiated power in a given geographic area regardless of whatever emission limits that may be placed on any single UWB emitter. This fact, combined with the fact that open questions as to the impact of persons and objects in the near field of the UWB antenna will remain even as to tested devices, and that a time-frequency analysis instead of a link budget analysis should be applied to test data, will prevent the Commission from adopting rules of general applicability for UWB devices on the basis of the results of the ongoing initial tests.

The comments also reveal that many existing radio services, particularly in frequency bands below 3 GHz, are very concerned about the prospect for interference from UWB transmissions. The comments, which generally reinforce the realization that the interference effects of UWB transmissions on existing radio services are not as benign as some proponents of UWB technology would have the Commission and the public believe, contain several recurring themes that must be factored into any Commission action to permit the overlay of time-domain-based UWB transmissions on the current frequency-domain regime. Among the themes are the following:

- UWB devices, with their discontinuous pulses, are starkly different from continuous wave pulses that are emitted by traditional radio devices and are unsuitable for assessment using traditional measurement devices and metrics.
- Each UWB waveform is distinct, and each one is unstable to the extent that its interference characteristics vary with the environment within which it operates.
- Each type of UWB waveform must be evaluated on an individual basis using measurement procedures and tools appropriate to paint an accurate picture of the interference characteristics of the subject UWB waveform.
- The Commission's timeline for testing the interference effects of UWB devices is too short to allow for testing of more than a few waveforms under a few limited scenarios; none of the ongoing tests will allow for generalization of results beyond the waveforms tested.
- The impact of interference from multiple UWB emitters – something none of the ongoing test programs is addressing – will be extremely problematic to frequency-domain receivers, even in cases of low peak power/low pulse repetition frequency UWB devices.

- There are a number of strong views to the effect that all UWB devices should be required to be licensed (some may be appropriate for "blanket licensing"), and that no unlicensed operation should be permitted.
- There is some point in the frequency spectrum, most likely around 3 GHz, below which UWB devices should be precluded.

It is notable that some proponents of UWB technology echo these themes in several critical areas.

On the other side of the issue, certain UWB proponents are apparently engaged in efforts to hide the interference effects of UWB transmissions by relying on interference metrics that are inappropriate for use with discontinuous-wave, transient pulses. Indeed, the recently-uncovered disregard of the some UWB proponents for the operational conditions imposed on below-3 GHz UWB radars in the waivers issued last year has caused the Council now to insist that no UWB devices can be permitted to operate on a co-frequency basis with GPS and the other safety and sensitive radio services that operate in frequency bands below 3 GHz. When techniques and tools appropriate for assessment of UWB emissions are employed (including sample-and-hold oscilloscopes that are capable of sampling at the Nyquist sampling rate necessary to capture the peak power of UWB signals), when the vagaries of the UWB waveforms (including their susceptibility to detuning due to objects and people close to the antenna) are factored in, and when time-frequency analysis captures composite peak power, the claims of these UWB proponents are exposed as false.

UWB proponents now concede that interference will be caused into GPS and other safety and sensitive services if operation below 3 GHz were to be permitted. The Commission is charged with the obligation to protect the needs of the radio-using public, and must live up to that responsibility even if it is necessary to relegate the most noxious applications of UWB technology to frequency bands well above 3 GHz.

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REPLY COMMENTS OF THE U.S. GPS INDUSTRY COUNCIL

The U.S. GPS Industry Council ("the Council"), by its attorneys and pursuant to Section 1.415 of the Commission's Rules, 47 C.F.R. § 1.415, hereby submits its Reply Comments in connection with the Commission's Notice of Proposed Rule Making ("*NPRM*") in the above-captioned proceeding.[1] The Council submitted detailed comments in response to the *NPRM* on September 12, 2000.[2]

I. INTRODUCTION

In its *NPRM*, the Commission has begun to examine the numerous technical and policy issues that surround the potential use of devices employing ultra-wideband ("UWB") technology. The positions taken in many of the more than 130 comments that were filed in response to the *NPRM* confirm the Council's assessment that the instant proceeding is of critical importance to the future of the nation's information/technology ("IT") infrastructure, and that the Commission can take no action to permit the operation of devices containing UWB technology until the basic science

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[1] *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, Notice of Proposed Rule Making, FCC 00-163, slip op. (rel. May 11, 2000) ("*NPRM*"). By order dated October 3, 2000, the Commission extended the deadline for submission of reply comments from October 12, 2000 to October 27, 2000.

[2] *See* Comments of U.S. GPS Industry Council, ET Docket No. 98-153 (filed September 12, 2000) ("Council Comments"). Unless specifically indicated to the contrary, all references in these Reply Comments to comments are to comments filed in response to the *NPRM*.

of UWB transmissions is understood and reflected in rules that ensure the protection of the radio services that operate and will operate in the frequency bands that would be impacted by UWB transmissions.

The Council, like many other commenters concerned about the use of UWB technology, supports the Commission's desire to make UWB devices available to the public.[3] If the potential applications of UWB technology described in the comments can be attained, the public would benefit.[4] The Commission, however, must remain mindful of the fact that its objective in this rulemaking proceeding is not to determine whether, in the abstract, UWB technology can be incorporated into devices and services that offer benefits to the public. Nor is it the Commission's role to assess the accuracy of claims from UWB proponents or their potential customers (however well-meaning these latter organizations and individuals are in their generalized beliefs that UWB technology will help facilitate the achievement of their particular missions and objectives).

The Council notes that the Commission believes it is obliged under the Communications Act "to encourage the provision of new technologies and services to the public."[5] The Council does not agree that this statute is applicable to UWB.[6] Even if the statute were applicable, however, the

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[3] *See* Council Comments at 14.

[4] *See* Letter from Desmond Byrne, Programs and Policies Coordinator, Department of Health and Human Resources, *State of West Virginia Department of Health and Human Resources*, to Magalie Roman Salas, Secretary, *FCC* (Sept. 11, 2000) (supporting the development of UWB technology to improve communications during natural or man-made catastrophes and monitor patients' activities and locations); Letter from James D. Recco, Director, *West Virginia State College*, to Magalie Roman Salas, Secretary, *FCC* (Sept. 12, 2000) (advocating the use of UWB technology for the benefit of the elderly population); Letter from Charles L. Fox, Executive Director, *Alzheimer's Association*, to Magalie Roman Salas, *FCC* (Sept. 12, 2000) (promoting UWB technology to enhance the quality of people suffering with Alzheimer's disease and other related disorders).

[5] 47 U.S.C. § 157(a).

[6] In its Comments, the Council observed that UWB technology is not a new technology, but rather is an example of the spark-gap, damped-wave emissions devices that were used in the earliest days of radio. These types of devices were effectively outlawed when the Commission (and its predecessor) established the frequency-domain model as the mechanism by which use of the radio frequency spectrum would be managed. *See* Council Comments at 2-3. In short, the Council does not accept the Commission's unsupported assertion, which is repeated without material elaboration by such UWB proponents as Time Domain Corporation ("Time Domain") (*see, e.g.,* Time Domain Comments at 6-7), that UWB is a "new" technology or is otherwise eligible for consideration under Section 7 of the Communications Act. *See, e.g.,* Comments of William E.N. Doty ("[s]ome 50 years ago, certain technical publications presented concepts of 'time

Commission's duty to encourage the provision of new technologies and services would be tempered by the Commission's companion obligation to ensure that any such new technology or service is consistent with the public interest.[7] Thus, public opinion regarding the potential markets for UWB becomes relevant if and only to the extent that the Commission is able to conclude that UWB devices are technically compatible with existing devices and services, and with future services that will operate in the frequency bands across which the UWB devices would radiate.[8]

The remarkable realization to be drawn from the initial comments in this proceeding is the sense of awakening on the part of at least a half-dozen radio services to the risks each of them faces due to the prospect of incurring harmful interference from UWB devices.[9] The extent to which the commenters were able to clearly articulate their concerns varies to some degree based on each commenter's grasp of the underlying science associated with transmissions in the unfamiliar time domain,[10] but all reflect an awareness of the magnitude of their risk exposure. There is no escaping the realness of the technical concerns raised and there is no hint of political artifice or of the type of "not in my backyardism" that so often characterizes spectrum allocation proceedings. Reading the comments provides one with the impression that the covers are slowly being removed from the truth behind the real impact of UWB transmissions.

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domain' information theory"). The proponents of UWB thus bear the burden of demonstrating conclusively that the use of UWB technology is consistent with the public interest. Moreover, the timing considerations of the statute should be deemed not applicable to this proceeding.

7 47 U.S.C. § 157(b).

8 Once the debate gets to that level, of course, the concerns of the Council and other potentially affected user communities will presumably have been satisfied, and the question of whether authorization of particular types of UWB devices or technologies is warranted will be principally between the UWB proponents, their competitors in the marketplace, and the Commission.

9 *See, e.g.,* Comments of AT&T Wireless Services, Inc., at 2 ("AT&T Comments").

10 *Compare* Comments of The Boeing Company at 10-13 ("Boeing Comments") (aware of science issues) with Comments of the Federal Law Enforcement Wireless Users Group at 4 (aware of problem but not fully cognizant of why).

Notwithstanding the ongoing attempts by some of the proponents of UWB technology and their immediate supporters to conceal the truth about UWB's impact on existing services by relying upon inapplicable interference metrics, the Council continues to believe that there are some applications of UWB that will prove to be compatible with radio services that operate in the frequency domain. It thus remains optimistic that ongoing tests will lead to the ability for at least some of these applications to be implemented under the types of conditions the Council set forth in its Comments.[11]

The comments and recent events, however, have inspired one adjustment to the Council's views on this particular subject. In its Comments, the Council expressed the view that UWB ground-penetrating radars and UWB through-the-wall imaging devices may be able to be operated on a compatible basis with the receivers associated with the U.S. Global Positioning System ("GPS") satellites,[12] provided that they were made subject to stringent technical and operational conditions and provided further that these restrictions were proven satisfactory through relevant testing exercises. Based on events that have recently come to light, however, the Council now believes that co-frequency operation of these devices and GPS cannot responsibly be permitted.[13] These events strongly suggest that even with strict operational requirements and licensing-type

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[11] *See* Council Comments at 22-25.

[12] *Id.* at 22.

[13] In particular, the Council now finds it unreasonable to believe that the presumption of good spectrum citizenship that accompanies the operational restrictions heretofore placed on UWB transmissions by the Commission remains valid. In waiver grants issued by the Commission last year (*see infra* at note 14), strict conditions – including the use of so-called "deadman" switches on authorized radar devices – were imposed on the UWB proponents. It has recently come to light that the one of the waiver grantees has routinely been granted authority by the Commission over the last 15 months to prototype UWB radar devices that do not include a "deadman" switch or any of the numerous other technical and regulatory conditions deemed necessary only last year by the Commission and other government agencies for the protection of GPS. *See* U.S. GPS Industry Council Letter, dated October 24, 2000, to Dale Hatfield, Chief, Office of Engineering and Technology (Council objects to Commission decisions to process, on an *ex parte* basis, more than 40 applications for "special temporary authority" by Time Domain Corp. for developmental and prototype UWB devices that fail to include necessary safeguards).

regulation, radio services such as GPS will not be provided the assurance they require that they will be free from co-frequency interference caused by UWB devices.

For UWB applications other than ground-penetrating and wall-imaging radars, it is increasingly clear that operations will have to be limited to frequency bands that are sufficiently removed from the GPS and other bands of concern to ensure that they remain free from the types of interference that such time domain devices can cause. This includes radars that do not meet the conditions described by the Council and UWB devices that would operate in networked applications or with higher peak power/higher pulse repetition frequency characteristics. Even so, appropriate regulatory provisions such as limits on unwanted emissions into the restricted bands and licensing of all UWB waveforms will need to be included in any rules that may be adopted in order to ensure such devices' compliance with the limitations. Furthermore, since antenna loading has been shown to cause drastic shifts in spectral emissions, an understanding of how to create antenna designs which minimize, or eliminate, this demonstrated problem will have to be achieved before widespread use of UWB devices can be allowed to proceed. This will require extensive testing and type approval of antenna designs, in addition to licensing of individual UWB waveforms.

In these Reply Comments, the Council reviews and assesses the comments that were filed. It then attempts to lay out the options that are available to the Commission at this early juncture in this proceeding, and to identify what steps, if any, the Commission may be able to take as it awaits the submission and consideration of data on what will surely be the first of several rounds of testing and assessments involving UWB equipment.

II. DISCUSSION

A. The Extent To Which UWB Technology Is Anticipated To Be Included In Ubiquitously-Deployed Communications And Commercial Radar Applications Is A Troubling Revelation.

Based upon a review of the *NPRM* and the three waivers the Commission granted last year to allow the limited marketing of UWB devices subject to certain conditions,[14] it appeared that the principal applications of UWB technology would be in limited-deployment radar devices used by public safety personnel for high resolution imaging of persons and objects behind walls or under debris.[15] Only one short paragraph in the *NPRM* was devoted to the prospect of using UWB devices for communications applications, mostly in indoor situations; the one "outdoor" communication application mentioned being potential use by police, fire, and rescue personnel to provide covert secure communications devices.[16]

The comments have dramatically changed that perception. All sorts of commercial communications applications, along with widespread, open-air use of radar devices that are envisioned for mounting on automobile bumpers, were described in the various comments.[17] UWB communications technology, which is characterized by multiple emitters in close proximity with one another, is apparently now being promoted for virtually ubiquitous use, indoors and outdoors.

This unanticipated projection of UWB as a communications technology that would be ubiquitously deployed on an unlicensed basis is particularly problematic for users of the U.S.

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[14] *See The Office of Engineering and Technology Grants Waivers for Ultra-Wide Band Technologies*, Public Notice, DA 99-1340 (rel. July 8, 1999) (reporting grants of waivers of certain Part 15 rules to Time Domain Corporation, U.S. Radar, Inc., and Zircon Corporation to allow the limited marketing of UWB devices subject to certain conditions) (collectively, "*UWB Waivers*").

[15] *See NPRM,* FCC 00-163 slip op. at 3-4 & nn. 16-17.

[16] *Id.* at 6 (¶ 12).

[17] *See* Comments of Fantasma Network, Inc., at 1, 2 (addressing wireless UWB systems capable of supporting high data rate throughputs of 60 megabits per second ("Mbps") and higher); Comments of Æther Wire & Location, Inc., at 13-15 (listing 30 different potential UWB applications). *See also* Comments of Xtreme Spectrum, Inc., at 11 (stating that UWB systems will provide communications at the 10-100 Mbps ranges).

Global Positioning System.[18] GPS technology is itself currently incorporated in millions of receivers that are used in hundreds of applications, and is ubiquitously deployed.[19] The importance of GPS to all sectors of the economy is profound, and is growing every day to new areas and sectors of the economy. The Council notes in this last regard that several manufacturers of GPS equipment, spurred on by the Commission's requirement for E-911 service, have now developed enhanced sensitivity GPS chipsets that enable GPS to be operated indoors.[20]

In light of the fact that there is no ability to control the placement of a UWB device in a networked or commercial radar application, and the intentions of UWB proponents to have millions of units in existence in just a few years, the Commission must assess the impact of most UWB devices on GPS receivers under a scenario whereby multiple interfering UWB devices are co-located with a victim GPS receiver (i.e., the interferers and the victim are within two meters of each other).[21] Any scenario that features unregulated and mobile UWB devices at distances greater than two meters from a victim GPS receiver will understate the scope of the interference to be caused, and thus is invalid.

Furthermore, the unanticipated emphasis on networking of UWB communication devices means that there is a glaring deficiency in the scope of the current round of UWB test programs, as

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[18] As the Council noted in its Comments, GPS satellites transmit a very low power, data-only signal (on the order of 50 bps), and there is no ability for the GPS user segment to accommodate any interference above the level at which the system was designed to operate. This is a fundamental constraint on the placement of in-band, out-of-band, or any other unwanted emissions into frequency bands where the GPS system operates. *See* Council Comments at 8.

[19] *See, e.g.,* Council Comments at 10 (containing list of example uses of GPS).

[20] *See* 47 C.F.R. § 20.18. Although the Commission's rules are technologically neutral, and consequently do not dictate the mode of automatic location identification ("ALI") for purposes of E911 calls, the Commission revised the E911 deployment schedule to implement stricter location identification requirements considering hand-based solutions such as GPS-based technologies. *See Revision of the Commission's Rules To Ensure Compatibility With Enhanced 911 Emergency Calling Systems*, Third Report and Order, 14 FCC Rcd 17388, 17391 (¶ 5), 17392 (¶ 10), 17408 (¶ 42) (Oct. 6, 1999); Fourth Memorandum Opinion and Order, FCC 00-326 (CC Docket No. 94-102), slip op., at 9 -10 (¶ 20), 12 (¶ 30) (Sep. 8, 2000).

[21] The only possible exception to this scenario comes in the cases of UWB ground-penetrating radars ("GPRs") and through-the-wall imaging devices ("WIDs") that are produced and operated under the conditions advocated by the Council in its initial Comments. *See* Council Comments at 22-25.

these programs all focus on single UWB emitters (as did the *NPRM).* Multipath and pulse aggregation effects, especially in an unlicensed environment, pose the problem of virtually unlimited radiated power in a given geographic area regardless of the limits placed on any single UWB emitter. Until the basic science of UWB emitter multipath and pulse aggregation can be fully understood, and measured with instrumentation developed for its monitoring and control, proceeding with unlicensed operation of network communication devices is destabilizing to all forms of radiocommunication and clearly not in the public interest.

To be sure, the co-location scenario for UWB and GPS is not a welcome development for some UWB proponents – particularly those who seek to provide communications applications in or near the frequency bands used by GPS. The issue of the sensitivity of GPS receivers to co-frequency signals from communications devices was studied extensively within the International Telecommunication Union ("ITU") for the last three years. Addressing the impact of communications services (specifically, the mobile-satellite service ("MSS")) on the radionavigation-satellite service ("RNSS") in which GPS operates and the companion terrestrial aeronautical radionavigation service ("ARNS") in the 1559-1610 MHz band, the ITU observed that:

> The core signal structures of MSS and RNSS/ARNS are fundamentally different: MSS uses a two-way signal while ARNS/RNSS transmits a weak, receive-only signal. Having systems from a radiocommunication service operate on a co-primary basis in the 1559-1610 MHz band would limit ARNS/RNSS operators' flexibility by reducing the spectrum available for use in the band, and could therefore hamper the development of a GNSS that meets evolving international needs and provides adequate protection for international civil use worldwide.[22]

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[22] *See* Report of the Conference Preparatory Meeting to 2000 World Radiocommunicaton Conference at Section 2.2.1.2.5 (pp. 14-15) (November 1999), *reproduced in* Document WRC-2000/03 (January 21, 2000). The ITU also recognized "the essential need to protect ARNS/RNSS systems operating in the 1559-1610 MHz band[,]" and that "[t]he unique technical characteristics of [RNSS], and its safety-of-life applications, makes it extremely difficult to predict the operational consequences of such signal sharing. *Id.* at Section 2.2.1.3. Moreover, the ITU observed that "[n]o practically implementable regulatory or procedural mechanisms have been presented to the ITU-R that could satisfy established fault monitoring and reporting requirements and ensure that [the communications service] signals would not have an negative effect on the continuity of flight operations." *Id.* at Section 2.2.1.4.

The ITU, with the support of the United States, concluded that sharing between the communications service and the RNSS/ARNS was not possible in any portion of the studied band.[23] The precedential impact of this conclusion is significant, and directly applicable to the consideration of UWB transmissions. It means that the United States Government should not consider allowing sharing between incompatible services, such as communications and radionavigation-satellite services.

B. Existing Radio Services, Particularly In Frequency Bands Below 3 GHz, Expressed Serious Concerns About The Prospect For Interference From UWB Transmissions.

In its Comments, the Council addressed the potential for interference into GPS receivers that UWB transmissions posed. Noting the inability to address some matters with certainty in the absence of test data, the Council nevertheless ventured that certain types of UWB radar devices (namely GPRs and WIDs, but not the open-air collision avoidance radars), if subject to stringent operating and deployment restrictions, may be able to be operated compatibly with GPS. As indicated above,[24] the Council, which originally was willing to reserve judgment on whether GPRs and WIDs could operate on a co-frequency basis with GPS and other safety services, has now been forced to conclude that the Commission cannot responsibly permit even these types of devices to be employed below 3 GHz.[25] The unwillingness of some UWB proponents to abide by restrictions

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[23] *See id.* at Section 2.2.1.3. There is no reason why the same considerations would lead to any conclusion other than that that sharing between a communications service and GPS in the other bands in which GPS operates is similarly not feasible.

[24] *See supra* at n. 13 and accompanying text, where the Council describes the developments that have led to one UWB proponent being granted nearly three dozen experimental authorizations to use UWB devices (sometimes multiple devices) without being subject to the stringent protective conditions that the Commission and NTIA determined in the UWB Waivers are necessary to protect GPS.

[25] The Council does not reach this conclusion lightly, and was very disappointed to discover that the same Commission office that imposed the conditions on Time Domain and the other grantees of the UWB Waivers has been systematically permitting those conditions to be ignored ever since. The Council's concern is straightforward: if there is no assurance that operational limitations and restrictions will both be embraced by the regulated industry and zealously enforced by the Commission, the potential for interference exposes manufacturers and operators of the safety equipment that would be impacted by the resulting interference to potentially unacceptable risk. The only way around this situation is an absolute preclusion of any UWB-occupied bandwidth below about 3 GHz.

deemed essential for the protection of GPS and the Commission's apparent willingness to permit the restrictions included in the UWB Waivers to fall by the wayside requires that GPS and other services in the sensitive bands below 3 GHz assume the risk that they will remain free from interference. This is an intolerable burden for any service, and one that leads inexorably to the conclusion that all UWB devices must be precluded from occupying any frequency bands below about 3 GHz.[26]

With respect to all other types of UWB devices, the Council expressed its belief that such devices, due to their technical characteristics and/or their operational scenarios, must be precluded from operating in the restricted bands below 3 GHz, and subjected to limitations on unwanted emissions produced into the GPS bands.[27] The Council went on to address the other matters set forth in the *NPRM*, including the Commission's erroneous tentative conclusion that only the closest UWB transmitter placing an emission into the frequency of concern is relevant; the lack of any serious multiple emitter (aggregation) studies including the non-linear effects on GPS as well as on the associated integrated communications devices essential to many GPS applications and services (cellular, paging, trunked radio, satellite communications, etc.); the fact that the shortness of time for testing will lead to incomplete results;[28] the need for precise and meaningful emission limits (based on total UWB peak emissions per nanosecond) and associated measurement procedures (including the requirement for the use of a 20-50 GHz sample-and-hold oscilloscope to measure

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[26] While such a preclusion may affect the implementation plans of some UWB radar providers in the short run, there is absolutely no valid technical reason why they cannot perform all of the desired radar applications in frequency bands above 3 GHz. In this regard, the Council applauds good spectrum citizenship demonstrated by Dephi Automotive Systems Corporation for designing effective collision avoidance radars for operation in the 17 and 24 GHz bands – specifically to preclude harmful effects on restricted bands. The Council reaffirms its strong opposition to the operation of UWB collision avoidance radars in restricted bands because of the likelihood that high-density deployment in urban environments would cause harmful interference and jamming. A medical emergency helicopter responding to an accident on a Los Angeles interchange during rush hour offers a realistic scenario.

[27] *See* Council Comments at 25-28, 30-32.

[28] Not only have there been no serious testing of factors leading to antenna loading of UWB devices or of the multipath and pulse aggregation effects of multiple UWB devices collocated in the same geographic area, results will be incomplete even for those devices being tested (i.e., only a subset of the GPS interference metrics are being assessed).

peak emissions from UWB signals); the need to apply a time-frequency analysis instead of a link budget analysis to the test data; and the fact that the Commission will not be in a position in this first phase of the instant rulemaking to adopt broad rules authorizing the use of UWB technology.

The Council has been concerned about the impact of UWB transmissions on GPS receivers from the beginning, and has participated in the instant proceeding since the adoption of the original notice of inquiry in 1998. A number of other commenters echo the concerns of the Council about the impact of UWB on GPS, and urge the Commission to take measures to ensure the freedom of GPS from such interference.[29]

It is also clear from the comments that many other licensees and users of radio services that operate in frequency bands targeted by the *NPRM* for UWB operation have concerns about the impact of UWB transmissions on their services that parallel the concerns expressed by the Council and others about UWB's impact on GPS. Comments were received from representatives of such varied user communities as radio and television broadcasters, providers of Personal Communications Services and cellular radio services, manufacturers of aeronautical telemetry equipment, Satellite DARS licensees, wireless communications service providers, and mobile-satellite service operators.[30] The comments reveal that as understanding of UWB technology and

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[29] Among the parties noting the potential for UWB interference to GPS and/or urging the adoption of preventive measures were: Aeronautical Radio, Inc. and the Air Transport Association of America, Inc.; the Aircraft Owners and Pilots Association; The Boeing Company; Carnegie Mellon University; Garmin International, Inc.; Lockheed Martin Corporation; the National Business Aviation Association; Qualcomm Incorporated; Saab Marine Electronics AB; the Satellite Industry Association; Rockwell Collins, Inc.; Sirius Satellite Radio, Inc.; SiRF Technology, Inc.; Stanford University; and the United States Department of Transportation.

[30] AT&T Wireless Services, Inc. notes the potential impact on cellular, Personal Communications Services ("PCS") and third-generation wireless services in the 1-2.6 GHz band. XM Radio, Inc. and Sirius Satellite Radio, Inc. both address UWB interference into the Satellite Digital Audio Radio Service ("Satellite DARS") in the 2320-2345 MHz band. Mobile Communications Holdings, Inc. and Qualcomm Incorporated address the potential for interference into nongeostationary MSS systems in the 1.6/2.4 GHz and 2 GHz ranges. The National Association of Broadcasters addresses the prospect of UWB interference into the broadcast radio and television services that operate in some of the restricted bands, as well as to Electronic News Gathering ("ENG") operations in the 1.990-2.110 GHz band. Metricom, Inc. has concerns about the impact of UWB on its 2.3 GHz Wireless Communications Service ("WCS") system. Nortel Networks Inc. expresses concern about UWB's impact on its PCS and software-defined radio ("SDR") equipment. Cisco Systems, Inc. believes that UWB devices could interfere with Multichannel Multipoint Distribution Service ("MMDS") and Instructional Television Fixed Service ("ITFS") operations in the 2150-2162 MHz and 2500-21690 MHz bands that are being used to provide high-speed Internet access. Rockwell Collins, Inc. seeks to protect sensitive radio altimeters operate in the 4.2-4.4 GHz band and microwave landing system receivers operating in the 5.03-5.09

its implications increases, so too does the realization that the interference effects of UWB transmissions on existing radio services are by no means as benign as some proponents of UWB technology would have the Commission and the public believe.

The comments filed by representatives of existing radio services, both public safety and mass market, contain several recurring themes that must guide the Commission's thinking and actions as it attempts to advance this proceeding. These themes can be summarized as follows:

- UWB devices, with their discontinuous pulses, are starkly different from continuous wave pulses that are emitted by traditional radio devices and are unsuitable for assessment using traditional measurement devices and metrics.[31]
- Each UWB waveform is distinct, and each one is unstable to the extent that its interference characteristics vary with the environment within which it operates.[32]
- Each type of UWB waveform must be evaluated on an individual basis using measurement procedures and tools appropriate to paint an accurate picture of the interference characteristics of the subject UWB waveform.
- The Commission's timeline for testing the interference effects of UWB devices is too short to allow for testing of more than a few waveforms under a few limited scenarios; none of the ongoing tests will allow for generalization of results beyond the waveforms tested.[33]

GHz band from UWB interference. Finally, noting broad concerns about the harmful interference potential of UWB, the Wireless Communications Association International, Inc. flagged the 2 GHz bands allocations to the MMDS, the ITFS, and the WCS; the 18 and 38 GHz bands allocated to the Private Operational Fixed Service ("POFS"); the 24 GHz bands allocated to the Digital Electronic Message Service ("DEMS"); and the Local Multipoint Distribution Service bands at 28 and 31 GHz as vulnerable to UWB interference.

31 *See, e.g.,* Comments of Cisco Systems, Inc. at 4.

32 GPS receivers are highly sensitive to the fine spectral line structure that is caused by UWB waveforms. *See, e.g.,* Comments of National Business Aviation Association at 13-14 (stating that one or more very low-level UWB spectral lines falling on the higher-order GPS sidelobes can degrade or completely negate the additional precision needed for critical operations such as landings). Unfortunately, it appears from initial testing performed by Multispectral Solutions, Inc. ("MSSI") that UWB waveforms are strongly affected by the antenna and the external loading of the antenna. *See* Comments of MSSI at 7-8 ("MSSI Comments"). Moreover, the mere proximity of the UWB antenna to human and inanimate objects will alter the UWB waveform, with the effect that the fine UWB spectral line structure actually varies with changes in the proximity of objects. This is a disturbing observation that both precludes the ability of test results even on actual UWB waveforms from being safely relied upon as applicable in all situations involving that waveform, and that confirms the wisdom of the engineers and regulators who saw fit to migrate the use of radio frequency spectrum from the initial time-domain approach to a frequency-domain regime in the early years of the 20th Century.

33 *See, e.g.,* Comments of XM Radio, Inc. at 12-13 ("XM Radio Comments").

- The impact of interference from multiple UWB emitters – something none of the ongoing test programs is addressing – will be extremely problematic to frequency-domain receivers, even in cases of low peak power/low pulse repetition frequency UWB devices.[34]
- There are a number of strong views to the effect that all UWB devices should be required to be licensed (some may be appropriate for "blanket licensing"), and that no unlicensed operation should be permitted.[35]
- There is some point in the frequency spectrum below which UWB devices should be precluded.[36]

It is notable that proponents of UWB technology echo these themes in several critical areas.[37]

Numerous parties, including the Council, Sirius Satellite Radio, Inc., the National Association of Broadcasters, Sprint PCS, AT&T Wireless, Aeronautical Radio, Inc. and the Air Transport Association of America, Inc. ("ARINC/ATA"), the Aircraft Owners and Pilots Association ("AOPA"), and Cisco Systems, Inc., emphasize in one way or another that there is a need to gain an understanding of UWB systems, as such systems "do not generally conform to the traditional model of spectrum management where finite bands are allocated to particular services."[38] UWB devices are unlike any other radiators, intentional or unintentional, within Part 15 or without. They emit significant power in discontinuous pulses over large swaths of frequency spectrum; they have peak powers that can be dramatically higher (multiple orders of magnitude) than the

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[34] *See, e.g.,* Comments of Rockwell Collins, Inc., at 6 ("Rockwell Collins Comments"). Limiting the power of UWB devices, whether peak or average, on a per-device basis does nothing whatsoever to limit the power produced by multiple devices or UWB devices that are specifically designed to be used in networked applications. Moreover, the precise aggregation effect of large networks of UWB communications devices is unknown, but it is clear that the total radiated power per unit area cannot be controlled in the case of unlicensed devices.

[35] *See, e.g.,* Comments of Sirius Satellite Radio, Inc., at 20-21 ("Sirius Comments"); Council Comments at 23, 49-51.

[36] *See, e.g.,* Comments of Mobile Communications Holdings, Inc., at 4 (proposing cut-off at 3 GHz) ("MCHI Comments"); Council Comments at 26-27 (proposing cut-off at around 3 GHz); Rockwell Collins Comments at 5 (proposing cut-off above 5 GHz).

[37] In its comments, UWB proponent MSSI, *inter alia,* argues against permitting direct-impulse UWB systems under Part 15 of the Commission's rules, proposes to restrict UWB systems (at least initially) to bands above 3.1 GHz, and calls for the establishment of emissions limits based upon measured instantaneous peak power. *See* MSSI Comments at 2, 13.

[38] *See* Comments of Cisco Systems, Inc. at 4.

emission's average power; each UWB waveform is unique and is uniquely affected by objects and propagation conditions in its path.

Under these circumstances, it is imperative that the Commission gain an understanding of the basic science of UWB and then conduct experimental tests to validate its understanding. It is necessary for the Commission and the affected user and operator communities to agree on appropriate interference metrics (e.g., peak power per nanosecond) to be applied to individual and composite UWB emissions, on the tools to use to measure the instantaneous composite emissions (tools which it now appears will have to be created from scratch or borrowed from the nuclear physics testing community), and on the appropriate regulatory mechanisms to ensure that the agreed emission limits will be complied with. It is woefully insufficient for the Commission to conduct experimental tests of single emitters without antennas on an average power basis for a limited number of UWB waveforms and hope to be able to develop a sound basis for regulation from the mountains of raw data that will be deposited into the record of this proceeding over the next few weeks.

On a related point, the Council notes that a number of commenters share its concern[39] that the ongoing testing efforts by the National Telecommunications and Information Administration ("NTIA"), Stanford University (on behalf of the Department of Transportation), and the University of Texas (on behalf of Time Domain, a UWB proponent) are not designed to achieve results that will enable the Commission to adopt rules of general applicability concerning the possible implementation of UWB devices. Several commenters decry the fact that only a limited sampling of UWB emitters is being undertaken,[40] and others echo the Council's concern that none of the testing programs will even begin to assess the impact of multiple UWB emitters (particularly those

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39 *See* Council Comments at 37-41.

40 *See, e.g.*, Rockwell Collins Comments at 6.

in networked applications) upon victim receivers.[41] Clearly, there will be no way that the results of the test programs that are to be submitted to the Commission shortly will prove anything that can be applied beyond the specific cases tested; generalization, even to other scenarios involving the tested equipment cannot occur.[42]

There also is strong agreement among the commenters that the October 30, 2000 deadline established by the Commission for submission of results of tests is too short to enable a reliable assessment of the impact of UWB on existing radio services to be made. The Council made its case on this point with respect to the testing programs addressing the impact of UWB on GPS.[43] Others, noting the paucity of test programs designed to evaluate other radio services and contending that any answers reached for GPS may not be applicable to other services, argued for extensions of the time period for submission of test results that ranged from 90 to 120 days on the short end, to a deadline of January 2002 on the outside.[44] All of these observations ignore that the final answer could be arrived at more swiftly if a basic science understanding were achieved first, or at least in parallel, to ensure that the right questions are being asked. This is especially important considering

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41 *See, e.g.,* Sirius Comments at 24-26.

42 As will be shown below, one concern with UWB is the fact that the waveforms tend to detune when objects or persons are in the near field. This leads to unpredictable shifting of the fine spectral lines, with the result that a device that produces no interference effect into a GPS receiver under one situation may, if for example a tree or person is moved into the near field of the device, experience a shifting of the fine spectral lines of the waveform that produces harmful interference into a nearby GPS receiver. This phenomenon will, as a general matter, make it difficult to draw any broad conclusions about the interference properties of any UWB waveform, and in effect serves to reinforce the wisdom of those who oversaw the outlawing of damped-wave emissions back in the early days of the Commission and the Federal Radio Commission.

43 *See* Council Comments at 35-37.

44 *See, e.g.,* Rockwell Collins Comments at 4 (recommending 120 day extension of the October 30 deadline); XM Radio Comments at 13 (stating that a more realistic deadline would be January 2002). Several of the non-GPS commenters expressed intentions to conduct their own tests of UWB equipment. *See, e.g.,* Comments of Metricom, Inc. at 4 (announcing intention to file test results with the Commission on or before November 30, 2000). Significantly, one commenter, Sprint Spectrum, L.P. ("Sprint PCS"), filed supplemental comments concluding that test summaries and models that it filed jointly with UWB proponent Time Domain "document that UWB devices *will* cause harmful interference to PCS CDMA networks – even at the more stringent –53.2 dBm/MHz average power level suggested in [the *NPRM*]." Supplemental Comments of Sprint PCS (filed October 6, 2000), at iii, 2. *See also* Comments of Nortel Networks Inc. at 8 (stating that test results require emission limits at least 30 dB below the levels provided in Part 15 of the Commission's rules).

that the Commission is contemplating the reintroduction into today's highly dynamic IT environment of a rejected approach to communications (i.e., time domain, damped wave impulses) that caused chaos in its first incarnation.[45]

The Council's views on this matter have not changed. The Council is supportive of the concerns expressed by others on the timeline issue, and endorses the calls for postponement of the October 30 deadline. The Council's support for an extension is made under the express understanding that the Commission's pledge not to establish any rules in this proceeding prior to the receipt of public comments and analysis[46] of test data remains in effect.

One issue on which very strong views were expressed is whether UWB devices should be permitted to operate under Part 15 rules at all. The Council for one came out strongly against any unlicensed operation of UWB devices.[47] It was joined in this opinion by a number of other filers, including at least one UWB proponent.[48] Sirius Satellite Radio, for example, recognizing the difficulties in arriving at a meaningful definition of "UWB" and that the variety of UWB waveforms lead to differing impacts on existing radio services, stated that a licensing procedure whereby device manufacturers are required to submit a formal application outlining specific technical parameters is more appropriate than unlicensed operation. It argued, and the Council agrees, that a meaningful licensing procedure would provide existing licensees in other services with information that will enable them to determine in advance the interference potential of a

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[45] Curiously enough, modern UWB technology embodies not one, but two historically rejected communication techniques. The first was the Marconi spark gap radio and the second is encoding based on pulse position modulation. The latter technique was rejected more than 50 years ago, with the advent of Shannon's insight into channel capacity limitations and subsequent improvements in modulations schemes, such as spread spectrum and code division multiple access.

[46] *See NPRM,* FCC 00-163, slip op. at 4 (¶ 7).

[47] *See* Council Comments at 29-31.

[48] In its comments, MSSI stated that "[t]he high power level requirements (up to several kilowatts), frequency of operation (over many restricted bands including GPS and TV), and limited market for UWB GPRs makes them inappropriate for Part 15 unlicensed use." Comments of MSSI at 12.

proposed UWB device and allow the identification of potential remedial or mitigation techniques that would ensure that no harmful interference is caused.[49] The Boeing Company similarly opposes the authorization of UWB systems (irrespective of power and pulse repetition frequency) pursuant to Part 15 of the Commission's Rules. It correctly contends that "[t]he potential aggregate impact of ubiquitously deployed UWB systems is too significant for the Commission to authorize using a regulatory structure that provides the Commission with insufficient means to control the number and means of the UWB units in use[,]" and urges the Commission instead to set appropriate limits for such equipment and issue authorizations exclusively through a new, tailored blanket licensing structure that would address individual UWB waveforms.[50]

The Council supports the views expressed by The Boeing Company and Sirius Satellite Radio, but is adamant that these helpful proposals must await a fundamental basic science understanding which demonstrates the way forward safely through the minefield of proposed reintroduction of time domain UWB technology. What is needed is a licensing procedure that requires device manufacturers to submit formal applications outlining specific technical parameters, which are then tested and certified by an independent regulatory body – not unlike the Underwriters' Laboratories. This means that if specific UWB devices are to be used in networks, the maximum density of the network must be certified and licensed.

Finally, the Council notes that a large number of commenters disagree with the Commission's proposal to draw a line of demarcation between restricted UWB devices and largely unrestricted UWB devices at 2 GHz, and that the cut-off line should be placed higher in the frequency spectrum. Several commenters, in addition to the Council, make the observation that the

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[49] *See* Sirius Comments at 20-21.

[50] *See* Boeing Comments at 13-14. The Boeing Company notes further that the use of a blanket licensing structure would provide recourse to existing users of the radio spectrum and help the Commission to identify any operators of UWB devices that cause unanticipated interference. *See id.* at 14.

Commission's assertions regarding the use of omnidirectional antennas in radios operating in restricted bands above 2 GHz is incorrect.[51] These commenters, along with others who together note the potential for interference to such services as MMDS, MSS, ITFS, WCS, Satellite DARS, and PCS which operate in the 2-3 GHz range, argue that the preclusion area should be placed no lower in the band than 2600 MHz, with many arguing for placement at or near 3 GHz.[52] One commenter, Rockwell Collins, Inc., states that the frequency below which UWB transmission systems should have special restrictions needs to be raised to 5.15 GHz in order to accommodate two flight-critical approach navigation systems.[53] Even UWB proponent MSSI calls for strong limitations on UWB operations below 3.1 GHz.[54]

Although the final cut-off line for the Commission's rules will not be able to be identified with particularity until the completion of comprehensive and rigorous testing, it is clear to the Council that the Commission's rationale for tentatively proposing the cut-off at 2.0 GHz fails to withstand scrutiny. The Commission should prepare to move the line higher in the spectrum, and to adopt the regulatory measures that are necessary to ensure the stability of the UWB spectral line structure and that unwanted emissions from UWB devices that operate above the final line into

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51 *See, e.g.*, MCHI Comments at 1-2 ("Big LEO" MSS receivers at 2483.5-2500 MHz use omnidirectional receivers); Sirius Comments at 10-11 (observing that satellite DARS receivers in the 2300 MHz region operate with omnidirectional antennas).

52 *See, e.g.*, AT&T Comments at 7 (suggesting that the cut-off should be placed at 2600 MHz); Sirius Comments at 11 (proposing cut-off at 2.9 GHz); MCHI Comments at 4 (proposing cut-off at 3 GHz); XM Radio Comments at 10 (calling for cut-off at 3 GHz). Metricom, Inc. calls upon the Commission to defer a final decision on the cut-off line until the results of tests are in and evaluated. The Department of Transportation asserts that there is no basis to grant unqualified approval to UWB devices operating above 2 GHz because sensitive systems function in restricted bands above that frequency. Comments of the United States Department of Transportation at 14.

53 *See* Rockwell Collins Comments at 5.

54 MSSI Comments at 2, 13.

bands below (including the GPS bands and other restricted bands) are at least 30 dB below those permitted under current Part 15 emission limitations, so as to prevent harmful interference.[55]

C. The Attempts By Some UWB Proponents To Claim An Absence of Harmful Interference To Co-Frequency Radio Services Rely On Inapplicable Standards, And Are Otherwise Seriously Defective.

When the rhetoric and posturing by UWB proponents is cast aside, there is really but one important question that must be answered by the Commission as it evaluates UWB technology: Will the operation of UWB devices introduce harmful interference into frequency bands that are used by existing radio services? The answer to that question, at least in the case of GPS, is an unqualified yes. UWB devices – particularly those used in open-air radar applications such as UWB collision-avoidance radars, and the proposed communications devices that will be both ubiquitously deployed and aggregated in networked applications – will cause harmful interference to GPS.[56] Under the scheme currently envisioned in the *NPRM*, these interferers would not be subject to deployment limitations, and would produce effects that are both incapable of accurate prediction due to the uniqueness of each UWB waveform and the detuning effects of objects and people in the transmission path. Moreover, the nature of these devices is that any interference they produce would be virtually impossible to trace to its source.

There are some in the UWB community who appear to understand the nature of their proposed transmissions and the fact that they will produce additional interference into bands occupied by radio services that are particularly sensitive to the types of interference to be produced. MSSI, for one, recognizes that without filtering of the excitation pulse prior to radiation by the UWB antenna, "it is virtually impossible to prevent *significant* changes in both frequency and

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[55] *See* Comments of Nortel Networks, Inc. at 8 (explanation of why emission limits in restricted bands must be at least 30 dB below Part 15 levels).

[56] The Council notes again that there may be a possible exception for certain UWB GPRs and WIDs, but only if they are subject to stringent operational and deployment conditions that the Council set forth in its Comments.

bandwidth with *accidental* changes or simple *external* modifications to the UWB antenna."[57] MSSI goes on to note that UWB systems that utilize non-filtered, impulse-excited antennas can be easily altered or tampered with to produce significantly narrower band emissions at frequencies other than the "design" frequency, and at power levels many dB higher than those produced by the original, unmodified emissions.[58] MSSI concludes that "[o]nly pulse filtering *prior* to radiation by the antenna can eliminate these indeterminate, yet potentially interfering, spectral components," and goes on to recommend that the Commission prohibit use of unfiltered UWB emissions on an unlicensed basis.[59] Although the Council continues to climb the learning curve with regard to the nuances of UWB transmissions, its current level of knowledge and analysis is sufficiently advanced to allow it to support the statements MSSI makes in its comments. MSSI is clearly cognizant of the vagaries of the UWB waveform and the havoc that such transmissions can wreak on unsuspecting and defenseless services, and is endeavoring to take positions that inure to the long-term view of UWB and the growth prospects of its technology.

Others in the UWB community, particularly those UWB proponents whose scopes of business are limited and whose prospects rest exclusively upon the outcome of this regulatory proceeding, do not appear to take such a reflective approach. There are very serious flaws, for instance, in the technical case advanced by Time Domain and several other UWB proponents in support of the Part 15-based approach the Commission tentatively endorsed in its *NPRM*. It is abundantly clear that a UWB device that operates across a frequency band places additional energy into that band. It is equally clear that the increase in energy and its likely impact on existing non-UWB devices cannot be accurately characterized through the use of tools and techniques that are

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57 MSSI Comments at 3 (emphasis in original).

58 *Id.*

59 *Id.* at 9 (emphasis in original).

designed for continuous wave emitters. When Time Domain and others claim that the Part 15 emission limitations would not be exceeded by the co-frequency operation of UWB devices, they are making a very carefully crafted assertion that they hope will be interpreted as a claim that there is no interference effect.[60]

Time Domain's repeated claim[61] that its technology is no different than the myriad devices (e.g., hair dryers, personal computers, electric razors, and automobiles) that radiate unintentionally into the restricted bands is specious. Some unintentional emitters produce broadband noise (e.g., electric motor brushes), but there is low power density and the signals do not propagate well; other unintentional emitters (e.g., personal computers) produce emissions that are not like Gaussian noise, but rather consist of spurious harmonics. Neither of these types of emissions, however, is likely to produce a broad spectrum or have a sustained effect on multiple radio systems. Moreover, unlike UWB transmissions, unintentional emitters are just that: unintentional. The functioning of the device does not depend on the generation and propagation of the signals, and in contrast with UWB signals, they do not emerge from antennas that are efficient and directional. Moreover, an unintentional emission may be mitigated in a way that allows the spurious signals to be blocked or filtered without impacting the functioning of the device. As intentional emitters are designed to emit, any blocking or filtering of the signals emitted would defeat their purpose. Finally, and in stark contrast to what UWB proponents plan to do, hairdryers and electric razors are not intended to be networked in a time-division multiple access ("TDMA") fashion in order to maximize band occupancy. The Council, for one, noted in its comments that GPS receivers lose their resistance to

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[60] For example, none of the UWB proponents provide their devices' peak power per nanosecond. This is important, as an ultra-short 1 watt pulse will effectively disable wideband (i.e., 10 MHz or greater) receivers at distances of 30-300 meters, while the average power of such devices on a dBW/MHz over 1 second will remain within nominally acceptable levels. The reality is that spectrum analyzers have band-pass filters, just like GPS receivers, and do not work for wideband receivers.

[61] Time Domain Comments at ii.

pulsed signals when the emissions have a high duty cycle – signals that may be analogous to those generated by large networks using TDMA signals.

Also without merit is Time Domain's assertion that measures of UWB device absolute peak power are of little value, as receivers are commonly too narrow to receive much of the spectral energy of individual pulses. In making this argument, Time Domain ignores the peak power spectral components arising from the periodic components (e.g., pulse trains, especially with narrowband signaling and coding applied), and peak-power enhancements due to multipath aggregation (e.g., time-overlap of pulses from the same emitter), and pulse aggregation effects from multiple sources (e.g., closely spaced emissions in time that have an additive effect in the victim receiver). Moreover, Time Domain's argument that the noise effect of UWB devices is limited to that of the nearest UWB emitter is clearly untrue in all but a few, unique geometries.

The fact that Time Domain advocates the use of techniques that are designed not to capture the real UWB interference picture cannot hide the fact that harmful interference would be caused.[62]

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[62] An examination of the ambiguity function of the signal in Figure 1 below reveals why, as the Council argued in its Comments (*see* Council Comments at 45 & n.81, Attachment A), the sampling rate of the measuring instrument must be at the Nyquist frequency of all signals measured:

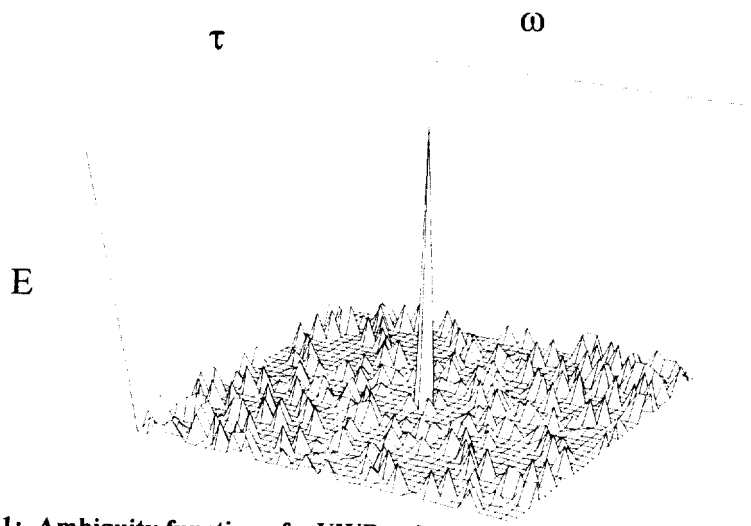

Figure 1: Ambiguity function of a UWB pulse and a sampling/measuring system.

In Figure 1, cuts along the ω-direction provide signal *cross-power density spectra* (there are as many cross power density spectra as there are sampling rates) – such as might be measured by spectrum analyzers. Cuts along the τ direction provide signal *cross-correlations* (there are as many cross-correlations as there are temporal delays). Thus,

When techniques and tools appropriate for assessment of UWB emissions are employed (including sample-and-hold oscilloscopes that are capable of sampling at the Nyquist sampling rate necessary to capture the peak power of UWB signals),[63] when the vagaries of the UWB waveforms (including their susceptibility to detuning due to objects and people close to the antenna) are factored in, and when time-frequency analysis captures composite peak power, Time Domain's arguments are exposed as illogical and contradictory and, in the end, do nothing to help the Commission find a safe way forward for UWB technology.

In summary, Time Domain offers only false promises of "an important new variation on the successful spectrum-sharing regime established by the Commission in Part 15 that effectively increases the utilization of existing spectrum." The Council anticipates that as understanding of the basic science of UWB implications increases on the part of those outside of the UWB community (including the Commission), and the results of appropriate tests and experiments are reported and analyzed, the truth about the dangerousness of UWB transmissions will emerge.

At this point in time, however, the Council urges the Commission to recognize that UWB proponents have not made the requisite demonstrations that they can operate devices in the GPS bands without causing harmful interference. Indeed, in a recent submission to NTIA, which is developing Operational Scenarios for UWB and GPS, Time Domain admits that UWB devices will interfere with existing services such as GPS, but attempts to shift the responsibility for resolving this interference to an unsuspecting public.[64] According to Time Domain, "NTIA must consider

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the cross-power density spectra are related to the cross-correlations by reciprocity relations. In the case of a UWB signal at 1 GHz, however, there is no spectrum analyzer that can operate at the Nyquist frequency. As a result, therefore, the central peak will not be measured, and the "power density spectrum" will be given by a cut along the ω-direction far removed from the central peak area. The inadequate sampling rate of spectrum analyzers will thus result in a fatally understated estimate of the true signal peak power.

[63] Contrary to the assertions of some commenters (*see, e.g.*, Comments of Time Domain Corporation at 25), it is not difficult to measure the –20 dB bandwidth of a UWB signal if a sample-and-hold oscilloscope is used.

[64] *See* Comments of Time Domain Corporation on Proposed NTIA GPS/UWB Operational Scenarios (October 18, 2000) (filed in ET Docket No. 98-153 as an *ex parte* submission by Time Domain).

additional 'real-world' factors that could affect the potential for interference between UWB devices and GPS receivers. In several scenarios, the UWB device will be under the control of the same entity responsible for use of the GPS receiver."[65] It goes on to observe, without substantiation, that "manufacturers, for example, would be unlikely to place the two technologies within proximity to cause interference," and further relies upon "the ability of the user to control interference by turning one of the devices off or increasing the separation between them."[66]

The transition of the UWB community from an argument that only weeks ago was "UWB operates completely transparently to existing radio services," to the current argument of Time Domain and others that UWB interferes, but external circumstances and complementarities will mean that the harmful effects of UWB will somehow be dealt with, is startling. The latter argument is also completely without foundation and contrary to the realities of the market place and expected co-location operational scenarios (i.e., it cannot be assumed that most interfering UWB devices and victim GPS receivers will be under common control or that increasing separation or turning off a device will be feasible). The Commission is charged with the obligation to protect the needs of the radio-using public; it must live up to that responsibility even if it means that some applications of UWB technology are relegated to frequency bands well above 3 GHz.

Based on the comments, the essential prerequisites to a compatibility demonstration between UWB and GPS are the following:

- There must be a meaningful quantification of the level of interference from UWB devices, on a per waveform basis, into existing services;[67]

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65 *Id.* at 2.

66 *Id.*

67 To be sure, this process, which entails the development of operational scenarios for UWB and existing services, the characterization of interference susceptibility of existing services, the characterization of interference characteristics of proposed UWB applications, and the testing of UWB waveforms against existing services, is already under way for a limited number of UWB waveforms. It is, however, a long way from completion.

- Link budget analysis cannot be employed until the fine spectral structure for a given UWB waveform is proven to be stable. This means that antenna structures and filtering techniques must be found that are insensitive to near-field antenna loading.
- A mix of continuous waves and transient signals can only be compared in a time-frequency analysis, not in a link budget analysis
- Peak power per nanosecond, not average power, must be used for this analysis.
- For each UWB waveform, there must be proof of the ability of the UWB manufacturer/operator to limit the interference produced to acceptable levels; and
- For all UWB devices, there must be the ability to control the composite interference that is produced into the GPS and other victim services at levels appropriate for those services.

Until Time Domain and its UWB counterparts make the requisite demonstrations – and these demonstrations can and probably will be made on a case-by-case basis for different UWB waveforms – the Commission has no choice but to withhold operating permission.

D. The General Letters Of Support For UWB Technology Do Not Address UWB Interference Issues; They Show Instead That UWB Could Be Established At Bands Far Removed From GPS And Other Sensitive Services, And That The Use Of A Co-Location Scenario For GPS And UWB Is Required.

As noted in Section I.A. above, the comments filed in this proceeding reveal that UWB technology is intended for widespread deployment in all manners of applications. Indeed, roughly one-half of all comments in this proceeding were made in the form of letters evidencing general support for the promise of UWB technology. [68] The Council has no doubt that these commenters are sincere in their belief that UWB technology has the potential to offer benefits that would assist the commenting individuals, organizations, and entities in the fulfillment of their missions. It also

[68] *See, e.g.*, Comments of the Tennessee Disability Coalition ("[o]ur interest in ultra-wideband radio technology is directly related to its potential use as a tool to enhance the independence and safety of persons with disabilities"); Comments of The Heart Center, P.C. (anticipating that UWB would allow transmission of large amounts of cardiac-related data over short-to-moderate distances using wireless techniques).

does not doubt that the promise of free, unlimited, unlicensed spectrum is very alluring.[69] The fact of the matter is, however, that in sum, the principal effect of these letters is to underscore the need for the Commission to proceed very carefully with UWB.

Two unifying characteristics are found in the general support letters: (1) the letter writers are generally interested in the promises of UWB, but do not state preferences for frequency bands of operation or address the interference prospects to other services (including those such as GPS and cellular radio that many rely upon to do their jobs); and (2) if all of the applications of UWB that are described come to pass, UWB will be everywhere that GPS and other services operate, and will cause them harmful interference. This proceeding is not addressing whether UWB technology has the potential to provide benefits to the public, and the Council does not intend to engage in an immaterial debate on whether or not the promotional claims UWB providers have made to potential customers are true. This proceeding is, as noted above, determining the extent to which UWB devices would produce harmful interference into bands used by existing radio services. On that score, the general letters offer no information relevant to the Commission's inquiry.

The Commission should nevertheless draw from the general letters the notion that potential customers of UWB applications want the technology, but are open on the question of acceptable frequency bands. Moreover, the letter writers have not indicated any willingness to accept interference to GPS and other sensitive services. In this respect, the letters correlate with the numerous substantive commenters who urge the Commission to limit the types of communications services the authors of the general letters seek to frequency bands above about 3 GHz. Given the potential ubiquity of UWB, as evidenced by the same letters, it is clear that if tests show that UWB devices have the potential to interfere with GPS receivers or other services under the likely co-

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[69] Several commenters indicated that they paid billions of dollars for access to their pieces of the precious spectrum resource. *See, e.g.,* Sprint PCS Supplemental Comments at 14.

location (i.e., within two meters of separation) scenario, such devices must be relegated to other portions of the frequency spectrum or precluded altogether.

E. The Commission Must Accept That It Is Not Now, And Will Not Be Upon Completion Of The Initial Round Of Tests, In A Position To Adopt Rules Of General Applicability Regarding The Implementation Of Devices That Utilize UWB Technology.

There can be no question that the determination of the compatibility of UWB technology and services such as GPS rests on a general understanding of the basic science and the outcome of a comprehensive testing program that uses metrics appropriate for the assessment of UWB interference. Each UWB waveform must be tested independently for the reasons highlighted above. Even then there will be open questions as to the impact of persons and objects in the near field of the antenna, and with regard to the aggregation effects of multiple versions of that waveform or of multiple types of wave forms on victim receivers, that preclude any results from applying to networked applications of UWB devices or to situations where more than one UWB device is likely to be in use at the same time within close proximity of a GPS or other victim receiver. Moreover, the test results must be processed through link budgets that use parameters, metrics, and operational scenarios that are appropriate for evaluating transmissions in the time domain. The type of analytic model that is appropriate for such assessments has yet to be fully articulated,[70] and the Council has substantial doubts as to whether any link budgets utilizing data generated in the NTIA tests will be useful in ensuring protection from interference caused by UWB emitters or in deriving appropriate emission limitations on UWB emitters or networks.[71]

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[70] The Council notes that, with respect to GPS, it is participating in an ongoing effort coordinated by NTIA to articulate operational scenarios, and has contributed several GPS scenarios to this effort. The NTIA group has had two meetings (one on September 7, and one on September 27, 2000), and is expected to hold further meetings to address new information recently provided by Time Domain.

[71] The Council has expressed to NTIA the types of interference metrics that are relevant to determining harmful interference into GPS receivers, and noted in the process that the relevant metrics vary with the applications in which the receivers are used. *See* Council Comments at Attachment C at 8-9 (Council Comments on NTIA Test Plan). As far as the Council is able to tell, its concerns have not been taken into account, and the data determined in the NTIA tests

The comments show that there are many services, particularly below 3 GHz, that are vulnerable to UWB interference. The Commission must focus its attention on establishing the basic science for overlaying time domain devices on a spectrum allocated in the frequency domain. Only then can it determine how to quantify – using the appropriate measurement tools and methodologies – the amount of energy that UWB devices and networks will be able to produce into bands used by existing radio services without causing harmful interference. As this process has to be accomplished for every UWB waveform, and even if the detuning effects of near-field objects are left out of the equation, it is clear that the Commission must accept that it will not be in a position to adopt rules of general applicability for UWB devices on the basis of the results of the initial tests now under way.

III. CONCLUSION

The comments reveal an emerging understanding among operators and licensees of existing radio services that UWB technology poses a serious threat to their technical well being and that of their customers. Radiated UWB waveforms are inherently unstable due to variations in antenna loading, and their effects on current services cannot be predicted with certainty. Moreover, use of multiple non-networked UWB devices and UWB devices in networked applications means that the total interference cannot be easily measured, predicted or controlled. These instability and multipath/pulse aggregation issues pose significant obstacles to the development of a rational and comprehensive regulatory environment for UWB devices. At the very least, they require a conclusion by the Commission that regulation of any UWB emitters on an unlicensed basis is out of the question, and that special measures to ensure the protection of GPS and other services (both safety and commercial) operating in frequency bands below 3 GHz are required.

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will be of limited if any use in establishing the effective isotropically radiated power that will be emitted from the UWB devices being tested.

The nation's IT engine (and other critical and restricted services) must not be exposed to UWB unless and until all of the technical and regulatory risks associated with UWB have been removed. The Commission is obligated to protect the tens of billions of dollars in direct and indirect economic investments that the U.S. public and private sectors have made in GPS and the other services that stand to be profoundly impacted by UWB transmissions. This obligation must be met – in this case especially, given the stakes, the Commission must make sure all of the "i"s are dotted and the "t"s are crossed – without regard to timelines that are driven by private interests as opposed to the public interest. Politics and the pecuniary interests of a few start-up companies must take a back seat to good science and the greater public good. Furthermore, the Commission should zealously guard against efforts to reallocate responsibility for precluding harmful interference from the proponents of new technologies to the users of existing radio services.

Clearly, the Commission can take no general action on UWB at this time, and the Council submits, for the reasons stated above and in its Comments, that the Commission will not be in a position to take general action even after the initial test data is submitted in the next few weeks. Instead, the Commission should continue to gather data and opinions in an effort to develop a sound basis for regulation and call for an elucidation of the basic science. Once the theoretical basis has been established – and the Council, as noted, believes that such a basis must at a minimum provide for regulation of UWB emissions under a peak power per nanosecond basis and require that

measurements be conducted of each waveform using a 20-50 GHz sample-and-hold oscilloscope – the Commission will be able to proceed to a further round of tests that will hopefully confirm the soundness of its approach.

Respectfully submitted,

THE U.S. GPS INDUSTRY COUNCIL

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TECHNICAL CERTIFICATION

I, Albert Merrill, hereby certify under penalty of perjury that I have either prepared or reviewed the technical information contained in the foregoing Reply Comments of the U.S. GPS Industry Council, and that I find this information to be complete and accurate to the best of my knowledge and belief.

By: _____

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Dated: October 27, 2000